Exploring ambient technology for connecting hospitalised children with school and home

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A B S T R A C T

Children undergoing long-term hospital care face problems of isolation from their familiar home and school environments. This isolation has an impact on the emotional wellbeing of the child. In this paper we report on research that explores the design of technologies that mitigate some of the negative aspects of separation, while respecting the sensitivities of the hospital, school and home contexts. We conducted design workshops with parents, teachers and hospital staff and found that there was a strong desire for mediated connection, but also a significant need to protect privacy and avoid disruption. In response we designed a novel technology that combined an ambient presence with photo-sharing to connect hospitalised children with schools and families. This paper reports on the field trial of the technology. The research provides new insights into how technology can support connectedness and provides a foundation for contributing to the wellbeing of children and young people in sensitive settings.

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1. Introduction

Children who are hospitalised for significant periods of time face a number of challenges to their wellbeing. Apart from distress caused by physical symptoms, children are likely to experience social dislocation from family, community and peers. This is exacerbated because the dislocation is occurring at a time in the young person’s life when engagement with peers is critical (Hopkins et al., 2014b). Prolonged absence from school can lead to isolation from friends and disruption to learning. While some paediatric hospitals offer education programs, hospitalised children miss out on opportunities to play and to engage in joint activities with friends. At the same time there is a risk that being “out of sight and out of mind” will disrupt friendships and lead to anxiety about returning to school.

Communication technology is frequently used to bridge geographical separation and to mediate support over a distance. Some schools and parents are already using off-the-shelf technology to connect with children in hospital (Nisselle et al., 2012), and research in the hospital setting has shown that children want to feel connected to their classrooms and friends and to feel ‘normal’ despite hospitalisation (Nisselle et al., 2012; Hopkins et al., 2014a, 2014b). However there is little research into the effects and suitability of this mediated communication with hospitalised children. The consequence is that there is little evidence about the specific communication challenges faced in this situation, and how hospital, school and home environments affect the use and usefulness of existing technologies.

This paper explores issues concerning the contextual factors surrounding mediated child–school–family interactions. Following exploratory work using ambient technology to connect the hospitalised child with their school (Vetere et al., 2012), we conducted design workshops with parents and hospital and school staff to better understand the problems they face in maintaining connection over a distance. We designed a tablet-based technology and conducted a field trial over several weeks in a paediatric hospital and in several homes and schools. We report on the results of the trial below. Our work contributes to an understanding of the challenges and constraints that apply in these sensitive contexts. It details our design of a technological support to address them and the impact of the technology on the users.

2. Related research

2.1. The impact of hospitalisation on wellbeing

Hospitalisation can be upsetting and stressful for children (Vernon et al., 1962; Bossert, 1994; Thomson, 2012). Protracted
periods of hospitalisation and repeat admissions can result in a disrupted school experience and discontinuity of learning (Wolfe, 1985; Shiu, 2001). This places children at risk of social isolation from their school community (Martinez and Erickan, 2009). For families, having a child in hospital means changes to routines and responsibilities. Siblings may respond emotionally and parents may experience stress, exhaustion, isolation, guilt and anxiety (Nicholas et al., 2011). Children living with a chronic illness are at higher risk of behavioural and emotional problems and psychiatric disorders (Hysing et al., 2007). Specifically, these children may experience higher rates of academic failure (Needham et al., 2004), increased risk of psychosocial problems (Lightfoot et al., 1999), reduced likelihood of completing high school (Conley and Bennett, 2000), and reduced likelihood of proceeding to post-secondary education (Haas and Fosse, 2008). These effects can impact longer-term outcomes such as attainment of employment, income and quality of life (Power, 2006).

Social support and emotional wellbeing are essential for children to experience mental and physical health (Stewart-Brown, 1998; Ryan and Deci, 2001). For children and young people school can provide a powerful source of social connectedness as well as an educative environment. While some paediatric hospitals offer education as part of an holistic model of care (Zazryn et al., 2012), hospitalised children still miss out on opportunities to work and play with their usual friends, peers and classmates. There is a risk that absence from school will disrupt friendships, leading to anxiety and ambivalence about the eventual return to school. Prolonged absence can also impact on a child’s motivation to keep up with school work, even when in-hospital programs are provided (Hopkins et al., 2013). Maintaining connection to school requires both that the child remain interested and engaged and that the school, classroom teacher and child’s classmates keep the absent child in mind both as a friend and as a learner (Yates et al., 2010).

2.2. Mediated connection for hospitalised children

When a child is physically absent from the classroom, using information and communication technology (ICT) can contribute to maintaining engagement with established educational pathways and with peer interactions (Jones et al., 2009). However while existing ICTs are efficient in exchanging information between the hospitalised child and the school (Nisselle et al., 2012; Wilkie, 2012), challenges associated with managing health issues and hospital settings, such as vulnerability and unpredictability (Yates et al., 2010), have ramifications for the design and use of technologies in mediating hospital–school separation. Privacy is a concern whenever children use communication technology, and this is especially relevant if a hospitalised child’s illness carries a stigma or their appearance has been changed by treatment. Use of communication devices presents a risk also in classrooms, where teachers can struggle to maintain control, and communication tools can be disruptive or be used to harass others (Campbell, 2005; Agatston et al., 2007).

While a number of research projects have explored the design of technologies for supporting social connection among families and couples separated by distance (e.g. Romero et al., 2007; Thieme et al., 2011), research investigating mediated connection for hospitalised children is only just emerging. Weiss et al. (2001) used a video-conferencing system to connect one hospitalised child with their classroom, finding that the child and her classmates enjoyed the system, and the parents approved of the education connection. However the classroom teacher reported increased workload, and problems resulted from trying to capture sound emanating from a group of people spread throughout a large room. Fels et al. (2003) trialled Blackberry devices for connecting hospitalised children with their schools via email, finding that participants valued the educational and social connection. Antón et al. (2011) designed a system which included a classroom-based video-camera that was remote-controlled by the patient, an audio feed, and the transmission of medical and school data: however the authors did not report a trial.

Other researchers have attempted to bridge the distance between hospital and home. Nicholas et al. (2011) found that young patients and their parents enjoyed connecting via video-phones. Parents praised the ability of video to create social presence: “it’s like you’re right there” (p. 215), and patients described it as a source of happiness. However, images of the child in distress were confronting for parents. Video interaction required significant emotional energy, and calls had to be carefully scheduled. Parapour et al. (2011) provided videoconferencing to families who lived considerable distances from hospital. Regular video calls were considered helpful, but raised concerns that children could be viewed without their knowledge or consent. Again, it was found that family members (especially siblings) could suffer emotional trauma by seeing the hospitalised child’s condition or treatment visualised. The researchers suggested caution when providing medical information through video links.

2.3. Designing social connection for hospitalised children

While voice and video allow users to experience social connection with non-collocated others at arbitrary times and places (Katz and Aakhus, 2002), the work cited in the previous subsection is ambivalent about the suitability of high-fidelity media to the hospital and school contexts. While the social presence afforded by audio and video can be engaging for a remote student (Weiss et al., 2001), other work has shown that synchronous video connection requires significant effort to set up and manage (Ames et al., 2010), can cause problems with privacy and disruption (Madell and Muncer, 2007), and may not be preferred by people who are shy or wish to control their presentation to others (Goby, 2006).

By contrast, ambient technologies do not demand attention, but operate in the background of primary activities. They are peripheral and lightweight (Mankoff et al., 2003) and can be used to unobtrusively create awareness of and connection to others (Dey and de Guzman, 2006). Ambient technologies have much in common with phatic technologies (Vetere et al., 2009; Wang et al., 2011), whose purpose is not the efficient transfer of factual information per se; but to establish, maintain and nurture human relationships. Communication systems often have a phatic dimension: for example, photo-sharing may communicate factual information about a certain activity, but also works to strengthen family ties and social bonds (De Greef and Ijsselsteijn, 2001; Brush et al., 2008; Waycott et al., 2013).

In our prior work, an ambient “Orb” was successfully used to connect hospitalised children with their classrooms (Vetere et al., 2012). The Orb was a large light globe containing an internal LED that allowed it to glow in different colours. It was located in classrooms and controlled remotely by the child in hospital. It was purposely designed to offer minimal functionality: the child could remotely switch the Orb on and off, and through a colour-wheel interface change the colour of the Orb.

Children in hospital and their classmates at school responded positively to the Orb. They felt that it created a sense of presence and a stronger connection between child and classmates. Classmates treated the Orb as a proxy for the absent child, pointing to it and even addressing it by the child’s name. They enjoyed attempting to interpret what the colour changes might mean, and what might be happening when it was not transmitting. They imagined associations between colours and feelings or activities such as “Blue means he’s crying”. While the Orb offered minimal functionality, it primed a desire to communicate further using other media such as email or video calls, thus acting as a phatic device. This
ambient technology respected the constraints of the classroom by maintaining a subtle, peripheral presence that did not interfere with schoolwork. However the Orb did not send signals from classroom to hospital: thus while the child's presence was manifest in the classroom, classmates and classroom activities were not made evident at the hospital. Furthermore parents who observed the interactions expressed interest in technology that would include them in the interaction.

This paper reports on work that builds upon the Orb project in facilitating bidirectional interactions and extending the communication network to hospital, school and home, while maintaining the benefits of a sense of presence generated by ambient technology. We report here on the design and trial of a technology to support ambient social presence using mobile devices.

3. Research design

We conducted our work in three phases.

**Phase A: Co-Design Workshops** – in phase A we held a series of co-design workshops to explore the desirability of, and constraints upon, mediated communication for children in hospital and their teachers and parents, with a view to informing the design of a supporting technology. We held workshops with stakeholders corresponding to each of the three contexts of hospital, school and home. This phase generated a rich understanding of the divergent needs of stakeholders and the constraints imposed by the contexts upon technology use.

**Phase B: Design and Implementation** – in phase B we used the insights derived from phase A to design and build a tablet-based application which created a sense of the social presence of the distant other, using mobile devices that could be easily integrated into hospitals, schools and homes.

**Phase C: Field Trial** – in phase C we arranged for 9 hospitalised children and their respective teachers, classmates and families to trial the technology designed in phase B. We interviewed participants before and after a period of several weeks of use, and analysed this interview data to draw out themes that can be used to collectively discuss each group's outputs. The large-group discussion was moderated by one of the researchers who recorded notes on a whiteboard. All notes and worksheets were collated and discussed by the researchers after each workshop.

4. Phase A: co-design workshops

We conducted workshops with three stakeholder groups: parents, teachers, and hospital staff. The aim of the workshops was to clarify the needs and constraints faced in the contexts of hospital, school and home and to generate and discuss ideas for technologies.

Understanding contexts of use was critical in this phase. Schools and hospitals are highly structured and regulated, particularly in relation to care of children, where the institution stands in loco parentis for a broad range of children and families. Both schools and hospitals take a highly conservative, risk-averse approach to communications technologies, particularly those which are accessed by children, and this regulatory environment strongly influenced the parameters within which the technology had to be designed. The involvement of children in the co-design workshop was thoroughly discussed and explored. We considered using child-centred design methods that have been successful in other domains (Druin, 2002). However ethical and safety considerations were a significant obstacle to conducting workshops with children. Workshops conducted in the hospital or elsewhere could expose children with chronic illness to unreasonable health risks. Rather than restrict the study to children who were not seriously ill and could potentially participate in a workshop, we chose to undertake a series of three workshops with key stakeholders – parents, teachers and professional carers. We acknowledge that this approach may bias the design towards the issues such as privacy (from parents), control (from carers), and minimising distractions (from teachers). However we were keen to stress the concerns of children during the field trial and evaluation of the technology.

4.1. Structure of workshops

Each of the three design workshops consisted of 10–15 people comprising representatives of a stakeholder group, technology experts (including interaction designers and programmers), and researchers (in HCI, health and education) including the authors. **Table 1** illustrates the series of workshops and the participants in each.

**Table 2** illustrates the format of each workshop. We began with an introductory session including a design scenario set in hospital, school or home respectively. After this, the participants broke out into small groups each consisting of at least one stakeholder and one researcher: these spent 30 min recording concerns and generating designs onto worksheets. Then all participants regrouped to collectively discuss each group's outputs. The large-group discussion was moderated by one of the researchers who recorded notes on a whiteboard. All notes and worksheets were collated and discussed by the researchers after each workshop.

4.2. Workshop outcomes

4.2.1. Hospital context

In workshop 1, hospital staff told us that some children were already using technology to connect with schools, friends and family, with significant benefit. We heard that many children already used Facebook and Skype to connect with others, including patients in other hospital wards with whom they had become friends. However we heard that mediated connection with school was uncommon. We heard that one school had fastened an iPad to a classroom wall in order to hold a Skype session with the patient once per week. Another school had set up the child's cricket bat to

<table>
<thead>
<tr>
<th>Use context</th>
<th>Stakeholders and experts</th>
<th>Technology experts</th>
<th>Researchers</th>
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<tbody>
<tr>
<td>Workshop 1</td>
<td>Hospital</td>
<td>4 Hospital staff</td>
<td>2 Experts + 1 developer</td>
</tr>
<tr>
<td>Workshop 2</td>
<td>School</td>
<td>2 School teachers, 1 school IT expert</td>
<td>3 Experts + 1 developer</td>
</tr>
<tr>
<td>Workshop 3</td>
<td>Home</td>
<td>3 Parents, 1 parent consultant</td>
<td>2 Experts + 1 developer</td>
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represent them at their desk while they were absent. We heard that core patient concerns included:

- What are my family/friends doing now?
- I wonder if they are thinking of me?
- Boredom.
- Keeping up with school work.

Hospital staff were ambivalent about high-fidelity media such as video. On the one hand they felt that transmitting video from class could give the child a sense of being with friends. But they felt that video should not be broadcast from the hospital, due to privacy concerns and patient self-consciousness, especially for patients whose appearance had been changed by disease or treatment. Suggestions were made regarding the blurring of video feeds or the use of avatars and motion detectors to give a sense of presence without breaching privacy. Mobile devices were felt to be highly suitable as they could move with the patient, and easily be placed in suitable positions throughout the day.

### 4.2.2. School context

In workshop 2 we heard that teachers were acutely aware of the absent child’s social and education needs, and agreed that mediated communication could help with these, but were also very concerned about disruption of classroom activities. Teachers noted that the absent child could not become the focus of the class and that the technology couldn’t “take over”. They noted there was a significant variation in the ability and willingness of teachers to use technology in class. They emphasised that teachers and students are busy, distractions are a problem in class, and teachers need to maintain control. Video in particular needed to be under the control of the teacher, and could only be switched on at pre-arranged times.

Privacy was also a significant concern when transmitting pictures or video of school children, with signed consent from parents usually required before footage could be taken at school. The workshop participants felt that photos would be more suitable than video, and that the technology should indicate each user’s readiness to communicate.

### 4.2.3. Home context

In workshop 3, parents of hospitalised children told us that their core concerns were:

- How is my child feeling?
- What is my child’s medical status?
- I wonder if she/he is awake?
- Should I visit today?

They emphasised that parents of chronically ill children were emotionally stressed and faced budgeting pressures regarding time and money, and that technology design should reflect this. They reminded us that most parents spent significant time in two contexts – work and home – and that the acceptability of engaging in mediated communication could differ significantly across contexts. They desired to monitor their child’s condition, though establishing social connection, especially with other relatives, was important too. However hospital-based researchers who participated in the workshop felt that hospitals would be unwilling to transmit a patient’s medical status, for fear of it being misinterpreted by families and causing alarm.

### 4.3. Overall themes arising from design workshops

The workshops generated many design suggestions and a large amount of sometimes passionate discussion. Analysing the data collected across all workshops, we identified the following themes:

#### 4.3.1. Desire for awareness and social presence

All stakeholders recognised a need for awareness of activities in the distant location and a greater sense of social connectedness. They reported that hospitalised children wanted to know what their friends and family were doing, and to gain some sense of the classroom activity that they were missing while in hospital. Teachers wanted to be aware of the wellbeing of the child in hospital, and believed the child should be in regular contact with school both for learning and social interaction. Parents wanted to know how their child was feeling, what they were doing, and whether the parent’s help was required.

#### 4.3.2. Potential for disruption from high-fidelity synchronous connection

Participants told us that connections such as video could be disruptive to classrooms, hospital wards and parents' workplaces: this was less of a problem in homes. Classrooms are dynamic environments, and teachers felt that uncontrolled communication might be too disruptive and that text and video modalities would invite misuse.

While video connections were being used already by some classrooms and hospitals, typically at pre-arranged times, participants expressed concern that video required effort to arrange suitable times and set up reliable connection, and could breach children’s privacy. The paediatric hospital has many private rooms, so it is often possible for children to use video chat with their school without disrupting or breaching the privacy of other patients. However it was noted that children undergoing treatment that results in changes to their appearance may not wish to broadcast images of themselves to school.

Children undergoing treatment were also not always available for synchronous communication. Such connection might be stressful if children were not sufficiently healthy to maintain communication over a period of time.

#### 4.3.3. Personal connections

Privacy concerns notwithstanding, a desire for personal connection was apparent. The use of linguistic media such as spoken or written messages, as well as graphical media like photographs,
was highly regarded for its ability to create personal connection. However the potential for misuse of these modalities was noted by teachers, and it was agreed that in a trial such messaging would need to be moderated for ethical reasons.

Unsurprisingly the preferences expressed by a given stakeholder group were sometimes in conflict with the concerns of another. There was significant variation in attitudes to video, with parents tending to be most enthusiastic and teachers least. Some parents desired real-time monitoring of medical data (such as heart rate), whereas hospital staff felt this might create problems and be stressful for parents and staff. Our challenge was to choose a design approach that afforded social connection while respecting the differing desires of stakeholders and the ethical and pastoral requirements for adults working with children.

### 5. Phase B: technology design and implementation

Based on the workshop findings we designed the Presence App to explore the role of technology in mediating social connections for hospitalised children.

#### 5.1. Conceptual design

We felt that the range of needs discovered, and the desire for choice and control, made it necessary that the technology offer multiple modalities though which to connect. Our design supported a variety of interaction styles to meet this desire for choice and control of interaction. However in response to concerns from teachers especially, we decided to rule out implementing synchronous video and audio and text messaging. Co-design made it clear that these modalities were unlikely to be acceptable for always-on use, while if desired for occasional use they were available through existing technologies such as Skype and email. Instead we decided to build upon the notion of ambient presence as a way of creating an ongoing social connection while being sensitive to the particular needs identified in the settings of hospital, home and school.

We used as a starting point for design the ambient and phatic approach of the Orb project, which had proven to be suited to the constraints of the hospital and classroom settings (Vetere et al., 2012). The Orb was a physical artefact located in the classroom which responded to remote activity, thus representing the absent child and keeping them in the minds of classmates. In a similar vein, workshop participants had spoken of classroom use of objects associated with the absent child, in order to represent them. The Orb study showed that selecting and transmitting a colour could serve as a simple phatic connection that did not disrupt or overly distract users or breach their privacy. We recognised that an ICT could easily implement two-way colour sharing, thus addressing a complaint of children in the Orb study. Furthermore an ICT could automatically detect and represent activity, and using an appropriate representation might convey a limited awareness that supported social presence without breaching privacy. In addition, an ICT connected to a timetable database could convey a sense of classroom rhythms.

We therefore chose a design which offered the following four connections:

##### 5.1.1. Representation of remote activity

An essential aspect of awareness systems is the understanding of the activities of others (Dourish and Bly, 1992). Awareness of activity was a strong emergent theme in design workshops. Design participants told us that children wanted to know what their classmates were doing in school; classmates wanted to know what was happening in the ward; and parents wanted to know about what their child was doing when they couldn’t be there. As discussed above, it is not always desirable to transmit a complete and detailed description of the activity. Our goal was to provide a simple account of whether there was any activity at the remote location and the magnitude of that activity. The design was intended to answer the question ‘Is there something going on at school/home/hospital?’ The answer would be given in simple terms, which would evoke a sense of the scale of activity at the remote location, but give no details of its nature.

We considered several methods for detecting activity level including comparing successive images taken with a camera, counting changes in the number of local Bluetooth devices, and using an external infrared sensor. In the end we chose a representation based upon the level of noise at each site as a rough proxy for level of activity. The app used the tablet’s microphone to periodically detect the local sound level, encode the reading and transmit this simple scalar value to the remote tablet for display. High levels of background sound suggest a busy place with lots of activity. Thus users gained a sense of whether action was occurring near the remote tablet. Despite being a very simple measure we believe sound level is a viable approximation for activity at a distant location.

##### 5.1.2. Colour sharing

We extended the idea of colour-sharing introduced in the Orb study by implementing it as a two-way medium in which both the child and the classmates/family could send and receive changes of colour on the tablet display. Colour-sharing affords a simple social connection which does not involve transmission of linguistic or audio-visual information. By sending a colour, the sender is conscious (if only for the moment) of the receiver and of how the signal may be received. By receiving the colour, the receiver becomes aware of the sender as a person and the signal as a purposeful act of connection. Following the phatic approach, the meaning of the message is less relevant than the degree to which it strengthens human bonds.

##### 5.1.3. Photo sharing

Colour-sharing and awareness of activity are important for generating a sense of connectedness, but lack the personal dimension desired by our workshop participants. To facilitate a connectedness that is more personal and yet simple and unobtrusive, we included photo-sharing in our design. The feature allowed children to take photographs and share them with their classmates or family. The classmates and family could also take and share photographs with the children.

The inclusion of photo-sharing represents a trade-off between a desire by users for meaning in communication and a concern especially by hospital and school staff that the technology not disrupt sensitive settings, invade privacy, or be used to convey distressing information. For safety in the trial and to allay ethical concerns, the technology was implemented so that photographs had to be checked by a moderator (one of the researchers) before transmission to the recipient. This was made clear to users, as were the reasons for doing it; thus the existence of bounds on how the technology should be used was clear to all participants.

##### 5.1.4. Timetable

The experience of being absent from school also meant not being part of the routines of school life. School routines are broadly bounded by the lesson timetable, and a reminder of the school timetable adds to the sense of awareness of school activities. The timetable is not an indicator of actual activity, but an alert to the routines (in general terms) of what has just happened and what will be happening next. Our app displayed
the current state of the classroom timetable to the hospitalised child to convey awareness of classroom routines, showing the previous, current, and next class that the child’s classmates were undertaking.

Thus the app was designed to support wellbeing by sustaining an ambient, always-on but non-intrusive mediated social connection between hospitalised children and their classmates and family. As discussed above, research has shown that social connection is critical to the wellbeing of children who are absent from school due to hospitalisation. On the other hand, a mediated connection must respond to the constraints of these special contexts. Our hypothesis was that a technology that provided ambient awareness and phatic communication might satisfy these needs and constraints.

5.2. Interface design

Following a suggestion that emerged from the co-design workshops, we implemented our design on tablet computers. These are inexpensive, easy to use, offer a range of inputs (such as cameras and microphones) and can be easily passed among people, relocated within a classroom, ward or home, or taken outdoors on excursions. We used Huawei 7-in. touch-screen tablets, running the Android OS with 3G Internet, and built a native software application. The tablets connected via a server that logged all exchanges.

The interface design was intended to be unobtrusive, to embody core aspects of ambient displays, and to afford both implicit and explicit interaction (cf. Vogel and Balakrishnan, 2004). We used the metaphor of a ‘lava lamp’, as these are popular ambient decorative objects which encode colour and movement. The core feature of the design consisted of animated ‘blobs’ that moved within a background medium, with a speed proportional to remote activity.

Since two-way colour-sharing requires the representation of both ‘sent’ and ‘received’ colours, we rendered the blobs in the received colour and the background as the sent colour. The impression was of the activity of others displayed as blobs of a colour they chose, moving within a home space of a colour chosen by the local user.

To the side, photographs were displayed as thumbnails which, when touched, expanded to fill the screen. Timetable information appeared as an unobtrusive text overlay on the child’s display (Fig. 1).

5.3. Implementation

Users were organised as school–patient–home triads, with communication restricted to within triads. Children in hospital
could connect to both their home and their school, while school and home users only communicated with their respective child (not with each other). To support this the hospital display had a split screen in which one side represented connection with school and the other side connection with home.

Fig. 2 illustrates a triad of users with their tablets. The hospitalised child on the left is holding their tablet for focal use. The parent at home (top right) has positioned their tablet for ambient viewing while doing chores. The teacher has placed their tablet on a desk at the front of the class for easy viewing by students.

6. Phase C: technology trial

6.1. Participants

We conducted a study with nine inpatients at a paediatric hospital using the Presence App. The hospitalised children were aged between seven and twelve years and were enrolled in a primary (elementary) school. Each child recruited to the trial had a serious health condition involving an expected inpatient stay of two weeks or more. They varied in the degree to which they were already using mediated connections to school and home. Their families were offered the opportunity to trial the tablet at home, although not all of them did so. Two cases dropped out because the child recovered sufficiently to leave hospital. These children were able to use the tablet for a short time and give feedback. The other cases used the tablet for periods varying between 1 week and 1 month. Human research ethics approval was granted by the hospital research committee and the school authorities.

Table 3 lists brief details of the child participants.

6.2. Materials

Each child formed part of triad case that included the parents/family and the school classroom. Each case was provided with three tablets: one each for the child in hospital, another for the family at home, and the third for the class at school. Our software was installed onto each tablet. Tablets were packaged in a colour-ful branded bag along with instructions, a charger, and a stand that allowed the tablet to be positioned vertically on a flat surface such as a shelf or table. No other materials were supplied.

6.3. Approach

Tablets were set up at the hospital, classroom and home. Upon setup we conducted pre-trial interviews with children, parents and teachers. The pre-trial interviews addressed questions about the nature of the social contact within the triad (e.g. type, frequency) and the current use of technology (if any) to mediate it. Each interview was conducted by one or two members of the research team and took place at school or hospital as appropriate. The hospitalised child and their parents were sometimes interviewed together, usually in the ward in which the child was normally located. Teacher and class were usually interviewed together in their classroom. Interviews were audio-recorded for later analysis.

The participants used the tablets for a period of several weeks. We asked participants to use a diary built into the tablet to record their thoughts about using the app. Other than brief observations at setup time we did not directly observe the system in use, as this would have been too disruptive to all contexts. After the period of use we retrieved the tablets and conducted post-trial interviews with all participants. The post-trial interviews concerned the use of the tablet (including any difficulties), and its impact on the social contact within the triad. All communication via the tablets was also recorded in a server database.

6.4. Analysis

Three kinds of messages were passed between tablets. Sound levels and timetable updates were transmitted automatically, whereas colour-changes and photos were deliberately sent by users, allowing us to track some aspects of use in a quantitative fashion. 127 photos were sent during the trial, averaging 14 per case. 2143 colour-change messages were sent, averaging 240 per case. There were too few participants to make claims about differences in means; however the data indicate that children in school and hospital used the tablets more than did family members at home: this was reinforced in interviews, as illustrated below.

There was no way for us to measure how often users attended to the messages they received. Furthermore it is doubtful that this would provide meaningful information about the usefulness of an ambient technology, as by design such a technology must not demand attention but merely be available to be attended to as desired. Therefore it was necessary to ask users about their

Table 3 Description of child participants.

<table>
<thead>
<tr>
<th>Age</th>
<th>Male/female</th>
<th>Notes</th>
</tr>
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<tbody>
<tr>
<td>10</td>
<td>F</td>
<td>Required frequent hospital admissions for recent onset health problem. Treatment caused her to changed appearance. Had recently changed schools, and was not well connected to current school.</td>
</tr>
<tr>
<td>8</td>
<td>F</td>
<td>Cystic fibrosis required frequent hospitalization. Family lived in country town, so school and home were a long distance from city hospital. Dropped out of trial due to early discharge.</td>
</tr>
<tr>
<td>11</td>
<td>F</td>
<td>A cancer patient who was rarely able to attend their school. Was already using Skype and email daily to connect with school.</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>This child had problems with speech and cognition. Child and parents were interested in trialling tablet, but school was not, therefore withdrew from trial.</td>
</tr>
<tr>
<td>8</td>
<td>M</td>
<td>Child had cystic fibrosis and needed frequent admissions to hospital. Was not well connected with school and peers. No existing mediated connection with school, though teacher tried to remind pupils of absent student.</td>
</tr>
<tr>
<td>9</td>
<td>F</td>
<td>Child was a cancer patient, therefore frequently absent from school. Well connected to class through her sister, but was not using mediated connection to school.</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>Child was socially well connected at school, but absent for a long time partly due to lack of wheelchair access to classroom. Had become disengaged from school work and was falling behind academically.</td>
</tr>
<tr>
<td>10</td>
<td>F</td>
<td>Child had been absent from school for a long time, but was well connected socially. Teacher emailed and sent letters and cards, and arranged visit by classmates to hospital.</td>
</tr>
<tr>
<td>12</td>
<td>M</td>
<td>Child was a long term cancer patient, who missed his school friends and was anxious about starting high school. His teacher maintained a connection using Skype, SMS and visits to the hospital.</td>
</tr>
</tbody>
</table>
experience of use and how it influenced their relationships over a distance. Below we present an analysis of interview data.

Interviews were transcribed and analysed independently by researchers from two research institutions. Initially all the data relating to each child were collated (child, parent and teacher interview data, server log data, photos) to produce a rich narrative case study centred around each participant. We also conducted a site analysis in which all data relating to each site (home, hospital and school) were collated to provide a richer picture of the nuances in context and usage across the different personal and institutional settings of the different sites. We used these to build our understanding of the cases, but do not explicitly repeat these analyses in this paper. We coded interview data using NVivo and identified a number of themes. These themes were compared by the two research teams and any discrepancies were negotiated until agreement was reached. We report on the themes below, noting that they are informed by all analyses that were carried out.

7. Results

The use of an ambient technology to support the social presence of a hospitalised child was generally well received by children and teachers in this trial, though less so by parents (which is explored further in Section 8).

Analysis of interview data revealed the following themes emerging in the research: the impact of a child’s illness; use of existing technologies; Connection to social life; and Ambience, awareness and presence. These themes are discussed below, while implications for technology design are drawn out in the section following.

7.1. The impact of a child’s illness

We include these observations, drawn mostly from pre-trial interviews, for the insights they offer into the complex problems faced by children, carers and teachers, which need to be taken into account in designing for this space.

Participants often spoke of the difficulties of managing a serious health condition. For the child this could range from feeling unwell, feeling angry or anxiety about particular treatments, dislike of physical changes brought about by medication (such as hair loss or weight gain), a sense of isolation and missing out on usual activities, and a disconnection both from the academic learning which happens at school and from their friends and peers.

Parent: She was great at sports, you know, like basketball and soccer and musical theatre and we had to drop out of every-thing. I mean her whole life just had to change. [family, pre]

Parents reported on the stress to themselves and other family members, especially siblings, when the child was away in hospital. They also reported that they faced competing demands for privacy and information sharing between the child, the health care team, the family and the child’s school.

Teachers noted that the child missed out on critical elements of the curriculum when they were away and also lost connection with friends and peers over time. In some cases this was exacerbated by poor pre-existing social connections for the child before they became unwell, which added a layer of complexity to the task of connecting the absent child with the classroom. Teachers also reported on the difficulties of managing a class full of inquisitive students (and sometimes other members of the school community) in handling sensitive information regarding the child’s condition. Classmates of the absent child tended to focus on friendship and social issues, reporting that they often missed the child and would like to have them return to school.

Teacher: I got their permission and we spoke about it with the children just sort of saying what it was, without being too graphic, and early on we just sort of talked about she might lose her hair, and then when she actually did we sort of said that to the children. [school, pre]

Despite the difficulties, many hospitalised children maintained their enthusiasm for school and in particular for the social interactions available there. Without the opportunity to play with friends, life in hospital could be boring. Several children emphasised that it was their friends, not their schoolwork, that they missed. Teachers also noted that children might miss the routines and security of the regular school day.

Researcher: When she’s in hospital are there things she talks about that she misses about being at school or…?

Parent: Not, she doesn’t miss the school work, she just misses the social aspect of it which I think is pretty common at this age. [hospital, pre]

Some (though not all) hospitalised children were confident that their friends missed them and were thinking about them. Some classmates and teachers thought and spoke frequently about the absent child. Unsurprisingly, some of what classmates and teachers discussed during the child’s absence concerns the nature of the child’s condition, what happens in hospital, and when the child was likely to return. Teachers recognised the sensitivity of discussing condition and prognosis, though some felt it was essential to provide some information to classmates.

Teacher: At first the [name]’s were quite reluctant, more out of appreciation for how kids might take it. … we felt it was best after a while and the [name]’s agreed we would share [child]’ story. … a bit about chemotherapy and what [child] might look like when he does return. [school, pre]

Children in hospital thought about what their friends at school were doing. Many found it difficult to stay in touch with friends while in hospital. Prolonged separation could damage a child’s relationships with classmates.

Parent: Now if she sits in a group she gets kind of ignored because she hasn’t been around for so long. [family, post]

Many of the hospitalised children in the study attended school at unpredictable times. Some were away for months at a time, while others attended sporadically as their health care permitted. Returning to school after a period away was a significant event for all concerned, capable of eliciting excitement.

Researcher: How do you feel when you think about going back to school?

Child: Excited.
Researcher: Excited? What makes it exciting?
Child: I can see my friends. [hospital, pre]

But returning after a long hospitalisation could also be difficult.

Student: It was a little bit awkward, ‘cause you didn’t know what to say and stuff, ‘cause you hadn’t seen him for a while. [school, post]

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1 Participant quotes are marked as [SOURCE, TIME] where SOURCE is ‘school’, ‘hospital’ or ‘family’, and TIME is ‘pre’ or ‘post’ trial.
Returning to school elicited anxieties for both parents and children about fitting in socially, catching up with school work, changes in appearance, and even bullying.

Parent: Her best friend didn't come up to her, and we're wondering if she - cause she's known her for years - if it was a bit too much. [family, pre]

Interrelated factors of ill health, the effects of treatment regimes, absence from school and disconnection from teachers and peers all combined to influence the hospitalised child's attitude to school, a known contributor to educational outcomes over time. The child's classmates also had an influence on the child's attitudes to school and successful experiences of reintegration after absence. We conclude that a technology which supports and enhances social connections between child, teacher and the classmates during prolonged absence may help to ensure the emotional and educational wellbeing of children with health conditions.

7.2. Use of existing technologies

Our pre- and post-trial interviews gave us insights into existing communication practices employed to connect with hospitalised children. Again, while these do not directly illustrate use of our technology, they are briefly discussed here to provide context and inform other researchers seeking to design for these contexts.

As well as frequent, prolonged face to face contact with one or both parents, children in hospital maintained connections with family through mobile telephones, landline telephones, email, online chat, video calls and visits. Some schools employed a similar range of telecommunication between the class, the absent child and in some cases the child's parents. Broadly, two strategies were employed by schools. One was to set up communication between the class and the absent child using ICT, snail mail and personal visits. The other was to use an object in the class to represent the child, such as a token on the child's desk or a container for gifts. The former strategy has the function of creating a connection between sites, while the latter serves to keep the absent child in the thoughts of their classmates. Our intention was to complement and enhance these strategies in a way that was engaging for children of the digital age.

All participants spoke positively about mediated connection while recognising problems with the context of communication. A problem with voice telephony was the need to find times when all members of the conversation were free, which was especially difficult at school. Thus asynchronous media emerged as a preference. Some teachers organised email accounts for students, and in one case distributed laptops so that the class could “bombard” the hospitalised child with messages:

Teacher: We now have an emailing roster so it is planned for one girl to email [child] each school day... but with absences, specialist lessons, special events etc – sometimes that is a challenge. [school, pre]

There was little reported use of mobile phones by children: one hospitalised child reported using SMS with a friend. Only a couple of participants mentioned using social network websites: possibly because few children of this age use these and because access is blocked at school. Several schools used multiple technologies to stay in touch with the hospitalised child and/or their family, including video conferencing. However use varied a great deal and there were some cases where little contact had occurred between classroom and hospital, as the following exchange indicates:

Parent: They'd sent notes and stuff... But I mean...

Researcher: Not really Skype or anything?

Parent: No they were setting up some blog that they could all connect to but it never happened. [family, post]

Many teachers kept the hospitalised child's desk free as a reminder of the presence of the child as a member of the class. Some assigned the absent child to study groups as though they were present. Some teachers included the hospitalised child's name when taking attendance even though they knew the child would be absent. Some schools made cards and gifts to send to the hospital, sometimes dovetailing this activity with art lessons. One teacher kept a box into which objects intended for the child were placed:

Student: We sent her some beautiful pictures and cards, and we have a little box over there, and we'd put stuff for her […] like cards or letters or presents. [school, post]

Most teachers sent printed or emailed handouts and/or homework sheets to the child or their parents, though they recognised that assigned work might not be able to be carried out.

Teacher: Even though I always keep the homework for him and I send it through, I'm very doubtful that he's able to complete it. It's more just so he can… really for his connectedness to school. [school, pre]

Where video was used, the intense social presence it enabled was appreciated by some.

Teacher: When she was first diagnosed we actually went to camp and she missed camp so we Skyped her every day from camp.

Researcher: What is it about Skype?

Student: Just because you can see her. [school, pre]

But video chat sessions pre-arranged by adults could be awkward for children (cf. Ames et al., 2010).

Teacher: I'll start the conversation and try to get the kids to take over, but I found that the kids are quite awkward with it. And they they'll sort of sit there … can't think of anything to ask and to say. [school, pre]

Clearly, mediated connections can be acceptable and useful. Yet there is evidence of a need for a design that is more sensitive to these contexts and users.

7.3. Using the Presence App to connect to social life

Most teachers had made some attempt to maintain the absent child’s educational involvement with their school, although in one case the teacher relied on the child's family to maintain the connection to school and in another case the teacher felt that the child's natural academic ability would allow the child to catch up with peers upon her return to school.

Even for those teachers who were active in maintaining the child's connection to friends and to learning through existing technologies such as email and texting, ambient presence was seen as a useful adjunct, and most teachers felt it could improve connection between their hospitalised students and the class.

Teacher: I do think that the tablet and application will keep [name] connected to school as he has a means to remind us
that although he is physically not at school he is still present. [school, pre]

In practice, ways of using the Presence App varied from school to school. In some, the children simply took the tablet and sent colours when they desired: this is the style of use we envisaged. However in many cases the teacher controlled the tablet or assigned a particular child to be in charge. Other classes discussed every morning what the “colour of the day” would be. (These approaches generate fewer colours than free use, which might impact the connectedness experienced by the recipient.) These restrictions can be taken as confirmation that teachers believe that introducing a new technology into a classroom requires careful management. No analogous issues were found to have occurred at homes or at hospital, demonstrating an asymmetry between these sites.

Participants at school liked colour-sharing and the ambient activity display. Children found these features easy to use and understand, and felt that choosing colours was creative and game-like. Teachers appreciated the lack of disruption imposed by the tablet, especially when compared with existing communication technologies.

Researcher: How did it make you feel when you were changing the colours?

Student: Well like an artist, like when you…

Student: I thought it was really good because then like we, just say [child] and say if people chose red then maybe she might have thought, well, we’re thinking of her now because red… and a love heart.

Student: I thought it was pretty cool. There’s like two things in two completely different places and they can still connect to each other and connect us to [child]

Student: It felt like I was like playing games on my iPod and like switching to like different games it was really cool. [school, post]

As occurred in the Orb trial, some students discussed what meaning, if any, the colours had. A common interpretation was that they should represent emotions. Although there have been suggestions for a psychology of colours and even colour therapy (O’Connor, 2011), we did not propose interpretations of this kind to participants. Most children did not assign meanings but simply chose their favourite colours and assumed that others had done likewise. Some children interpreted colour-changes in a rational way, for example as indicating that “the child in hospital is awake” or “my classmates at school are bored”. Others desired that meanings should be pre-assigned, as reported by one teacher:

Teacher: We did want to have a code about, like does red mean that you’re very happy and blue means you’re a bit sad. [school, post]

This is evidence that phatic interaction prompted the desire for meaning-laden communication via other modalities.

There was considerable enthusiasm among children for the activity-detection feature, whereas adults were less engaged by it. Activity-detection was successful at conveying a sense of the absent other and engaging children in the technology. It was most appreciated in classrooms; evidence that ambient presence is suited to this context. Most children liked the moving dots and seemed to be fascinated by what they might represent:

Student: We could see how busy the hospital was or her home. There’s like little snowflake things on the screen and if they were moving fast it was really like loud and busy. If it was like really slow it wouldn’t be.
have learned from experience that there is a risk that communication technology can be abused.

One child reminded us that under some circumstances privacy is desired strongly by children, and that photos can breach this.

Child: I don’t like pictures. I don’t even like you taking pictures when it was my birthday. I don’t like pictures now that I’m fat ’cause of steroids. [hospital, post]

Despite the limitations of ambience, the app successfully facilitated social connection between hospital and school:

Researcher: And do you think having the tablet in class made you think about [child] more?

Student: Yes, it was like a reminder.

Student: It’s like [child] but in the technology version. [school, post]

Student: It felt like we were more connected to her.

Student: It felt like you could write something on a piece of paper, take a photo and she would get that message.

Student: Yeah I did ’cause we were like closer to her and we could text her pictures and all that. [school, post]

Before the trial, parents were sceptical about colour-sharing as a support for connectedness:

Parent: I don’t really get the significance of the colours going back and forward. [family, pre]

This comment gets to the heart of the parental lack of engagement with the ambient technology observed in the trial. While parents in the design phase were enthusiastic about the possibilities of an ambient display to connect them with their child, in practice parents of a child suffering a serious health condition requiring them to spend time in hospital had more immediate needs for communication and information sharing with their child than the ambient display could provide. Parents were either present in the hospital in person or were highly engaged with their child through telephone, Skype and other ICT. Although we did not see it in practice during the period of our trial, one parent felt the tablet would have been useful for grandparents:

Parent: When he [grandpa] gets quite sick they have to be separated. He can’t go and see him in the hospital. It would have been handy during those quarantine times. [family, post]

This indicates that while parents generally did not find ambient presence useful, it might be suited to other relatives not directly involved in caring for the child.

Our design was not intended to directly address teaching support, though we hoped it would aid learning outcomes by supporting social connectedness. Regardless several teachers used the photo-sharing feature to convey classroom activities to the child in hospital. Without an accompanying narrative the photos possibly were ambiguous, although one teacher did send photos of students at work in the classroom followed by a photo of text explaining what was happening. Children reported becoming more tuned in to what was happening in the classroom via the activity display. The timetable feature did not inspire much comment; however no one criticised it and we would include it in future designs.

7.4. Ambience, awareness and presence

A key question for this project was whether an ambient technology could create connection without disrupting local activity. Our technology appears to have created a sense of the ‘presence’ of the absent child.

Student: It sort of felt like she was here with the tablet because like she’d be sitting up there except she’s not. [school, post]

Hospitalised children spoke of gaining a sense of awareness of their distant classroom, where the activity monitor conveyed information about what friends were doing in class:

Child: The balls were… moving really fast because they were really loud.

Researcher: So what do you think they were doing?

Child: Usually when they’re loud it’s probably at art time. [hospital, post]

For a device to be visible but not distracting depends partly on where it is positioned. Teachers tended to keep the tablets near the front of the class for visibility as well as for easy control. One tablet was placed on the absent child’s desk. Only in a few classrooms did the tablet move around. This was somewhat surprising as we expected the tablet’s mobility to be exploited more. Lack of movement was partly due to the need to recharge the tablet battery; however a high degree of teacher control was exercised over the tablet.

Teachers felt that the tablet was more distracting early in the trial but that distraction reduced over time.

Teacher: It was pretty exciting the first couple of days, but it did blend into the background after a while. [school, post]
This hints that the problem of maintaining the balance of visibility and intrusiveness may change over time.

Our aim was not to transmit explicit knowledge about activity, but rather sufficient awareness of activity to give a sense of daily rhythms and to prompt interest and discussion. This was achieved between the classroom and the hospital. It did not work as well for between the home and the hospital. It is possible that the emotional intensity experienced by a parent whose child is in hospital is incongruent with the subtle characteristics of an ambient display. The findings suggest parents have a need for greater connection to their child during these difficult times, but the nature of that need and the appropriate technological response to it require additional research.

8. Discussion

Prolonged or frequent hospitalisation can present significant challenges to the social and emotional wellbeing of young patients and their connectedness with family and peers. Hospitals and classrooms are uniquely challenging contexts for the use of communication technology. Through human-centred design and evaluation this study sought to shed light on the complex issues relating to communication between a hospitalised child and their family and friends, and on the basis of this understanding explore designs for novel technology that might address these issues.

8.1. Technology for the school and hospital contexts

The suitability of off-the-shelf ICTs to school–hospital connections is reduced by the potential for disruption of scheduled classroom-based education, breach of children's privacy, problematic use, and broadcast of inappropriate or emotionally distressing images. However some people work around these limitations to employ ICT to ameliorate social disconnection in this context. Schools and families use telephone and video calls to stay in touch with the child, with video clearly delivering the benefits reported by Weiss et al. (2001) and Nicholas et al. (2011). Email remains popular for the school–hospital link. Hand-written letters and handmade gifts are a popular way for classmates to stay in touch, suggesting that personalisation and physical objects are important to the connection. But mobile phone use by children was rarely reported during our study, which is not surprising in a primary-school setting, and young children in hospital rarely have social contact that is not arranged by adults.

Hospital and school are unique and problematic contexts for the use of high-bandwidth technologies. Education and health institutions take their responsibilities in regard to duty-of-care of children seriously, so any technology that is implemented across these settings needs to account for protocols and policy. An important ethical consideration of interventions is that they do not cause harm; thus transmission of potentially distressing images or information needs moderation, socio-technical parameters that guide the information flow between hospital, home and school need to be considered, and participants need to acquire a shared understanding of each other's concerns.

8.2. Lightweight communication technologies suit sensitive settings

Ambient technologies to establish social presence show promise for sustaining social connection in these sensitive settings. Ambient awareness creates a sense of the rhythm and patterns of the school or hospital, and is interesting to children and acceptable to teachers and hospital staff. Colour-sharing, a simple phatic interaction, is enjoyed by children, who find it playful and creative. A lightweight medium is less demanding of attention and requires less effort than “rich” media. This may be useful for hospitalised children made weary by illness or treatment, as well as for children in class who are frequently busy, and sometimes find it awkward to speak with or view the hospitalised child directly.

Photo-sharing in particular is highly acceptable to these user groups and a successful medium for social connection, as it has been in other settings (e.g. Waycott et al., 2013). Photo-sharing can convey awareness of feelings and activities, without disruption. Photos, which can be composed, selected and moderated, are less likely to raise privacy concerns than are video-cameras or microphones. But whilst photos can be more compelling than ambient media, they are more apt to create problems. There is likely a correlation between the degree of social presence a modality can support and the degree to which it can breach privacy or disrupt a classroom. Thus the appropriate medium in a situation is likely to be a compromise that might vary over time.

Some users asked for “richer” media, and several participants said they would prefer that the tablet allowed them to send and receive text messages. But our research indicated that teachers often consider text messaging inappropriate in the classroom. Furthermore, when text is desired it can be provided by existing technologies such as email: our aim was to explore alternatives to traditional media rather than duplicate them. An ambient technology does not prevent participants from using other technologies when circumstances permit: rather it can fill the gap between opportunities to use synchronous media, stimulating curiosity and providing topics for later discussion. Some of our participants worked around our omission of text messaging by transmitting photos of handwritten messages. This takes time and is a public and often supervised action, which reduces the likelihood of frivolous use and gives rise to a “personalised” aesthetic which contributes to social connection.

8.3. Communication between child and family

The Presence App was more frequently used by children and teachers than by parents and other relatives at home. We believe this resulted from a combination of two factors. The first was that many parents in the trial spent much of their time in the hospital together with their child, negating the need for mediated connection. The second is that during the difficult and highly stressful period of their child’s illness the parents’ need for information and communication outstripped the capabilities of the ambient technology. Parents of seriously ill children often require close connection and communication with their child, as well as with the health care team. This need for real time, information-rich communication made the ambient technology less appealing in the home setting than in the classroom and hospital ward. Voice emerges as a strong preference for these acts of communication. Parents want to discover in a very direct fashion how their child is feeling and whether there is anything the parent needs to do. They do not need to be protected from disruption: usually if their child is distressed a parent wants to know right away and to provide any support they can.

Other researchers have provided phatic technology to families and found that higher bandwidth was desired. Varosh and Abowd (2011) found that parents separated from their children preferred regular use of a high-bandwidth communication medium. De Greef and Ijsselsteijn (2001) provided a photo-sharing system to separated family members and found that while it induced social presence, participants asked for video-chat as well. Brush et al. (2008) provided photo- and calendar-sharing to members of extended families, finding that photo-sharing was welcomed but that participants asked for asynchronous text chat to be added. Thus significant differences can be discerned between the hospital–home and hospital–school connections.
8.4. The voice of the child

As we argued in Section 4, the contexts of use and the constraints they impose are critical in designing communication technology for use in paediatric hospitals and schools. While our preference was to include children in the design process, risks associated with the well-being of the children were an understandable obstacle. Ethical and practical constraints made it difficult to conduct co-design workshops in the paediatric hospital or to bring children from the hospital to another location. Given the difficulty and sensitivity of this context we adopted an approach where the children's voice was expressed through their carers (parents, teachers and hospital staff) during the design phase. We acknowledge this is a proxy, but nonetheless valuable.

On the other hand children enthusiastically embraced their roles as informants and evaluators of our prototypes during the field trial. Use of the technology, as well as pre- and post-trial interviews, were held on school and hospital premises, where research could be conducted with minimal impact on children's care and routines.

The posting of images was moderated, but we do not believe this affected the integrity of the child's voice. The moderation is likely to have been more effective at allaying concerns of carers (which were expressed in the workshops) than to prevent misuse of the communication technology.

9. Conclusion

Children who are absent from school for long periods due to hospitalisation can benefit from a mediated connection with their school, friends and family. The views expressed during co-design and the positive reaction to our technology, as well as prior work on mediated connection, indicate that awareness of activity and a sense of daily rhythms at school assists with maintaining and strengthening connections between hospital and school. But significant constraints regarding privacy and disruption in school and hospital settings create a challenge for technology designers. Though “rich” technologies are attractive, they can be problematic in these settings. Ambient displays that offer constrained communication and prioritise phatic interactions are a promising solution. An artefact that is associated with the distant other and which reacts to the other’s activities can sustain social connection by inducing a subtle sense of social presence. However constrained ambient awareness is not always sufficient and needs to be supplemented by conventional voice, text or video based communication when available and appropriate.

This research has provided insights into the need for connection between hospital and school and the specific constraints that govern communication between these sites, and explored the practicality and effectiveness of an ambient technology in meeting these constraints. A communication technology, appropriately designed and respectful of sensitive contexts, can reduce isolation and improve the emotional wellbeing of children undergoing long-term hospitalisation.

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