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Telepresence Goes to School: An Evaluation of the P.E.B.B.L.E.S.TM
Videoconferencing System for Ill Children

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Abstract

P.E.B.B.L.E.S.TM (Providing Education By Bringing the Learning Environment to Students) is a videoconferencing robot designed to reconnect ill children with their classmates and teachers. The purpose of this study was to assess the impact of PEBBLES on children's telepresence-related behaviours and perceptions in the classroom.

Ten laboratory sessions with four children each were conducted to compare PEBBLES against a standard desktop computer with videoconferencing capability. In each school-like session, one child participated remotely while the other children and a teacher participated from a classroom.

There were no differences between PEBBLES and the desktop system in number of glances made towards the remote child, amount of participation of the children, feelings of group-integration, or descriptions of the experience. There was a tendency for the remote children to speak less often, but for longer amounts of time, on average, than the children in the classroom.

Remote children in the PEBBLES and Desktop conditions raised their own hands equally often. However, remote children in the PEBBLES condition also used the PEBBLES hand the same number of times as they raised their own hand. Nearly all of hand-waving behaviours were successful at getting attention.

Implications for the design of PEBBLES and the measurement of telepresence are discussed.

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Telepresence Goes to School: An Evaluation of the P.E.B.B.L.E.S.TM

Videoconferencing System for Children

It has been estimated that 10-15% of all children will experience chronic illness in childhood (Cadman, Boyle, Szatmari, & Offord, 1987, as cited in Northam, 1997).

Chronically ill children continually face physical and psychological stressors. Physical stressors may come from pain, symptoms of illness, unpleasant medical procedures, therapeutic intervention, and feeling ill. Psychological stressors may come from feeling different, being different, restricted activity and separation from friends and family (Northam, 1997; Bossert, 1994).

Due to these stressors, chronically ill children are at risk for psychological problems. There is evidence of a two-fold increase in psychological maladjustment in chronically ill children (Northam, 1997). Independently of disease symptom patterns, they are at increased risk for “internalizing spectrum disorders” such as anxiety, depression, sleeping and eating disturbances and excessive fears. The risk for externalizing problems such as aggression, disobedience and lying is lower, but still elevated in these children (Northam, 1997).

A number of variables have been identified which may present children with greater risk for these psychological problems. For example, boys seem to be at greater risk of psychological morbidity, and children with poor or uncertain prognoses are at greater risk as well (Northam, 1997).

Further, the stability of family and other social supports seems to be important (Northam, 1997). Classmates and teachers of the ill child may provide very important social support for ill children. However, most children are separated from these people

while they are treated in hospital or recovering at home. Although most children have access to in-hospital tutors to help them with their schoolwork and sometimes even in-hospital classrooms, the separation from their own social network may be very painful and may contribute to ill children's increased psychological risks. A way to overcome feelings of separation from these important people might provide some stress relief for these children.

P.E.B.B.L.E.S.TM

Researchers at Ryerson University, the University of Toronto and Telbotics, have created a videoconferencing technology to reconnect ill children with their classmates and teachers. P.E.B.B.L.E.S.TM (Providing Education By Bringing the Learning Environment to Students) was designed to create a physical and social telepresence for children who are too sick to attend school (Fels, Waalen, Zhai and Weiss, 2001). It consists of two robotic videoconferencing units: a *classroom unit* and a *remote unit*, which are shown in Figures 1 and 2. The two units send live videoconferencing data between the classroom and the hospital room via Integrated Services Digital Network (ISDN) lines so that the remote child (in the hospital) can communicate in real-time with the local children (in the classroom) and teacher.

Figure 1. The PEBBLES classroom unit.

Figure 2. The PEBBLES remote unit.

Note. Photos of PEBBLES shown with permission of Dr. Deborah Fels of Ryerson University.

The classroom unit is about the same size as an elementary school-aged child, and can be moved around on wheels by classmates. A video monitor is embedded in the “head” of the robot, as are the camera, microphone, and speakers. The hospitalized child interacts with a similar interface on the remote unit and controls the classroom unit with a video-game-pad controller. With this device, the child can control the camera functions such as zoom, tilt, and turning the head in order to attend to different tasks in the classroom. In addition to these standard video controls the child can activate a mechanical waving hand as an attention-getting device.

The PEBBLES project has had much support from industry and government. Among its fifteen sponsors are The Bay, Wayne Gretzky, CIBC World Markets and CANARIE. Currently, the PEBBLES system is being commercially manufactured and marketed internationally. The commercial cost of one system is approximately \$90,000.

History

The developers of PEBBLES wanted to construct a system for children to maintain social interaction with the school while in hospital (Williams, Fels, Treviranus, Smith, Spargo and Eagleson, 1998). Important system criteria included a need to support teachers, support-staff, parents and other children as well as the sick children. The first design consisted of a remote and a classroom unit. The remote system comprised a standard computer with a camera, speakers, microphone and game-pad. The classroom system consisted of a television screen atop a wagon with a camera and an attention-getting light. See Figure 3 for a photo of the device.

Figure 3. The classroom unit of the predecessor to PEBBLES.

This design was further developed based on research on attention-getting devices. Fels and Weiss (2000) tested four different devices: a red light, a yellow rotating light, a wire hand and a fan with ribbon streamers. They found that the yellow light and the wire hand elicited the fastest response times in the classroom from teachers.

The next PEBBLES design came out of this research: the hand was chosen as the attention getting device, and a playful outer shell was added to the remote and classroom units to make them more child-oriented and fun (see Figures 1 and 2 above).

Very recently, a new design for PEBBLES has emerged. It is similar to the egg-shaped version in Figures 1 and 2, but the head is smaller and sits atop a metal shaft, as in Figure 4. The functionality of this version of PEBBLES is the same as the egg-shaped version.

In the present investigation, the older version (in Figures 1 and 2) was studied.

Figure 4. The newest version of PEBBLES.

The developers of PEBBLES are now working on a new system that is wireless, small and portable, with increased functionality such as remote collaboration tools. The intended users are secondary school students and possibly university students and business people.

Videoconferencing

There are four main types of videoconferencing systems: desktop, group, media space, and special purpose systems. *Desktop videoconferencing* is designed to connect

physically distant collaborators in the business environment with their personal computers (PCs). In these systems, users connect to each other through their desktop computers with a telephone line or local area network (LAN), and can even share data or applications. These systems can be used as point-to-point connections between two users, or as multipoint connections between multiple users (Angiolillo, Blanchard, Israelski and Mane, 1997). Since the purpose of PEBBLES is to connect a single child with a large group of children in the classroom, and the purpose of desktop videoconferencing is to connect single users with each other, PEBBLES cannot be classified as a desktop system.

Another type of videoconferencing systems is *group systems* (Angiolillo, Blanchard, Israelski and Mane, 1997). These systems are designed to support meetings between groups in different locations. Some systems are set up in specialized videoconference rooms; however, portable systems are also available. These group systems usually use dedicated transmission lines for better quality image than desktop conferences, but at a higher cost than a regular telephone call. The PEBBLES system could be classified as a group system, albeit a “roll-about” one, because it is designed to connect a large group of people (an elementary school class) with a sick child.

Two other types of systems are *media spaces* and *special purpose systems*. Media spaces are usually developed for researchers to experience and study the dynamics of remote collaboration. Special purpose systems are designed to fit specific business needs, such as banking kiosks that allow a distant banking expert to provide personalized advice. PEBBLES could also be classified as a special-purpose system because it is designed for a special user group and circumstance and is not for general business use. Thus, PEBBLES could be considered a hybrid of group and special purpose systems.

Research on Videoconferencing System Design

There has been a great deal of research on the impact of specific videoconferencing design issues on communication protocols and social norms (see Finn, Sellen and Wilbur, 1997 for a thorough review). Two of these issues are directly relevant to the PEBBLES videoconferencing system: eye contact and turn taking.

Eye contact. In most videoconferencing situations, the image of the remote participant is not co-located with the camera that captures the local user. As a result, it is difficult for the users to establish eye contact with each other. A solution to this problem is to use half-silvered mirrors or teleprompters to facilitate looking at the camera and screen simultaneously (Buxton, 1992; Mantei, Baecker, Sellen, Buxton, Milligan, 1991), but these solutions are complicated and uncommon.

The difficulty with eye contact is compounded in multiparty conferences where multiple users are displayed on the same screen in a Picture-in-a-Picture (PiP) format. In addition to the problem of eye contact, it is difficult for users to be aware of whom, if anyone, is attending to them. Sellen, Buxton and Arnott (1992) tried to resolve this issue with their four-way “Hydra” communication system, which consisted of four monitors and speakers with co-located cameras for each user. This system allowed users to hold parallel conversations as well as to determine who was attending to whom.

The PEBBLES system also helps resolve this issue because the head of the robot (which contains the monitor and the camera) can be turned to face different people in the classroom. As a result, the local users are aware when the remote child is looking at them because the monitor with the remote child’s face is facing them. This design feature of PEBBLES is atypical of most systems, which do not allow remote control of the camera,

and if they do, do not also turn the monitor with the image of the remote participant.

Thus, the issue of eye contact will be investigated in this study.

Turn taking. Among others, Mantei and colleagues (1991) point out the need for a moderator to control turn-taking in videoconferences. There is a loss of traditional status cues for indicating the desire to speak (such as leaning in to speak) in group decision making. The problem with turn taking in videoconferencing could be extended to the PEBBLES use-case where the normal social cue for turn-taking in the classroom is raising one's hand. However, PEBBLES may help moderate turn-taking by providing a robotic hand for the remote child to wave. Thus, the use of the robotic hand will be examined in this study.

Telepresence

Telepresence, or the sense of “being there” (Ishii, Kobayashi, Arita, and Yagi, 1997, p. 444) is often discussed in the videoconferencing literature. It has been defined as “the use of technology to establish a sense of shared *presence* or shared *space* among geographically separated members of a group” (Buxton, 1992, p. 123). It can be considered in terms of two spaces: the person space and the task space. The task space refers to a presence in the domain of the task being undertaken, such that if a group was working on a budget, each user would have the budget in front of them as a shared spreadsheet and could make changes, annotations or indicate cells that are the subject of discussion. The person space is the “collective space between/among group participants” and includes facial expression, voice, gaze and body language (Buxton, 1992, p.123). It has also been described as a “sense of full presence” that requires the establishment of a shared space of the people and of the shared space of work materials. The successful

implementation of this presence gives an awareness of the social periphery- the sense that would otherwise be afforded in a shared corridor or open office (Buxton, 1997). It is not clear if this sense of full presence has ever been achieved.

The definition of telepresence (Buxton, 1992, 1997) seems to encompass two domains: users' perceptions and users' behaviours. Users' perceptions are feelings of "being there" or feelings they have a "presence". Users' behaviours are facial expression, gaze, and body language, and perhaps even participation in group activities, such as speaking and listening.

In the case of group videoconferencing systems such as PEBBLES, where a group of users is together in one location and one user is participating remotely, these feelings and behaviours of telepresence should occur, to a greater or lesser degree, in both the remote and local participants. For example, remote users will have perceptions about how present they feel in the local group, and the local group will have perceptions about how included the remote user is. Also, the remote participants might exhibit certain behaviours that reflect how present they are, and the local participants might exhibit certain behaviours that reflect how present they feel the remote user to be.

Research on telepresence usually presents descriptive accounts of users' experiences rather than quantitative data about users' perceptions of telepresence. For example, Mantei and colleagues (1991) describe their "experiences in the use of a media space", which summarizes their personal experiences during the initial use of a videoconferencing technology. Although such work is rich with anecdotes and design ideas, it provides little information on how to measure telepresence. Clearly, more research is needed in this area.

The purpose of this study is to assess the impact that PEBBLES has on children's telepresence in the classroom. This research attempts to quantify telepresence for all users, but especially for children. It also provides information on the extent to which children react differently in response to PEBBLES' unique design features than to a traditional videoconferencing system. If such differences are found design recommendations for a range of systems could be made.

An additional benefit of this research is that any evidence suggesting that PEBBLES makes a difference to users' telepresence could help to justify the very high cost of this technology. School boards and hospitals, which are already struggling financially, want to know that the benefits of PEBBLES justify the cost. However, if a standard computer with readily available hardware and software were to have the same effect on users, it could be much less expensive to connect sick children with their classmates and teachers.

The only study to date that has assessed the impact of PEBBLES in the classroom is Fels, Waalen, Zhai and Weiss' (2001) case study of three ill children who were using PEBBLES. Their goals were not to assess telepresence, but rather to examine the patterns of academic behaviours in sick children over time. They report that "despite teaching style, grade level, setting (hospital or home) and distraction, each child was able to participate in concentrated activities at a level appropriate for the grade level and curricular activities carried out at school" (Fels, et. al., 2001, p. 623) and that "PEBBLES helped the remote students behave in ways appropriate to the educational and social requirements of school" (p. 624).

Although Fels and colleagues' (2001) study may be helpful in promoting the technology by describing children's academic behaviour, it provides little information about how PEBBLES affects the children's presence in the classroom. Also, the study took place in a naturalistic setting and it was therefore not possible to exercise experimental control. For example, there was no comparison group of children without PEBBLES or children with a different system, and no pre- and post-session data to compare children's behaviour before and after using PEBBLES.

In studying the impact of PEBBLES on telepresence, it is essential that comparative data be available so that statements can be made about the system's impact relative to other systems. Therefore, to assess the impact on telepresence in the classroom, children in this study were randomly assigned to two experimental conditions; PEBBLES and a desktop computer with videoconferencing capability. In order to provide a controlled environment, the study was conducted in a laboratory setting, with healthy children. Apart from the fact that it would be unfair to assign ill children, or healthy children in a classroom, to a control condition, sick children differ along so many dimensions that it would be difficult to establish well-defined groups. The same is true for classroom teachers and experiences.

In every session, one child participated remotely from another room while three other children participated locally with a teacher in a classroom-like setting. The children performed age-appropriate and school-related tasks, including a collaborative assignment.

Perceptions and behaviours relating to telepresence were defined and assessed since telepresence encompasses both of these domains. Whereas perceptions are related

to feelings of being there, behaviours encompass facial expression, voice, gaze, body language and participation.

Telepresence Behaviours

Facial expression, voice and body language are extremely difficult to measure because these behaviours are complex. For example, distinguishing reliably between a smile and a smirk, or a laugh and a giggle is very challenging. However, one behaviour that can be measured relatively easily is gaze.

Gaze

Although specialized eye tracking equipment is required to determine the exact direction of a person's gaze, it is possible to determine the general direction they are looking by watching the position of their head and eyes. Little precision is needed to determine if a child in the classroom is looking at the remote child. Therefore, every instance of this event was examined. However, the direction of gazes of the remote children was not examined because it would be nearly impossible to measure it effectively. The direction of gaze of the remote children was not examined since the local children could not tell when the remote child was looking directly at them. As a result, eye contact from the remote children was not expected to contribute to the local or remote children's feelings of telepresence.

Participation

Participation in group activities may be another indication of how present a person feels in a group. For example, the degree to which the remote participant speaks, relative to the local participants, may be directly related to the degree to which the participant feels present, and thus part of the group.

Every interaction in the laboratory sessions was examined to determine if there were differences in the amount of interaction between children who used PEBBLES and the children who used the desktop computer. Also, the amount of interaction among the three local children was compared with the amount of interaction between the remote child and the local children to see if the remote children participate as much. Specifically, the number of utterances, the average duration of these utterances, and the total time of speech were recorded in this study.

Use of Robotic Elements

The robotic elements of PEBBLES (waving arm and turning head) make it unique as a videoconferencing system and may set PEBBLES apart from other systems in affecting degree of telepresence. Thus, every instance of robotic use (head turns and hand waves) by the remote children was examined in an attempt to understand the reasons for and reactions to their use. The number of robotic hand waves was also compared with the number of times the remote children raised their own hands to see if there were differences in how they attempted to gain the attention of the teacher and local children.

Perceptions of Telepresence

Some studies of media spaces have used measures that may relate to perceptions of telepresence. For example, Moore (1997) describes an evaluation of a remote learning task of the Ontario Telepresence Project. The goal of her research was to determine if the addition of a second audio-visual channel would affect students' evaluation of "presence", comfort, and ease of interacting. Although details of the "poll-type evaluations" used are not described, they report that the addition of a second visual channel improved the students' evaluations of presence, comfort and ease of interacting.

Therefore, asking users to evaluate each other's presence may be an option when measuring perceptions of telepresence, and is assessed in some form in this study.

Olson, Olson and Meader (1997) conducted similar research in their evaluation of different remote collaboration methods. They asked university students in collaborative groups of an MBA class to rate their satisfaction with the process used for generating the task requirements for the design of an "automatic post office", as well as with the design result. Students also rated the evenness of the participants' contributions and reported if a leader had emerged. Finally, users rated how easy it was to understand the other participants and be understood. Details of the actual questions asked are not presented.

These ratings of contributions, leadership and understanding may be related to telepresence because if the remote participants were able to contribute, understand and be understood, perhaps they could be considered to be as "present" as the local group members. Such surveys might be useful in the assessment of telepresence.

However, perceptions of presence of the children cannot be assessed in the same manner as Olson, Olson and Meader's (1997) study of adults. Asking children to rate the contributions of their peers would not be suitable because children might become uncomfortable or upset by this task. Children might also have difficulty understanding these concepts. Fortunately there are some established self-report measures appropriate for children in the developmental psychology literature that could be used in an assessment of how much a child feels like she is "there" or how much she feels she is part of a group. These scales come from research on loneliness, a feeling that may result from the separation that occurs when sick children have to miss school.

Loneliness and Peer Group Integration.

Loneliness has been defined as “the unpleasant experience that occurs when a person’s network of social relationships is deficient in some way, either quantitatively or qualitatively” (Perlman and Peplau, 1981, as quoted in Parkhurst & Hopmeyer, 1999). Several self-report measures of loneliness are available for children.

Goossens and Beyers (2002) conducted internal consistency and confirmatory factor analyses on six currently available self-rating measures of loneliness for school-aged children. They found that the Children’s Loneliness Scale (CLS; Asher, Hymel & Renshaw, 1984, Asher & Wheeler, 1985) and the peer-related loneliness subscale of the Loneliness and Aloneness Scale for Children and Adolescents (LACA; formerly known as Louvain Loneliness Scale for Children and Adolescents; Marcoen, Goossens & Caes, 1987) were most reliable, but that all six scales were at least moderately reliable.

Also, four different but interrelated constructs emerged: negative attitude to being alone and positive attitude to being alone; family-related loneliness; and peer-related loneliness (Goossens & Beyers, 2002). The two attitudes (positive and negative) toward being alone refer to general reactions to being alone. The two types of loneliness (family-related and peer-related) refer to the two major types of relationships that children have: with peers and with family.

Attitudes to being alone are not appropriate to assess in this study since these attitudes refer to chronic loneliness rather than transient loneliness, in that they are not likely to change or be affected over a short period of time. Thus, it is unlikely that they would be affected by the use of PEBBLES, especially in a two-hour laboratory session. This subscale is therefore not employed in this study. Likewise, since family-related

loneliness has little to do with a child's perception of telepresence in the laboratory it is not investigated here. However, the use of PEBBLES may affect peer-related loneliness, because PEBBLES connects children with their peers (i.e., classmates). Therefore, peer-related loneliness can be assessed as a potential impact of PEBBLES on children.

However, the peer-related type of loneliness is very specific and any one scale contains only a few items that tap into this factor. In addition to this problem, most scales contain many other items from other non-relevant subscales.

Goossens and Beyers (2002) recommend that since all six scales they examined were moderately reliable, the selection of loneliness scales should depend on the particular research objectives. They specifically suggest that if researchers want to concentrate on loneliness in children's relationships with their peers the Illinois Loneliness Questionnaire and the peers subscale of the CLS should be used. They also point out that Peer Group Integration subscale of the Relational Provisions Loneliness Questionnaire (RPLQ; Hayden, 1989, as cited in Goossens and Beyers, 2002) is a suitable alternative. Although compiling a new scale from other scales without specific validation poses problems with psychometrics, it was not appropriate to use one of the established scales for this laboratory study. Thus, items from these scales/subscales were used in the laboratory study of PEBBLES. A detailed discussion of the scale used is presented later. It should be noted that since the items chosen for the scale in this study were primarily peer group-integration type questions, the outcome measure used to assess loneliness was called *group-integration*.

Interviews

Another way to examine how present children feel is to ask them. Therefore, unstructured interviews were conducted with the children at the end of each session to give them an opportunity to express whether or not it felt like the remote child was present. Each group was asked “did it feel like the remote child was here?” and the rest of the interview flowed from there.

Extraneous Variables

There may be factors external to PEBBLES and videoconferencing that could affect children’s perceptions and behaviours related to telepresence. Gender, strength of friendship of the children, and shyness may all be related to these measures.

Gender

Gender may affect perceptions and behaviours related to telepresence in ways that cannot be predicted or accounted for. Groups of girls may behave differently than groups of boys. Boys and girls who are in the same group are also likely to behave differently. Girls tend to be easier to recruit, so they were chosen as participants for this study.

Strength of Friendship

Participation in group activities could be affected by how well the children in any one group know each other. For example, best friends are more likely to interact freely and comfortably with each other than children who do not know each other. It was important that this factor not interfere with the chosen outcome measures, so a viable solution was to ensure that the participants did not know each other before they participated in an experimental session.

Shyness

In addition to videoconferencing type, shyness may affect participation, gaze and perceptions of group-integration. According to Buss (1980), shyness is as a tendency to react to strangers or casual acquaintances with tension, concern, feelings of awkwardness and discomfort, as well as gaze aversion and inhibition of normally expected social behaviour. Shyness differs from sociability, which refers to a tendency to affiliate with others and a preference for being with others rather than being alone (Buss, 1980).

Since the children in the laboratory study of PEBBLES were interacting with strangers, level of shyness could affect the results. Shy children might interact less with the other children. Alternatively, it is possible that shy children could find a new confidence with the videoconferencing equipment and behave more socially than usual. To assess any effects of shyness, this factor was measured and controlled for to ensure that any effect on participation, gaze or feelings of group integration could be attributed to the videoconferencing equipment and not shyness.

There is one shyness self-report measure for school-aged children: the 26-item Children's Shyness Questionnaire (CSQ; Crozier, 1995). This scale contains items such as "I find it hard to talk to someone I don't know" and "I am usually quiet when I am with others". Since PEBBLES was designed for school-aged children, the CSQ was employed in this study.

Summary

In summary, the present investigation took place in a laboratory setting with groups of unfamiliar girls interacting with each other through PEBBLES or a desktop computer. Outcome measures were telepresence-related behaviours and perceptions.

Behaviours were operationalized as gaze, amount of participation, and use of PEBBLES' robotic elements. Perceptions were assessed using group-integration questionnaires and interviews. Finally, self-reported shyness was measured and controlled for.

Hypotheses

The following hypotheses were developed based on the idea that PEBBLES' unique design characteristics would impact positively on the outcome measures described above. Overall, it was expected that there would be differences between the children who used PEBBLES and the children who used the desktop computer in terms of gaze, degree of participation, level of perceived group-integration, and descriptions of the experience in interviews.

Gaze

(a) It is expected that the local children will look at PEBBLES more often than the desktop computer.

Participation

(b) It is hypothesized that the remote and local children who use PEBBLES will speak more frequently, for longer amounts of time on average, and for more total time than the remote and local children who use the desktop computer.

(c) It is hypothesized that the local children will speak more frequently, for longer amounts of time on average, and for more total time than the remote children, regardless of which videoconferencing type they use.

Group Integration

(d) It is hypothesized that remote children who use PEBBLES will report feeling more integrated in the group than remote children who use the desktop computer.

(e) It is hypothesized that the local children who use PEBBLES will report the same degree of group-integration as the local children who use the desktop computer.

Interviews

(f) It is hypothesized that more children in the PEBBLES condition will report that it felt like the remote child was “there”.

Method

For each session, four children, a teacher, and the experimenter came to the laboratory for approximately two hours. After a short orientation, one child, the “remote” child, was placed in a separate room, while the other children, the “local children”, remained in a classroom-like room with the teacher. During the experimental sessions, the remote child connected with the classroom through videoconferencing. Data on group-integration, participation and shyness were collected at different points in the sessions.

Participants

There were four children per experimental session and twelve sessions in total. However, the first session was not analyzed because of audio problems, and the eleventh session was not analyzed because one child did not show up and another was an hour late. Thus, 47 children participated in total. However, only data from ten of the sessions and 40 children were analyzed.

PEBBLES was designed to be used by elementary school-aged children (ages five to twelve). To increase statistical power, age of the subjects was kept relatively constant, from nine to eleven years. This age group was selected because the children in the study

must be competent at reading and writing in order to complete self-report measures. All of the children were of this age except for one who was eight and a half years old.

Gender was kept constant to increase statistical power. All of the participants were female. Participants were recruited primarily from Girl Guides of Canada in the Ottawa region. Guide leaders were contacted directly for permission to recruit within their units. Recruitment packages were handed out in person to the girls at the Guide meetings. These packages contained a letter explaining the study, a consent form and a map of the university (see Appendix A).

After several weeks of recruitment through Girl Guides, it became obvious that an insufficient number of girls could be enlisted to participate. Therefore, notices were posted around the university to increase the number of participants (see Appendix B). Additionally, some girls were recruited via word of mouth through the university, friends and family. The same recruitment package was sent to parents of interested girls.

A further criterion for participation was that girls did not know each other before the session to ensure that the possible confound of strength of friendship was eliminated. Thus, girls from the same Guide group, and girls who were friends, were scheduled into different laboratory sessions.

Materials

The classroom units consisted of two different videoconferencing types: PEBBLES and a standard desktop computer with videoconferencing capabilities. In all conditions, the remote unit was a standard computer with videoconferencing capabilities.

Classroom Unit

The classroom unit created for the experiment appeared nearly identical to the actual PEBBLES classroom unit in Figure 1. It consisted of a real PEBBLES housing (a yellow and aqua egg-shaped head) which contained an LCD screen and a Canon VC-C4 digital video camera. The head of the unit sat atop an audio/visual (A/V) cart containing the computer hardware. In the real PEBBLES unit, the hardware is encased in a cylindrical housing below the head; however, this housing was not available. Instead, the cart was covered with a blue sheet to hide the hardware from view. The head rotated from side to side by means of a motor controlled by a game-pad held by the remote student. This controller also allowed the child to activate the motor of the hand-waving mechanism.

The classroom unit transmitted live images and sound from the child in the remote location to the classroom. Only the child's face and shoulders were visible on the screen of the classroom unit.

In the Desktop condition, the classroom unit consisted of a standard desktop computer with videoconferencing hardware. A standard monitor and Canon digital camera were placed on a small table near the children. As with most videoconferences, the remote child did not have control of the camera in the classroom.

A single computer was used for both experimental conditions. This computer was housed on the A/V cart underneath PEBBLES. There was a direct RCA connection through the ceiling from the camera of the classroom to the video card of the remote computer. Likewise, there was another direct connection between the remote camera and the classroom video card. The video signal in the classroom was split between the two

monitors and was controlled with a simple A/V switch. When one videoconferencing type was used in a session, the other equipment was pushed into the corner and covered with sheets.

The video signal was transmitted by using Videum Capture software such that the image from opposite locations was visible on the entire surface of the desktop of each monitor. Sound was transmitted by using two professional conference phones. In the classroom, a Mitel full-duplex audio conference phone was placed on the table with the local children and partially covered with a colourful box. In the remote room, a Polycom Soundstation full-duplex audio conference phone was placed on the desk behind the monitor. Audio was transmitted simply by telephoning one extension from the other and leaving the phones on for the duration of the session.

Remote Unit

In contrast to the classroom unit, it was not possible to create a visual replicate of the actual PEBBLES remote unit because the yellow and aqua casing, which does not add functionality, was not available. However, not all hospitalized children who have used PEBBLES have had this casing. The remote unit consisted of a traditional desktop computer, a Canon digital video camera, conference phone, and the game-pad controller. All other equipment (including keyboard and mouse) was hidden from view. The computer was set up in such a way that the remote child saw a full-screen image of the children and teacher in the other room.

Teaching Supplies

In order to conduct a school-like session, the teacher used some standard teaching supplies. She had classroom aids such as a whiteboard and markers, paper, pencils and

pencil crayons. Four colouring books were available for the children to play with quietly when they were waiting for the sessions to begin. A beanbag was also used for the ice-breaker activity (see below).

The children were given gifts at the end of the sessions. They each chose a fancy pen or pencil. No food was needed as the children were asked to bring their own snacks (to prevent issues with allergies). However, water was available to them.

Audio-Video Equipment

Audio-visual equipment was used to collect behavioural data (see below for a description of the data collected). Three Canon VC-C4 digital cameras were set up on the walls of the laboratory, two in the classroom and one in the remote room, and recorded to videocassette recorders (VCR's) in the control room. Since these cameras do not record audio, microphones were hung from the ceiling in each room and fed into the VCR's. A time-stamping mechanism was used so that the three tapes from each session could be synchronized. The resulting videotapes were used for coding the children's behaviour.

Procedure

Pilot Study

A pilot study was organized to ensure the procedure and technical set-up of the actual study would run smoothly. The pilot followed the same procedure as the actual study, except the children were boys. The lesson plan proved to be fine; however there were serious technical problems. At this point, Microsoft NetMeeting was used as the videoconferencing method, with microphones and speakers for audio transmission. The video, the size of a credit card, was too small to be usable, and the audio was unreliable and poor. Therefore, the videoconferencing set-up was changed to the one described in

the materials section above. The video and audio recording worked quite well and only needed to be fine-tuned after the pilot run.

Experimental Design

There were two experimental conditions: Desktop and PEBBLES videoconferencing types. For reasons described above, only data from ten of the twelve sessions was used. There were four children per session, and five sessions of each experimental condition (see Table 1).

Table 1

Number of Sessions and Number of Children

Condition	Number of Sessions	Number of children per session	Total number of children
Desktop	5	4	20
PEBBLES	5	4	20
<i>Total</i>	<i>10</i>	<i>4</i>	<i>40</i>

In the *Desktop Condition*, the remote child was represented in the classroom by a traditional desktop computer with videoconferencing capabilities. In the *PEBBLES Condition*, the remote child was represented in the classroom by the PEBBLES robot. The two-hour sessions took place on Saturdays and Sundays. It took approximately two months to complete data collection.

Recruitment and Contact with Parents

When parents called to schedule their daughters into a session, they were given the details of the study. If the parents agreed to have their child participate, they were

scheduled in a session. Girls from the same Guide units were placed in different sessions to ensure that they did not know each other. To increase attendance, parents were called the night before their session and reminded of the study. Only one child, whose parents could not be contacted the night before her session, failed to show up.

Despite the scheduling precautions, there were a few instances where children in a given session knew each other. In one session, two children knew each other by chance, but in the session they did not appear to know each other very well. In two other cases, two girls from the same Guide unit were placed together because it was not possible to find children who did not know each other. Their Guide leader was consulted to ensure that they were a good match. In both cases, these children were from a 30-child Guide unit, and were not in the same “patrol” or elementary school. During the session, these girls also did not appear to know each other well.

Beginning of Session

As families arrived for the sessions, the experimenter greeted children and parents and collected consent forms. The girls were ushered in the conference room of the laboratory and introduced to the teacher. They were given colouring books while they waited for the other children.

Once all of the children arrived, the group was moved into the classroom. The experimenter thanked them for coming, introduced herself and the teacher, and explained what would be happening during the session. This introduction usually took about ten minutes. Appendix C contains the full script of the session.

Each session consisted of six main activities: (a) an ice-breaker, (b) a discussion with and lesson from the teacher (c) group work, (d) short presentations to the teacher, (e)

individual work and (f) recess with a snack. Table 2 displays a breakdown of the activities of each session. These activities are described in more detail below.

Table 2

Session Activities

Activity	Time (minutes)
Beginning of session	10
(a) Ice breaker	15
(b) Lesson with teacher	20
(c) Group work	15
(d) Presentations	5
(e) Individual work	15
(f) Recess	15
End of session	25
<i>Total</i>	<i>120</i>

(a) *Ice Breaker.* The teacher and experimenter began each session with an activity to “break the ice” so that the children would get to know everyone and become comfortable in the environment. Everyone started by telling the group their name, age, and other personal information such as favourite colour and pets. Once everyone had taken her turn, one child was given a beanbag, which indicates the speaker. The child would throw the bag to another child and say “zip” or “zap”. Zip meant that the person holding the bag had to recite the information of the person to their right, and zap meant they had to recite the information of the person to their left. Then the beanbag would be

passed on again and the game would continue until everyone knew each other's name.

This activity took about ten to fifteen minutes.

Once the ice-breaker was complete, the remote child was selected by drawing a name at random. However, the selected child was allowed to decline, which occurred three times. Also, if an extremely quiet child was chosen, the experimenter read the name of another child to prevent a situation where the remote child did not talk at all. This occurred once.

When the remote child was selected, the experimenter escorted her to the other room with the remote unit. Then the experimenter briefly introduced the videoconferencing unit. Meanwhile, the classroom children tested the audio levels and video placement. When the child was oriented to the equipment, the experimenter explained that she would be available to the remote child throughout the session, and then she left the room. For the rest of the session, she observed the session through the one-way mirror and televisions from the cameras on the walls.

(b) Lesson with the Teacher. Once the remote child was settled, the teacher introduced the lesson to the children. She began by writing "camping" on the board and circling it. She then asked the children:

- What does camping mean?
- Has anyone been camping before? Where? When?
- What different kinds of camping are there?
- What different kinds of places can you go camping?
- What time of year can you go camping?

ERROR: typecheck
OFFENDING COMMAND: restore

STACK:

(Resource/ProcSet/CIDInit)
-savelevel-

The teacher then explained that the children were to generate a list of things they would need to take on a camping trip. They would need to consider pack weight, safety, climate, mode of transportation, and length of trip. This part of the lesson took about twenty minutes.

(c) *Group Work.* The children collaborated to assemble the list to be presented to the teacher. A discussion followed about which items to bring and why. This part of the session took about 15 minutes.

(d) *Presentations.* When the list was complete, the group was asked to present it to the teacher. They took turns telling her an item and why they would bring it. This activity took about five minutes.

(e) *Individual Work.* In this section, the children worked independently. They began by filling out the shyness scale. Once they were done the questionnaire, they drew or coloured until the time was up. This activity took approximately fifteen minutes.

(f) *Recess.* Once the individual work was complete, the children ate the snack they had brought and interacted with each other however they pleased for 15 minutes. This part of the session was designed to feel like a “recess” that children normally have in the morning at school.

End of Session

Once the free time was over, the children filled out the group-integration questionnaire, which took about five minutes. Then the remote child returned to the group with the experimenter. At this point, the children were interviewed as a group for about ten minutes about their impressions of the technology. Then they had the opportunity to “play” with PEBBLES while waiting for their parents.

Data Collection

Participation, gaze, use of robotic elements, hand raises, and the end-of-session interviews were recorded on video. Children also completed the self-reported shyness and group-integration questionnaires during the session.

Participation. Participation, operationalized as speech utterances between the children, was recorded on video and coded after the sessions were complete. Different data were collected from different parts of the sessions. Group work was chosen as the most important part of the sessions for speech utterance data collection because it maximized interaction among the children and minimized the teacher's involvement.

For every utterance, speaker and recipient were coded. For the group work component, duration of each utterance was also coded to the nearest second.

Gaze. Glances from the local children towards the remote child were noted in the group work component of the sessions. Those instances of gaze when someone was speaking to the remote child or the remote child was speaking were not noted because it was expected that the children would look at the remote child during these events. Since participation and gaze were expected to be highly correlated under these circumstances, gaze was only measured when the remote child was not engaged in conversation.

Use of robotic elements and hand raises. Every time a remote child in the PEBBLES condition activated the robotic hand or head, the reason for the behaviour was noted, as well as the response from the teacher and local children. The same procedure was followed for the remote children in both conditions when they raised their own hand. For example, if the teacher asked the children "who here has been camping?", and the remote child raised her hand, and then the teacher said, "you've been camping before

[remote child]? Where did you go?” then the reason would be classified as “the teacher asked a question” and the response would be “the teacher responded immediately”.

Sometimes the reasons and reactions were not obvious, but an effort was made to be consistent and accurate. The hand raises of the remote children only were noted.

Shyness. Children completed The Children’s Shyness Questionnaire (Crozier, 1995) during the individual work component of each session. They were asked to answer the 26 questions with ‘Yes’, ‘No’ or ‘Don’t know’ (responses were coded 2 for ‘Yes’, 1 for ‘Don’t know’ and 0 for ‘No’). The items were phrased as statements like “I find it hard to talk to someone I don’t know”, and “I am usually shy in a group of people”. The complete questionnaire can be seen in Appendix D.

Group-Integration. Self-reported group-integration of all children was assessed at the end of each session. Of the 16 primary items in the Children’s Loneliness Questionnaire (CLS), five were chosen for this study. These items include “I’m good at working with other kids” and “I am well liked by the kids in my class”.

The peer scale of the RPLQ consists of seven items, two of which were used in this study. These items are “I feel like other children want to be with me,” and “when I am with other children, I feel like I belong.”

For some items chosen from these two scales, it was necessary to modify the wording slightly to emphasize the laboratory activities that activities the child participated in. For example, the item “I’m good at working with other kids” was modified to “I’m good at working with the other kids in the group” and “when I’m with other children, I feel like I belong” was modified to “I felt like I belonged in the group”. These modifications were made to ensure that when the children answered the questions

they were specifically thinking about the laboratory sessions and not about school or other activities.

Two more items were added to the loneliness scale to ensure that children's feelings of being part of the group were being assessed. These are: "I feel I am an important member of the group" and "I feel that I fit in with the other children in the group".

Finally, five filler items were added to prevent the scale from seeming too repetitive to the children. Examples of filler items are "I like to read" and "I liked doing the camping planning activity".

Thus, the final scale had 14 items. Children were instructed to "think about today's session" when answering the questions. The items were:

1. I liked doing the camping planning activity.
2. I feel like the other children in the group want to be with me. ^b
3. I watch TV a lot.
4. I feel that I fit in with the other children in the group. ^c
5. I felt like I belonged in the group. ^b
6. I like camping in cabins.
7. I am well liked by the other kids in the group ^a
8. I like to read.
9. I was good at working with the other kids in the group ^a
10. Camping is fun, especially with friends.

^a Denotes that item comes from the Relational Provisions Loneliness Questionnaire (RPLQ; Hayden, 1989)

^b Denotes that item comes from Children's Loneliness Scale (CLS; Asher & Wheeler, 1985)

^c Denotes that item was added by the authors

11. I got along with my group ^a
12. I feel left out of things that go on in the group ^a
13. In the group, I felt lonely ^a
14. I feel I am an important member of the group ^c
15. I liked using videoconferencing for doing today's activities
16. I like wilderness camping.

For each question, they circled one of the following responses:

Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
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The complete group-integration scale is presented in Appendix E.

Interviews with the children. At the end of the sessions, children were interviewed as a group. The unstructured format included questions such as:

- What did you think of the session today?
- What did you think of your videoconferencing experience?
- Did it feel like [the remote child] was part of the group? Did it feel like she was there or did it feel like she wasn't there?

Data Analysis

For all analyses, the unit of analysis was a *session* not a *child*. Thus, there were ten subjects, not 40. The reason for this approach was that within each session, children were not randomly assigned to the local (classroom) and remote conditions. Rather, those who were not selected as remote were local by default. Also, the dependent measures were not independent between the local and remote locations. For example, the amount

local children talked probably affected how much the remote child talked, and vice versa. Therefore, as with a focus group, data were analyzed by session rather than by child.

The between-groups independent variable for the analyses of variance (ANOVAs) was videoconferencing type; and for most of the analyses a within-groups independent measure, labeled “seat”, was used. In each session, the children sat in one of four places: in the remote room (Seat 1); to the right of the videoconferencing equipment in the classroom (Seat 2); adjacent to the equipment (Seat 3); and to the left of the equipment (Seat 4). This distinction made it possible to determine any differences between the remote and local children.

The dependent measures were number of glances at the remote child from the local children, number of spoken utterances, total seconds of speech, average utterance length, and total group-integration score.

For the speech- and gaze-related data, three of the measures were made relative to the total time of the sessions so that differences in the duration of the sessions could be accounted for. Thus, the number of glances per minute, number of utterances per minute, and seconds of speech per minute were used in the analyses.

Analysis of covariance (ANCOVA) was performed with shyness as the covariate. ANCOVA data are reported only where the covariate was significant or changed the relation between the independent and dependent variables.

Finally, since the sample size for this study was relatively small, and statistical power was low, the alpha level was increased from the standard value of 0.05 to 0.10. However, since there were five dependent measures (number of glances at remote child, number of utterances per minute, seconds of speech per minute, average utterance length

and group-integration), the Bonferroni approach was used and the alpha level was divided by the number of dependent measures. Therefore, alpha was 0.02.

Results

Gaze

To test hypothesis (a) that the local children look at PEBBLES more often than the desktop computer, the number of glances made by the local children towards the remote child was recorded during the group work portion of each session. A two way mixed-factorial 2 x (3) ANOVA was performed to determine the effect of videoconferencing type (PEBBLES, desktop computer) and seat in the classroom (Seats 2, 3 and 4) on the frequency with which classroom children gazed at the remote child. Number of glances per minute of group work was used as the dependent measure; however, analyses with raw number of glances were also performed and gave similar results. Details of the results from both types of analyses are presented in Appendix F.

There was no significant videoconferencing type-by-seat interaction ($F_{(2,16)} = 2.44$, $p > .11$). There also was no significant main effect of videoconferencing type (PEBBLES, desktop computer) ($F < 1$). Thus, hypothesis (a) was not supported in that the local children looked at the PEBBLES and Desktop remote children equally.

Although the main effect of seat was not significant, there was a tendency for the children who sat directly opposite from the videoconferencing equipment (Seat 3) to look most often ($M = 1.39$, $F_{(2, 16)} = 3.16$, $p = .07$). This result is not surprising considering that since the child in Seat 3 was facing the remote child, it was most difficult to determine if the child in this position was looking at the remote child or at other parts of the room.

Participation

Participation was operationalized as spoken utterances between the children. For the group work part of the session, data is available on number of times each child spoke per minute, total seconds each child spoke per minute and average utterance duration.

The raw dependent measures (number of utterances per session, total seconds of speech per session) were also analyzed in parallel to all of the analyses below and yielded nearly identical results. Results from both analyses are presented in Appendix G.

It was hypothesized that (b) the remote and local children who used PEBBLES would speak more frequently, for longer amounts of time on average, and for more total time than the remote and local children who used the desktop computer and that (c) the local children would speak frequently, for longer amounts of time on average, and for more total time than the remote children, regardless of which videoconferencing type they used. These hypotheses are investigated below.

Number of Utterances per Minute

Group work. A two-way 2 x (4) ANOVA of number of utterances spoken per minute of group work was performed to test hypothesis (b) and identify potential differences in how often children in the PEBBLES and the desktop computer conditions spoke per minute of group work. Seat was used as a four-level within-subjects variable to compare the frequency with which each of the four children spoke.

There was no significant videoconferencing type-by-seat interaction ($F_{(3, 24)} = 1.03$). There also was no main effect of videoconferencing type. Thus, children who used PEBBLES spoke as often as those who used the desktop computer ($F < 1$). Therefore, hypothesis (b) was not supported by this data.

There was no significant main effect of seat: the children in the four seats in the laboratory spoke equally often ($F_{(3, 24)} = 2.79$, $p = .062$). Thus, hypothesis (c) was not supported by this data. However, there was a tendency for the remote children to speak the least often, as evidenced by the mean number of utterances per minute, in Table 3.

Table 3

Mean Utterance Rates for Remote and Local Children

Seat of Children in the	Mean Number of	Mean Number of
Laboratory	Utterances Spoken per	Utterances Spoken per
	Minute of Group Work	Minute of Whole Session
Seat 1-Remote	2.34	1.63
Seat 2- To right of equipment	2.65	1.71
Seat 3- Adjacent to equipment	4.08	2.32
Seat 4- To left of equipment	3.81	2.36

Note. Differences in the number of utterances per minute between group work and the whole session were expected because of the nature of the lesson plan. Group work was designed to engage the children in conversation, and much of the other parts of the session required the children to listen or work quietly.

Whole session. Hypothesis (b) was also tested on the utterance data from the whole session. The same pattern of rate of speech emerged in the whole session as in the group work portion of the session. There was no videoconferencing type-by-seat interaction, ($F_{(3, 24)} = 1.44$, $p > .25$). Again, there was no main effect of videoconferencing type. That is, there was no difference between children in the two videoconferencing

conditions ($F < 1$). Thus, hypothesis (b) was once more unsupported. Further, as with the group work findings, the main effect of seat was not significant. Thus, hypothesis (c) was again unsupported, but there was a tendency for the children in the remote location to speak least often ($F_{(3, 24)} = 2.66$, $p = .071$). Table 3 (above) contains mean utterance rates for remote and local children in group work and the whole session.

Seconds of Speech per Minute of Group Work

Hypothesis (b) was also examined using seconds of speech per minute of group work as the dependent variable. There was no videoconferencing type-by-location interaction in amount of time children spoke per minute of group work ($F < 1$). There was no main effect of videoconferencing type. Hence, no difference between children who used the desktop computer and children who used PEBBLES in seconds of speech per minute during group work was found ($F < 1$). Thus, hypothesis (b) was again unsupported.

Further, there was no main effect of seat, such that there was no difference among the four locations in the laboratory in terms of how much the children spoke ($F_{(3, 24)} = 1.71$, $p > .15$) and hypothesis (c) was unsupported.

Mean Utterance Length from Group Work

To further test hypothesis (b), mean utterance length was calculated by dividing the total seconds of speech by the number of utterances spoken. The videoconferencing-by-seat interaction was non-significant ($F < 1$). As with the other speech variables, there was no main effect of videoconferencing type (PEBBLES, desktop computer; $F < 1$) or of seat ($F_{(3, 24)} = 3.00$, $p = 0.05$) on average utterance length. Thus, hypotheses (b) and (c) were again unsupported. However, there was a tendency for the remote children to speak

longer on average than the local children. Table 4 shows the average utterance length for the children in each laboratory position.

The finding that the remote children spoke longer on average is consistent with their tendency to speak the least often, but to have spoken in total for as long as the other children. Thus, the remote children spoke the least often, but when they did speak, their utterances were longer. As a result, there was no difference in the total amount of speech between the local and remote children.

Table 4

Average Utterance Lengths by Location of Children in Laboratory

Location of Children	Average Duration of Utterances Spoken
Remote	3.41
To right of equipment	2.03
Adjacent to equipment	2.46
To left of equipment	1.97

Group-Integration

It was hypothesized that (d) remote children who used PEBBLES would report feeling more integrated in the group than the remote children who use the desktop computer and that (e) the local children who used PEBBLES would report the same degree of group-integration as the local children who used the desktop computer. Detailed findings from the analysis of group-integration are reported in Appendix H.

Remote Children

To test hypothesis (d) that remote children using PEBBLES would feel more integrated in the group than the children using the desktop computer, a one-way ANOVA was conducted on total group-integration score (derived from the self-report questionnaire) with videoconferencing type (PEBBLES, Desktop) as the independent variable. Higher group integration scores indicate feelings of greater group-integration. The maximum score on the group-integration questionnaire is 45.

For this analysis, scores for the *remote children only* were compared. There was no significant main effect of videoconferencing type, thus, hypothesis (d) was not supported by this analysis. However, there was a tendency for children using PEBBLES to report feeling less integrated in the group ($M = 31.60$) than children using the desktop computer ($M = 40.80$), $F_{(1, 8)} = 7.84$, $p = .024$.

Local and Remote Children

Another approach to assessing potential differences in group-integration between the PEBBLES and Desktop conditions was to perform a two-way mixed factorial $2 \times (4)$ ANOVA with videoconferencing type (PEBBLES vs. Desktop) and seat of the children (1, 2, 3, or 4) on total group-integration score. This approach also allows for hypothesis (e) to be examined.

Hypothesis (e) stated that the local children would not differ in terms of mean group integration scores regardless of videoconferencing type (PEBBLES, desktop computer). This hypothesis was explored by examining the videoconferencing type-by-seat interaction. The interaction was non-significant ($F_{(3, 24)} = 1.82$, $p > .20$). Thus, there

were no systematic differences among the children in the PEBBLES and Desktop conditions of the four different seats in how they responded to the questionnaire.

As with analysis of remote children only, there was a main effect of videoconferencing type, such that the remote and local children using PEBBLES reported feeling less integrated in the group ($M=33.95$) than children using the Desktop computer ($M=38.10$, $F_{(1,8)}=11.73$, $p<.01$). In other words, children in the PEBBLES condition reported feeling less integrated in the group than those in the desktop condition.

Further, there was a main effect of seat such that there were no systematic differences in group integration among the children at the four different seats in the laboratory, independent of videoconferencing type ($F<1$).

Shyness as a covariate. An ANCOVA was performed to determine if shyness might account for the differences in group-integration between the PEBBLES and Desktop conditions when all four locations were included. Shyness was not a significant covariate ($F=2.28$, $p>.20$). However, when shyness was used as a covariate, the effect of videoconferencing type (PEBBLES, desktop computer) on group-integration again became non-significant ($F<1$). Therefore, hypothesis (d) was again unsupported because there was no difference between the PEBBLES and Desktop children in group integration scores once shyness was accounted for. However, hypothesis (e) is supported because all of the children (local and remote) in the PEBBLES and Desktop conditions had similar group-integration scores.

Interviews

It was hypothesized that (f) more children in the PEBBLES condition would report that it felt like the remote child was “there”.

In each interview, the children were asked to comment on whether it felt like the remote child “was there” or if they felt like she was “not there”.

Was it like she was there?

Local children. Of the 30 local children in the study, 17 said they felt like the remote child was really there. Nine of these children were in the PEBBLES condition, and eight were in the desktop condition. Responses of this type included

- “It felt like she was here.”
- “I think she was here.”
- “It felt like she was here just for real.”
- “I thought that she was here and that was...she could do all the things we could do.”

Five children said they felt like the remote child was “not there”. Three of these children were in the PEBBLES condition, and two in the Desktop condition. Examples of these comments are:

- “She wasn’t really here.”
- “She wasn’t here exactly even though we know she was here.”
- “It felt like she was somewhere else.”
- “I keep forgetting that she was over there.”

Two children did not comment and three nodded in agreement with the other children. Three children commented that it felt like she was there *and* it felt like she was not there. Two of these children were in the Desktop condition and one in the PEBBLES condition. For example:

- “She was sorta here and she wasn’t because she was talking, participating and everything like she was right here.”
- “It was kinda in the middle.”
- “A bit of both.”

In sum, it appears that there were no differences between the PEBBLES and Desktop local children in how much they felt the remote child “was there”.

Remote children. Remote children were also asked if they felt like they were “there” in the classroom. Six children said they felt like they were there, two of whom were using PEBBLES and four of whom were using the desktop computer. Responses included:

- “It felt like I was right on the table. It was really cool.”
- “Like I really was in this room.”

Two children said they felt like they were not there. Both were in the PEBBLES condition. Responses were:

- “It’s like I wasn’t.”
- “It felt like I wasn’t. It’s just cause like I’m sitting in another room and it sorta feels like, it sorta feels like e-mail except it’s like live and you can see each other.”

Given that there were few systematic differences between videoconferencing type in the number of responses in each category, it appears that there are no differences between the remote children in how much they felt they were “there”. Thus, hypothesis (f) was not supported. Local and remote children in the two conditions reported almost equally often that it felt like the remote child was really there.

Use of Robotic Elements

Every instance of robotic use (PEBBLES hand, head) and real hand raise in the *remote children only* was noted, as were the reasons for the behaviour and the response to the behaviour. The data were further coded to determine if the reason for the behaviour appeared to be internally driven or externally driven. For example, a behaviour would be coded as internally driven if the child appeared to “play” with the head turning

mechanism, without any encouragement from others. However, a behaviour was deemed to be externally driven when triggered by others, such as the teacher asking the children a question.

The behaviours were also coded to reflect whether they were distracting to the others in the classroom. For example, if the waving of the PEBBLES hand caused an interruption in speech between the children and/or teacher, the behaviour was considered disruptive. However, if waving the PEBBLES hand caused the children and teacher to look at the remote child but carry on their conversation until it was the remote child's turn to speak, the behaviour was considered to be non-disruptive.

Further, the effectiveness of the behaviour was assessed. For the real and PEBBLES hand waves, if the behaviour gained the attention of the teacher or local children, it was considered effective. However, if the remote child was ignored or not noticed, the behaviour was considered ineffective.

Frequency of Behaviours¹

Frequency of behaviours was calculated for each experimental condition. As shown in Table 5, the remote children made approximately the same number of real hand raises in the PEBBLES and Desktop conditions. However, in the PEBBLES condition there were an additional 22 PEBBLES hand waves.

¹ Although it would have been interesting to track the change in these behaviours as the session progressed, it was not practical to do so because they were so diverse in the types of activities performed and it was expected these different activities would elicit different behaviours.

Table 5

Frequency of Attention-Getting Behaviours by PEBBLES and Desktop Remote Children

Behaviour	PEBBLES Condition	Desktop Condition
Real Hand Raise	25 (0/25)	29 (3/26)
PEBBLES Hand Wave	22 (11/11)	n/a
Total Attention-Getting Behaviours	47 (11/36)	29 (3/26)

Note. Values in brackets represent the frequency of drive for behaviours (internal/external). Thus for real hand raises in the PEBBLES condition, 0 hand raises were internally driven and 25 were externally driven.

Drive for Behaviours

Head turns. Nearly all of the PEBBLES head turns (40 out of 45 or 89%) were internally driven. This is not surprising because the children had no need for turning the head because the view they saw at the beginning of the session showed all three local children, the teacher, and the whiteboard.

Hand waves. Half of the PEBBLES hand waves were internally driven (11 of 22). However, nearly all of the real hand waves were externally driven (25 of 25 in the PEBBLES condition and 26 of 29 in the Desktop condition).

Were the Behaviours Distracting to Others?

Head turns. Two of the 45 head turns were distracting.

Hand waves. None of the 54 real hand raises (in both experimental conditions) were classified as distracting to the participants in the classroom. However, five of the 22

PEBBLES hand waves appeared to distract or disrupt the local children and/or teacher.

For example, when one child waved the PEBBLES hand while a local child was talking to the teacher, their conversation was interrupted.

Effectiveness of Behaviours

Head turns. This feature is not designed for attention-getting but for allowing the remote child the opportunity to visually scan the space, which, in the laboratory setting was not necessary. When the children turned PEBBLES' head, they always appeared to be experimenting or playing. These behaviours were not included in the attention-getting effectiveness measures.

Hand waves. Twenty-three of 25 real hand raises in the PEBBLES condition and 25 out of 29 in the Desktop condition were effective at gaining a response from the teacher or local children. In other words, 47 out of 54 hand raises were effective. For example, one remote child raised her hand when the teacher asked "has anyone here been camping in a museum?" The teacher immediately acknowledged her and asked her to elaborate. There were a few instances with the real hand raises where the local children would point out to the teacher that the remote child had a question before the teacher noticed. However, this was a rare event.

Of the PEBBLES hand waves, all 22 behaviours were effective at gaining a response from participants in the classroom.

Overall, it seems that the robotic elements of PEBBLES were used mainly for play or experimentation, but that these behaviours were not disruptive to others. Additionally, whether the remote children chose to raise their own hands or wave the PEBBLES hand, they were nearly always effective at getting attention.

Other Qualitative Data

Videoconferencing-Related Content from Group Work

Content of conversations related to videoconferencing was noted during group work. In four of the ten sessions, no such content was observed. Of the other six sessions, most of the content pertained to audio issues. Five of those six sessions had mild audio problems, with comments such as “can you hear that?” (audio feedback) and “can you please speak up”. One other session had audio-related content because the sounds from the remote child (such as pencil sharpening and erasing) were being amplified in the classroom, causing the local children to giggle.

Two sessions had content related to the videoconferencing equipment or set-up. One remote child hid from view of the camera and the teacher asked if she was ok. In another session, one child (Child 4) was fascinated by PEBBLES. When the remote child was working on something on her desk, this child asked, “why are you putting your head down?” to which the remote child did not respond. Child 4 then waved at the remote child and said “helloooooo? It looks like you can't see us.” The remote child responded, “I can see you, you're on a computer.” Child 4 responded, “yeah you are too”. At this point a discussion amongst the children occurred about where the remote child was.

Overall, it was interesting to note that the children very quickly became accustomed to the videoconferencing equipment and very infrequently made reference to it.

Other Comments from Interviews

In addition to being asked to comment on whether it felt like the remote child “was there” the children were also asked how they felt about their videoconferencing

experience. The most common responses were that it was “fun,” “cool,” “good,” and “interesting”. For example,

- “I think it’s great. I really like it.”
- “It was good... cause it was different.”
- “It was pretty cool.”
- “I think it was fun because it was very funny to talk to each other through a screen.”
- “It’s cool that someone can be in their own room and you can be hearing them and seeing them. They could be far or close.”
- “I wanna do it again!”

Two groups mentioned specific “fun” events that took place: one group spontaneously played hide-and seek (with PEBBLES) and the other played hangman (with the desktop system). The children seemed impressed that these games were possible: “she even played hangman!”

A few children described their experience as “weird” or “strange”. For example,

- “It was kinda strange at first because like their voice was a little like fuzzy but it was cool.”
- “It’s kinda weird talking to a machine.”
- “It’s weird but it was our first time.”

Others had unique ways of describing the videoconferencing experience.

- “It was like we were talking to a box with a face on it”
- “It’s sorta like a TV except you can talk back.”
- “Like someone is inside PEBBLES and there is a little camera.”
- “It was like talking to [the remote child] but still you’re talking to a machine but with a face on it.”
- “Like seeing somebody else in a different world.”

No one mentioned the specific robotic elements of PEBBLES, although the girls from one session alluded to them when they talked about having played hide and seek: “yeah when we were playing hide and seek but she couldn’t find us because we just ducked

down there... And then she couldn't see us behind and when she turned away from us, we... I stooded (*sic*) up and then said over here then ducked back down". Also, one child mentioned that she could "turn everything".

Some children commented on how videoconferencing could help people:

- "It would probably help people if they were in the hospital and they're sick and they could do stuff."
- "It would give them enjoyment by seeing what everybody else is doing."
- "It wouldn't let them feel left out."
- "I think the kids in the hospital would really appreciate it."
- "I think this is a really good idea because I know how it feels to be left behind in school work cause I was like away for like 3 weeks and I think this is a really good idea."

Some children commented on specific technical and design issues with the videoconferencing system they used. Most of these comments were related to video and audio quality.

- "It was sometimes a little hard to hear because it was so far back and it was sometimes hard to see on the board ...but it was really cool."
- "You can't see the colours of the person very well."
- "It's a little blurry."
- "You looked darker on the screen. I'm glad to see you in 3D again!" (upon the return of the remote child to the classroom for the interview)
- "Well I just think it should be clearer, I couldn't see very well and sometimes the words would be muffled."
- "She seemed to always be looking down and instead of straight through the camera.... She looked like she was looking to the side, she was never looking at us."
- "I didn't know what they were looking... I didn't know what they could see."

There was no clear pattern in how the children from the PEBBLES and Desktop sessions responded to these questions or described their experience. Most of the children were very enthusiastic about their experience, whether they had used PEBBLES or not. It

seems that all of the children were fascinated and awed by the equipment and were very excited about their experience.

Discussion

The purpose of this study was to assess the impact PEBBLES has on children's telepresence in the classroom and to examine whether children react differently in response to PEBBLES' unique design features than to a traditional videoconferencing system. A second goal was to attempt to quantify telepresence for children.

Differences between PEBBLES and the Desktop System

Contrary to prediction, no advantages of PEBBLES over a desktop system were demonstrated in this study. In terms of telepresence-related behaviours, PEBBLES fared no better than the desktop system: the local children glanced at the remote child equally often in both conditions. The same was true for the frequency with which the children spoke, how long they spoke in total, and the average length of each utterance.

In terms of telepresence-related perceptions, the first analysis of group-integration (as measured by a self-report questionnaire) suggested that the children who used PEBBLES felt less integrated in their group than the children who used the desktop system. However, when self-reported shyness was used as a covariate in the analysis, this difference vanished, suggesting that any differences between these groups in group-integration could be attributed to differences in shyness and not to videoconferencing type. The similarity between groups was supported by qualitative data from interviews with the children, whose comments suggested that videoconferencing type did not affect their feelings of telepresence.

Since there were no differences in telepresence behaviours, as measured by the number of glances at the remote child and amount of spoken interaction, or telepresence-related perceptions, assessed via the group-integration questionnaire and comments from interviews), it is possible that the PEBBLES system is no better at facilitating telepresence than a regular videoconferencing system. However, the above results are not conclusive and there are other possible explanations for the lack of significant differences between groups on these outcome measures.

It is possible that characteristics of the research design made it impossible to detect actual differences. For example, a larger sample would generate more statistical power, thereby increasing the probability of detecting differences between the two videoconferencing types. Also, since the children were unfamiliar with one another, being separated from each other might not affect feelings of group-integration or amount of interaction in the early phases of being acquainted. Differences in these feelings and behaviours might thus have become evident over a longer period of time. Children may interact very differently with one another if they know each other well and are friends, as is true for the children who use PEBBLES.

Another possible reason for this finding could be related to the technical set-up of the study. The quality of the audio and video of the study prototypes was better than a real PEBBLES and typical videoconferencing connections. As a result, the quality may have been so good that it negated any differences between PEBBLES and the desktop system. In other words, the unique design characteristics of PEBBLES (e.g. the robotic elements) may have been less important because the quality of the videoconference was so good.

It is also possible that the design of the lesson plan affected the results. The plan was designed to feel like school, but the activities were fun so that the children enjoyed the experience and felt good about participating. Perhaps they were having so much fun, their interactions were optimized and the technology played little or no role. In addition, the sessions were much shorter than an average school day, possibly affecting the interactions and perceptions of the children.

Differences between Remote and Local Children

Although there were no differences between the PEBBLES and desktop groups on any of the outcome variables, there was a tendency, although not statistically significant, for differences between children in the same sessions. The children who were in the remote location spoke the least often, but when they spoke, their utterances lasted longer, on average. This suggests that remote children may “save up” their thoughts so that when they speak they have more to say. Also, from observation, it seemed that the local children made a lot of short utterances such as “yeah” and “ummm” which were not observed in the remote children. It is possible that these utterances from the remote child were not detectable. However, the audio quality of the recordings was very good, so this explanation is unlikely.

Despite the differences in speech between children in the same sessions, there was no tendency for the remote children to feel less integrated in the group. Even though these children spoke less often, they reported feeling as much a part of the group as the other children. This finding contradicts the explanation above that the lack of difference between the videoconferencing types could be attributable to the lack of difference in

amount of speech. Clearly, in this study, amount of speech did not affect the children's feelings of integration in the group.

Use of Robotics

The remote children in the PEBBLES condition raised their own hands as often as the remote children in the Desktop condition. Additionally, the PEBBLES remote children also used the robotic hand as much as their own hand, such that the PEBBLES children had nearly twice as many attention-getting attempts. Clearly, the PEBBLES hand did not cause the remote children to use their own hand less.

In terms of effectiveness of getting attention by means of real or robotic hand waves, nearly all of the remote children's attempts were successful. The majority of the real hand waves and all of the PEBBLES waves were successful at gaining the attention of the teacher or children. These data suggest that the PEBBLES hand waves may not have been crucial to attention-getting.

To follow up on this idea, the data were coded to distinguish between externally and internally driven attention-getting behaviours. Internally driven behaviours were those that were not solicited or encouraged by others, whereas externally driven behaviours were solicited by events such as the teacher asking a question. In the PEBBLES sessions, half of the PEBBLES hand waves were internally driven and all real hand raises were externally driven. In the desktop condition 90% of the real hand raises were externally driven.

These results suggest that when events called for a child to raise her hand, such as the teacher asking a question, the children most often chose to raise their own hand, even when they could use the PEBBLES hand to respond.

Given that raising one's hand is taught in school as standard practice, it may have been hard for the children to remember to use the robotic arm, especially since they only had 90 minutes to learn to do so. It is possible that in a longer study period, the use of the robotic hand would increase as the children became accustomed to using it. However, this pattern of behaviour is likely to be highly dependent on how effective a real hand raise is. If the children were continually reinforced for raising their own hand, they would likely not feel the need to use the robotic hand. However, it is clear that sometimes (13% of the time) real hand raises went unnoticed. Even if it is not the primary mechanism for attention-getting, the robotic hand may serve as an excellent back-up, since it was always effective at getting attention. An alternative explanation to this finding is that the children did not need any help in getting the attention of the teacher and students because the group was so small. It may have been easy for the children to be aware of one another. However, in a larger class, real hand waves may go unnoticed more often and the PEBBLES arm might be more crucial for getting attention.

The teacher is likely to go through an adjustment period with PEBBLES. It is possible that over time the PEBBLES unit would become more integrated in the classroom and real hand-waves would go unnoticed more often. As a result, the child might learn to use the robotic arm more. It is also possible that the robotic arm might go unnoticed more often as well, such that the remote child got no more attention than the local children in the classroom, who surely are not addressed every time they raise their hands.

Children rarely needed to turn the robotic head in this study. The classroom was very small, with only four people to look at with the camera. The initial set-up in each

session ensured that the view shown from PEBBLES included the four people and the whiteboard. Therefore, for the most part, any use of the robotic head was probably for experimentation or play, and the above data are unlikely to reflect the use of robotic head turns in a real classroom.

There were a few unmistakable instances of play. One remote child was encouraged to play hide and seek by the local children. The remote child then moved the PEBBLES head back and forth, in search for the two children who were crawling on the floor around PEBBLES. During this time, the teacher left the room for a moment and when she returned, using the door to the far right of PEBBLES, the remote child had turned the robot to face the door and greet the teacher. This behaviour suggests that the child understood and was able to use the PEBBLES head effectively.

Other instances of the use robotic head were not so clear. Some children would turn the head at seemingly random times, for example, when they were working on the camping assignment. In these instances, it seemed that they were experimenting with the control.

In a real classroom with more children and more space, the use of the robotic head would likely be necessary and driven by external reasons. In fact, additional functions, such as tilt and zoom are necessary for the child to view the board as well as the students around her. These functions are available in the real PEBBLES system, but were not required in this study given the physical space, nor possible to implement due to technical constraints.

In the 45 instances of head turning, the noise and movement only distracted or disrupted the other children twice. Thus, data from this study did not suggest that the

turning head would detract from the children's classroom experience, even though it moves and makes noise when it is activated.

Observations

In group interviews, the children were asked what they thought of their experience with videoconferencing, and they had some interesting insights and opinions. A few were very perceptive about problems with the technology, such as establishing eye contact, and audio and video problems. These insights were already known, but it was interesting to know that the children were aware of these issues as well.

Some challenges were encountered in the interview process. Ten minutes had been allotted for each interview, but they usually only lasted two or three minutes before the children seemed to run out of things to say. It is possible that a more experienced interviewer of children would be able to elicit more responses and ensure that all of the children's ideas were being brought out. However it is also possible that the children did say all they wanted to say as they were not accustomed to reflecting at length on specific experiences such as interacting with technology.

During the group work portion of each session, any conversation about videoconferencing (as opposed to the task at hand) was noted. Only six of the sessions had any such content, which may indicate that technological implementation of the systems was largely successful and from an experiential point of view, uneventful. In these sessions, the teacher and the children very occasionally required repetition of speech. However, from observation and participation in the study, it was evident that audio problems were so minor that they did not affect the sessions in a negative way.

Aside from the occasional request to repeat something that was said, conversation flowed smoothly from participant to participant with few difficulties.

Limitations and Suggestions for Future Research

There are some limitations to the generalizability of the results of this study. The first limit relates to the characteristics of the participants. First, the study was limited to girls. Second, it was limited to children aged 9 to 11. PEBBLES is intended for use by all elementary aged children- from 6 to 12 years of age. In future studies of PEBBLES, children of both genders and from a wider age range should be included to better reflect the actual population of PEBBLES users.

Also, in terms of generalizability, it is likely that different quantities and qualities of behaviour would have been observed in a study of familiar children. Even if children were initially unfamiliar when grouped together, should they return for additional sessions, the behaviours would likely change as they got to know each other.

For future laboratory studies, it is recommended that the children be given more time to interact with each other with the teacher absent. The few times the teacher did leave the room it seemed that the children began to interact more freely with one another.

Also, in future laboratory studies, a larger group of children and a larger classroom would be desirable. This study had four children per session, in a small room. The size of the room and number of participants meant that the children did not need to turn the head of the robot, and may not have needed the robotic hand for attention-getting. Additionally, the group dynamics of a larger group of children would likely be different than what was observed in this study.

Another possible limitation of the study was the group-integration questionnaire administered to the children at the end of each session. This questionnaire was specifically assembled for this study and its psychometric properties were not evaluated. The scale was based on children's loneliness questionnaires and an attempt was made to use only those questions that pertained to transient feelings of loneliness. It is possible that the children were not thinking of the specific experience in the laboratory when they answered the questions, but rather their general life experiences. Further, even if this questionnaire could assess transient loneliness, it may take more than 90 minutes for these feelings to develop and therefore be detectable by self-report. The best solution for this problem is more likely to do with the duration of the laboratory sessions than the scale administered.

Another issue was the absence of an analysis of the spoken utterances *received* as well as those spoken. Every interaction was coded such that it was possible to determine how much each child was spoken to. However, it quickly became clear that there were problems with these data. It was very difficult to detect from the camera angles who the local children were talking to when they spoke. Many times, the children would be looking at their work on the desk as they spoke. Unless they said the child's name or looked up at them, it was impossible to reliably detect who they were speaking to. However, when local children addressed the remote child, quite often they would look up, or say their name, or speak louder. The reason for this difference is likely because videoconferencing equipment was set back one foot from the table with the local children. It was clear that there were more coded instances of the remote child receiving

speech than the other children. However, it is possible that many instances of speech received by the local children went undetected.

It is unfortunate that data on utterances received were not usable because it would have been interesting to know whether or not the type of equipment affected the detection of utterances. Such a measure may be a good indication of telepresence. In future studies, enhanced methods for detecting the children's targets for their verbal utterances, such as cameras at eye-level for each child, would help resolve this issue.

Measurement of Telepresence

The secondary goal of this research was an attempt to quantify telepresence for children. Telepresence was assessed using behavioural observations and measures of perception that were chosen specifically for this study.

It is difficult to say whether the study measured telepresence successfully because it has never been explicitly measured before and there was no data to compare against for convergent validity. However, there is some evidence that the study may have been successful.

There were *consistently* no differences between PEBBLES and the desktop computer on the measures of telepresence. This finding could mean that there were no differences between the groups and that the measures were all measuring telepresence. If the results had been inconsistent, then the measures may have been measuring different things.

However, there were differences (although non-significant) between the remote children and the local children for both videoconferencing types on two of the participation measures, but no differences on any of the other measures. It is possible that

these two measures were assessing telepresence while the rest were not. In other words, the only real differences in telepresence in this study occurred between the local and remote children, and they were detected with the speech variables. Perhaps number of utterances and average utterance length are the two most valid measures of telepresence.

The finding that there were no differences between videoconferencing groups could also suggest that none of the measures used in this study were measuring telepresence. As discussed earlier, it is possible that existing differences in telepresence went undetected by the measures used.

It is also possible that the measures were not sensitive enough to detect small differences between the groups. Since the children were having fun, and the technology was of high quality, it is possible that the measures would have had to be more sensitive than measures used under different circumstances.

Another consideration would be to conduct a study with a true control group of children with no videoconferencing equipment. In this investigation, the local children served as controls to compare the remote children to, but it is likely that different behaviours would be observed in a group of children interacting face-to-face with one another.

Recommendations and Conclusions

It is recommended that more research on quantifying telepresence be conducted to determine if it can be measured reliably and accurately. A measurement tool for assessing the degree of telepresence would be useful for designers and users of videoconferencing systems to evaluate the effectiveness and impact of the designs. A starting point in the development of measures of telepresence would be to conduct this study again using the

same measures but taking into consideration the limitations and suggestions mentioned above.

In terms of the PEBBLES system, there is some evidence from this study to suggest that PEBBLES provides few advantages in terms of telepresence over traditional, less costly videoconferencing systems. However, in a real classroom situation, traditional systems would clearly require enhancement of functionality such as that available through PEBBLES (e.g., robotic hand). The only design characteristic that does not add functionality is the innovative and colourful casing of the robot. In introducing PEBBLES to the children and their parents, it was clear that this feature was attractive to them and possibly influenced acceptance of the videoconferencing technology. However, the children were quite excited about the desktop system as well. While this study did not explicitly explore the impact of the visual design, anecdotal experience suggests that it may contribute to a positive experience for participants.

Finally, based on the results of this study there is little evidence to suggest that designers of traditional videoconferencing systems should consider using PEBBLES' unique design features. However, results from a study in a more naturalistic setting with a larger group and larger room may suggest otherwise.

References

- Angiolillo, J. S., Blanchard, H. E., Israelski, E. W., & Mane, A. (1997). Technology constraints of video-mediated communication. In K. E. Finn, A. J. Sellen and S. B. Wilbur, (Eds.) *Video-Mediated Communication*, (pp 51-73). Mahwah, NJ: Lawrence Erlbaum Associates.
- Asher S. R., Hymel, S., & Renshaw, P. (1984). Loneliness in children. *Child Development*, 55, 1456-1464.
- Asher, S. R. & Wheeler, V. A. (1985). Children's loneliness: A comparison of rejected and neglected peer status. *Journal of Consulting and Clinical Psychology*, 53, 500-505.
- Bossert, E. (1994). Stress appraisals of hospitalized school-aged children. *Children's Health Care*, 23, 33-49.
- Buss, A. H. (1980). *Self consciousness and social anxiety*. San Francisco: Freeman.
- Buxton, W. (1992). Telepresence: integrating shared task and person spaces. *Proceedings of Graphics Interface '92*, 123-129.
- Buxton, W. S. (1997). Living in augmented reality: Ubiquitous media and reactive environments. In K. E. Finn, A. J. Sellen and S. B. Wilbur, (Eds.) *Video-Mediated Communication*, (pp 363-384). Mahwah, NJ: Lawrence Erlbaum Associates.
- Crozier, W. R. (1995). Shyness and self-esteem in middle childhood. *British Journal of Educational Psychology*, 65, 85-95.
- Egido, C. (1988). Videoconferencing as a technology to support group work: review of its failures. *Proceedings of the ACM Conference on Computer-Supported Cooperative Work*, 12-24.

- Fels, D., & Weiss, T. (2000). Toward determining an attention getting device for improving interaction during video-mediated communication. *Computers in Human Behaviour*, 16, 99-122.
- Fels, D. I., Waalen, J.K., Zhai, S., & Weiss, P.L. (2001). Telepresence under exceptional circumstances: enriching the connection to school for sick children. *Interact 2001, Japan*, 617-624.
- Finn, K. E., Sellen, A. J., & Wilbur, S. B. (Eds.). (1997). *Video-Mediated Communication*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Ishii, H., Kobayashi, M., Arita, K., & Yagi, T. (1997). Iterative design of seamless collaboration media. . In K. E. Finn, A. J. Sellen and S. B. Wilbur, (Eds.) *Video-Mediated Communication*, (pp 435-456). Mahwah, NJ: Lawrence Erlbaum Associates.
- Goossens, L. & Beyers, W. (2002). Comparing measures of childhood loneliness: Internal consistency and confirmatory factor analysis. *Journal of Clinical Child Psychology*, 31, 252-262.
- Holden, G., Bearison, D. J., Rode, D. C., Rosenberg, G., & Fishman, M. (1999). Evaluating the effects of a virtual environment (STARBRIGHT World) with hospitalized children. *Research on Social Work Practice*, 9, 365-382.
- Mantei, M. M., Baecker, R. M., Sellen, A. J., Buxton, W. A. S., & Milligan, T. (1991). Experiences in the use of a media space. *Proceedings of ACM Conference on Human Factors in Computing Systems*, 203-208.

- Marcoen, A., Goossens, L., & Caes, P. (1987). Loneliness in pre- through late adolescence: Exploring the contributions of a multidimensional approach. *Journal of Youth and Adolescence*, 16, 561-577.
- Moore, G. (1997). Sharing faces, places, and spaces: The Ontario Telepresence Project field studies. . In K. E. Finn, A. J. Sellen and S. B. Wilbur, (Eds.) *Video-Mediated Communication*, (pp 301-321). Mahwah, NJ: Lawrence Erlbaum Associates.
- Northam, E. (1997). Psychological impact of chronic illness in children. *Journal of Paediatric Child Health*, 33, 369-372.
- Olson, J. S., Olson, G. M., & Meader (1997). Face-to-face group work compared to remote group work with and without video. In K. E. Finn, A. J. Sellen and S. B. Wilbur, (Eds.) *Video-Mediated Communication*, (pp 157-172). Mahwah, NJ: Lawrence Erlbaum Associates.
- Parkhurst, J. T. & Hopmeyer, A. (1999). Developmental changes in the sources of loneliness in childhood and adolescence: Constructing a theoretical model. In K. Rotenberg and S. Hymel, (Eds.) *Loneliness in Childhood and Adolescence*, (pp. 56-79). Cambridge, UK: Cambridge University Press.
- Sellen, A., Buxton, B., & Arnott, J. (1992). Using spatial cues to improve videoconferencing. *Proceedings of ACM Conference on Human Factors in Computing Systems*, 651- 652.
- Williams, L., Fels, D., Treviranus, J., Smith, G., Spargo, D., & Eagleson, R. (1998). Control of a remote communication system by children. *International Journal of Industrial Ergonomics*, 22, 275-283.

Appendix A

Recruitment Package and Consent Form

Dear Girls and Parents,

I am a Master's student at Carleton University and am conducting a study on a technology for hospitalized children. PEBBLES (Providing Education by Bringing the Learning Environment to Students) is a robot that connects children with their classroom by transmitting live two-way audio and video between the classroom and the hospital. This system is already used in some hospitals in Canada and the US and will soon be used internationally. You can learn more about PEBBLES at www.ryerson.ca/pebbles.

The purpose of my research is to evaluate how well PEBBLES works from the child's perspective. I hope to make suggestions on how the system could be improved, and also strengthen the argument for justifying the cost of the system, which is very expensive.

Volunteers

I am looking for children to help me with this research. Volunteers would come to Carleton University for approximately **two hours** in January and February. They must be aged **9 to 11** and **female**.

The Study

The study has been designed to be *fun* and *interesting*. All sessions will be supervised by myself and one other adult. This research has been approved by the Carleton University Ethics Committee for Psychological Research.

There will be four children in every two-hour session. For about half of the session, one of the four children will get to participate in activities from another room using a computer. She will be by herself, and the other children will get to interact with her through *videoconferencing*. In other words, the children will see and hear each other using computers.

The remote child will be selected by a random draw and I will confirm with her that she is willing to participate in activities from the other room. I will then accompany her to the room, orient her to the computer and then leave and observe via the video cameras. I will re-join her if she needs assistance or a break.

While the child is in the remote location *all of the children* will:

- Talk to a grown-up about a cool activity
- Work on a fun group project
- Fill out some questionnaires
- Have snack time/free time
- Talk about the videoconferencing experience

Appendix B

Children's Shyness Questionnaire

Please circle one answer for each question.

1. I find it hard to talk to someone I don't know.	Yes	No	Don't know
2. I am easily embarrassed.	Yes	No	Don't know
3. I am usually quiet when I am with others.	Yes	No	Don't know
4. Do you blush when people sing "Happy Birthday" to you?	Yes	No	Don't know
5. I feel nervous when I am with important people.	Yes	No	Don't know
6. I feel shy when I have to read aloud in front of the class.	Yes	No	Don't know
7. I feel nervous about joining a new class.	Yes	No	Don't know
8. I go red when someone teases me.	Yes	No	Don't know
9. Do you say a lot when you meet someone for the first time?	Yes	No	Don't know
10. I enjoy singing aloud when others can hear me.	Yes	No	Don't know
11. I am usually shy in a group of people.	Yes	No	Don't know
12. I feel shy when I am the centre of attention.	Yes	No	Don't know
13. Do you blush a lot?	Yes	No	Don't know
14. I feel shy when the Head Teacher speaks to me.	Yes	No	Don't know
15. If the teacher asked for someone to act in a play would you put your hand up?	Yes	No	Don't know

16. It is easy for me to make friends.	Yes	No	Don't know
17. I would be embarrassed if the teacher put me in the front row on stage.	Yes	No	Don't know
18. When grown ups ask you about yourself do you often not know what to say?	Yes	No	Don't know
19. I go red when the teacher praises my work.	Yes	No	Don't know
20. I feel shy when I have to go into a room full of people.	Yes	No	Don't know
21. Are you embarrassed when your friends look at photos of you when you were little?	Yes	No	Don't know
22. Would you be too shy to ask someone to sponsor you for a good cause?	Yes	No	Don't know
23. I enjoy having my photograph taken.	Yes	No	Don't know
24. I usually talk to only one or two close friends.	Yes	No	Don't know
25. I am usually shy when I meet boys.	Yes	No	Don't know
26. I go red whenever I have to speak to a boy of my age.	Yes	No	Don't know

Appendix C

*Script for Sessions***Introduction- 10 min**

Rachel:

Hello girls! My name is Rachel and this is Cassandra. We are both researchers at this university and we are conducting a study about videoconferencing for children. We want to see what happens when children interact with a group using computers. A real life example of when you could use a computer to interact with a group is if you were in the hospital and you still wanted to go to school.

Cassandra is going to be like your teacher today. We are going to do some activities that are a little bit like school, but more fun, and she is going to lead you in these activities. I am going to be here to watch and help.

You may have noticed some cameras in this room. These cameras are here to help us record what goes on while you are here. We want to be able to go back and watch the sessions again once you leave to make sure we don't miss anything. These tapes will only be watched by researchers, and by your teacher and classmates. I am also going to take some pictures with the digital camera to give to your teacher.

Now, what's special about today is that in order to see what happens when one child uses a computer to interact with a group, we need someone to go into another room for a little while and interact with the group using a computer. In other words, for part of the session today, three of you will be in here with Cassandra and one of you will be in another room but using a computer to see, hear and participate in what's going on. We are going to pick a name out of a hat to choose this person. Any questions?

Ice Breaker- 10 mins

Cassandra:

Cassandra explains the game. We all take turns telling the group our name, age, and other personal information such as favourite colour. Once everyone has taken their turn, one person is given a beanbag. The beanbag signifies who the speaker is. The person throws the bag to another person and says "zip" or "zap". Zip means that the speaker must recite the information of the person to their right, and zap mean the person must recite the information of the person to their left. Then the beanbag is passed on again and the game continues until the children are relaxed and laughing.

Selection of Remote Child- 15 mins

Cassandra:

Now we will get on to some other activities. But before we do that, we need to choose who gets to go in the other room. Please write your name on a piece of paper and put it in this hat. Cassandra chooses a name from the hat.

To selected child- Are you ok with going into another room for part of the session and interacting with the group through computers? If not, choose another child, and repeat as necessary.

Rachel:

Now, I am going to take [the remote child] into another room and show her how to use the videoconferencing system so that she can interact with you.

Rachel shows the child the computer, he takes a few minutes to become comfortable with it, and meanwhile, Cassandra and the other children practice interacting with him. Rachel explains to the child that just like in school, if he needs to go to the bathroom, or he needs assistance, to alert the teacher. I will then assist the child. Once the child is comfortable, I will leave her alone and watch the rest of the activities from the control room (via the video cameras) and only come out when help is needed.

Beginning of Lesson- 10 mins

Cassandra will then introduce the lesson to the children. She will begin by writing “camping” on the board and circling it. She will then ask the children questions such as:

- What does camping mean?
- Has anyone been camping before?
- Where? When?
- What different kinds of camping are there?
- What different kinds of places can you go camping?
- What time of year can you go camping?

Cassandra will write on the board all the answers the children give. She will then begin to explain the lesson: the children will be expected to generate a list of things that they need to take on a camping trip and explain their choices.

Camping Scenario:

- Canoeing to an island in Algonquin Park
- First week of September
- Some portaging
- No drinking water
- 2 nights, 3 days
- 4 people
- No electricity
- Outhouses

Cassandra will show the children a photo of an island for a visual. She will also have a long list of items prepared in case the children struggle.

Group Work- 20 mins

The children will now collaborate to decide on a list to be presented to the teacher. At this point, the group will have to assign a secretary to write the list, and everyone should participate. A lively discussion should take place about which items to bring and why. When the list is complete, the group must hand it to the teacher and explain it to her. This activity should take about 20 minutes.

Individual Work- 10-15 mins

Following group work, the children will work quietly on their own. They will begin by completing **Questionnaire #1**. Then they will be asked to draw a colourful picture of a camping experience that they have had or would like to have until the time is up.

Unstructured Free Time- 15 mins

Once the individual work is complete, the children will eat the snack that they have brought with them and can interact with each other however they please for 15 minutes. This part of the session should feel like a “recess” that children normally have in the morning at school. They will have the option to continue with their artwork if they wish.

Loneliness Scale and Interview- 15 mins

Once the free time is over, the children will fill out **Questionnaire 2**. This should take about five minutes. Then the remote child will return to the group with the experimenter. At this point, Rachel will interview the children and teacher as a group about their impressions of the technology. The interview will be unstructured and should last about ten minutes. It will start with “so what was it like to play with this videoconferencing equipment,” and will continue based on the children’s answers.

Oral Debriefing of Children- 2 mins

Now I’m going to tell you a little more about the purpose of your visit to the university today. You are one of several groups of children to come into this laboratory for this study. What we did today was supposed to be a bit like school. You did some activities with the teacher, you did some group work, you worked by yourselves, and you had a recess. The reason the session was like school is that some children are attending school through videoconferencing just like you did today because they are sick or in the hospital. PEBBBLES the robot does this for sick children.

PEBBLES is a very special robot, and what I want to find out is if PEBBBLES works better than a regular computer for video conferencing. I will be looking at the answers you gave to the questionnaires today and watching how much you talked to each other and interacted with the teacher to see if there are differences between PEBBBLES and other technologies. I am very grateful that you came today because it will help me understand the differences between videoconferencing technologies for children and that information can be passed on to the people who designed PEBBBLES. In a way, you have helped sick children by participating because one day PEBBBLES might work better thanks to you.

End of Session- 10 mins

Then they will have the opportunity to “play” with PEBBBLES for ten minutes until it is time to leave. They will get to choose one item from the box of **gifts** before they leave. They will also receive a **Certificate of Participation**, and a **Parent Debriefing Form** to take home.

Appendix E
Group-Integration Questionnaire

1. I liked doing the camping planning activity.				
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
2. I feel like the other children in the group want to be with me.				
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
3. I watch TV a lot.				
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
4. I felt that I fit in with the other children in the group.				
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
5. I felt like I belonged in the group.				
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
6. I like camping in cabins.				
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
7. I am well liked by the other kids in the group.				
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

8. I like to read.				
Strongly	Agree	Neither Agree	Disagree	Strongly
Agree		nor Disagree		Disagree
9. I was good at working with the other kids in the group.				
Strongly	Agree	Neither Agree	Disagree	Strongly
Agree		nor Disagree		Disagree
10. Camping is fun, especially with friends.				
Strongly	Agree	Neither Agree	Disagree	Strongly
Agree		nor Disagree		Disagree
11. I got along with my group.				
Strongly	Agree	Neither Agree	Disagree	Strongly
Agree		nor Disagree		Disagree
12. I feel left out of things that go on in the group.				
Strongly	Agree	Neither Agree	Disagree	Strongly
Agree		nor Disagree		Disagree
13. In the group, I felt lonely.				
Strongly	Agree	Neither Agree	Disagree	Strongly
Agree		nor Disagree		Disagree
14. I feel I am an important member of the group.				
Strongly	Agree	Neither Agree	Disagree	Strongly
Agree		nor Disagree		Disagree

15. I liked using videoconferencing for doing today's activities.				
Strongly	Agree	Neither Agree	Disagree	Strongly
Agree		nor Disagree		Disagree
16. I like wilderness camping.				
Strongly	Agree	Neither Agree	Disagree	Strongly
Agree		nor Disagree		Disagree

Appendix F
Analysis of Variance for Gaze

Table F1
Analysis of Variance for Number of Glances at Remote Child

Source	<i>df</i>	<i>F</i>	<i>p</i>
Between subjects			
Videoconferencing Type	1	1.34	.28
Error	8	(140.35)	
Within subjects			
Seat	2	2.72	.096
Seat X Videoconferencing Type	2	2.03	.16
Subjects within-group error	16	(30.77)	

Note. Values enclosed in parentheses represent mean square errors.

Table F2
Analysis of Variance for Number of Glances per Minute at Remote Child

Source	<i>df</i>	<i>F</i>	<i>p</i>
Between subjects			
Videoconferencing Type	1	1.34	.45
Error	8	(140.35)	
Within subjects			
Seat	2	3.16	.07
Seat X Videoconferencing Type	2	2.44	.12
Subjects within-group error	16	(.16)	

Note. Values enclosed in parentheses represent mean square errors.

Appendix G
Analysis of Variance for Participation Variables

Table G1

Analysis of Variance for Number of Utterances in Group Work

Source	df	F	p
Between subjects			
Videoconferencing Type	1	.51	.49
Error	8	(2273.71)	
Within subjects			
Seat	3	2.74	.066
Seat X Videoconferencing Type	3	.93	.44
Subjects within-group error	24	(533.10)	

Note. Values enclosed in parentheses represent mean square errors.

Table G2

Analysis of Variance for Number of Utterances per Minute in Group Work

Source	df	F	p
Between subjects			
Videoconferencing Type	1	.42	.54
Error	8	(10.15)	
Within subjects			
Seat	3	2.92	.062
Seat X Videoconferencing Type	3	1.03	.40
Subjects within-group error	24	(2.61)	

Note. Values enclosed in parentheses represent mean square errors.

Table G3

Analysis of Variance for Number of Utterances Spoken in Whole Session

Source	df	F	p
Between subjects			
Videoconferencing Type	1	.41	.54
Error	8	(12049.31)	
Within subjects			
Seat	3	2.73	.066
Seat X Videoconferencing Type	3	1.41	.26
Subjects within-group error	24	(2579.16)	

Note. Values enclosed in parentheses represent mean square errors.

Table G4

Analysis of Variance for Number of Utterances per Minute of Whole Session

Source	<i>df</i>	<i>F</i>	<i>p</i>
Between subjects			
Videoconferencing Type	1	.13	.73
Error	8	(2.92)	
Within subjects			
Seat	3	2.66	.071
Seat X Videoconferencing Type	3	1.44	.26
Subjects within-group error	24	(.58)	

Note. Values enclosed in parentheses represent mean square errors.

Table G5

Analysis of Variance for Total Seconds of Speech in Group Work

Source	<i>df</i>	<i>F</i>	<i>p</i>
Between subjects			
Videoconferencing Type	1	.24	.64
Error	8	(12611.85)	
Within subjects			
Seat	3	1.22	.33
Seat X Videoconferencing Type	3	1.00	.41
Subjects within-group error	24	(6830.93)	

Note. Values enclosed in parentheses represent mean square errors.

Table G6

Analysis of Variance for Seconds of Speech per Minute of Group Work

Source	<i>df</i>	<i>F</i>	<i>p</i>
Between subjects			
Videoconferencing Type	1	.006	.94
Error	8	(1.00)	
Within subjects			
Seat	3	1.71	.19
Seat X Videoconferencing Type	3	.88	.46
Subjects within-group error	24	(.59)	

Note. Values enclosed in parentheses represent mean square errors.

Table G7

Analysis of Variance for Average Utterance Length in Group Work

Source	<i>df</i>	<i>F</i>	<i>p</i>
Between subjects			
Videoconferencing Type	1	.33	.58
Error	8	(2.57)	
Within subjects			
Seat	3	3.00	.05
Seat X Videoconferencing Type	3	.41	.75
Subjects within-group error	24	(1.46)	

Note. Values enclosed in parentheses represent mean square errors.

Appendix H

Analysis of Variance for Group-Integration

Table H1

Analysis of Variance for Group-Integration with Remote Children Only

Source	<i>df</i>	<i>F</i>	<i>p</i>
	Between subjects		
Videoconferencing Type	1	7.84	.023
Error	8	(211.60)	

Note. Values enclosed in parentheses represent mean square errors.

Table H2

Analysis of Variance for Group-Integration with Remote and Local Children

Source	<i>df</i>	<i>F</i>	<i>p</i>
	Between subjects		
Videoconferencing Type	1	11.73	.009
Subjects within groups Error	8	(14.69)	
	Within subjects		
Seat	3	.619	.61
Seat X Videoconferencing Type	3	1.82	.170
Seat X Subjects within-groups error	24	(29.54)	

Note. Values enclosed in parentheses represent mean square errors.

Table H3

Analysis of Covariance for Group-Integration with Remote and Local Children

Source	<i>df</i>	<i>F</i>	<i>p</i>
	Between subjects		
Videoconferencing Type	1	.08	.79
Error	7	(2.21)	
	Within subjects		
Seat	3	2.93	.055
Seat X Videoconferencing Type	3	.52	.67
Subjects within-group error	23	(1.47)	

Note. Values enclosed in parentheses represent mean square errors.