Mobile Robotic Telepresence Solutions for the Education of Hospitalized Children

by Neelkamal Soares, MD; Jeffrey C. Kay; and Geoff Craven

Abstract

Hospitalization affects children’s school attendance, resulting in poor academic and sociodevelopmental outcomes. The increasing ubiquity of mobile and tablet technology in educational and healthcare environments, and the growth of the mobile robotic telepresence (MRT) industry, offer opportunities for the use of MRT to connect hospitalized children to their school environments. This article describes an approach at one rural healthcare center in collaboration with local school districts with the aim of describing strategies and limitations of MRT use. Future research is needed on MRT implementation, from user experiences to operational strategies, and outcome metrics need to be developed to measure academic and socioemotional outcomes. By partnering with educational systems and using this technology, hospital information technology personnel can help hospitalized children engage with their school environments to maintain connections with peers and access academic instruction.

Introduction

When a student has a medical condition that requires hospitalization during regular school hours for a period of time, the current practice is for each school district or regional educational service agency (ESA) to provide appropriate instructional services to the student. Larger districts may provide instructional services themselves, whereas smaller districts (particularly in geographically diverse rural areas) typically do not have the personnel or resources to provide these services. Much less research is available about the education of hospital-bound students, compared with that of homebound students, in terms of consistent application and the types of instruction implemented. At the same time, hospitals have increased their family-centered design focus and offer increased availability of media.

Although media are mostly used for entertainment, electronic devices are increasingly being used for healthcare interactions (such as accessing the patient electronic health record portal, communicating with nursing staff, and making nutrition requests).1 Hospitalized children have access to, and use at high rates, a variety of screen media at the bedside.2 Similarly, mobile robotic telepresence (MRT) is being used to connect homebound children to their schools to address limitations related to having consistent access to education and inclusive social experiences. With the increasing use of MRT for the education of hospitalized children, there will be a need for publications examining the processes and systematic deployment of such programs, as well as research on the outcomes related to them. In this paper, we aim to formulate a model for the deployment of MRT for the education of hospitalized children and to outline barriers and strategies so that other groups can replicate (and improve on) our experience.
Background

In 2012, 5.9 million children were hospitalized in the United States (US), at a rate of 7,928 hospitalizations per 100,000 children. Inpatient stays for children with chronic conditions have increased, and their lengths of stay have become longer, in the last decade compared with the hospital stays of those without chronic conditions. Yearly, an estimated 5 million to 7.5 million students miss nearly a month of school, and health conditions are the primary reason for missed school days. Absenteeism is correlated with increased dropout rates, grade retention, and achievement gaps, with academic and social consequences.

Most hospital/home-to-school transition programs for children with chronic illness include homebound instruction, flexible attendance, and social supports. Generally, hospitals avoid the education business; however, major quaternary care centers, particularly those caring for children with chronic conditions (such as cancer) may engage either a full-time teacher or a child life specialist to be involved in education. Innovative arrangements include hospital-funded personnel through cost sharing with school districts, and grants from philanthropic foundations.

The last 10 years have seen explosive growth in the penetration of broadband and mobile (phone, tablet) technology in the United States. Almost a quarter of adolescents report being online “almost constantly,” and three-quarters have access to a smartphone. Simultaneously, schools have been moving toward increased use of educational technology in instruction, evidenced by increased use of individual computers for students, increased expenditure on digital content, and increased use of technology for testing. This expansion of technology has been aided in part by funding that has resulted in 75 percent of all students connected to high-speed broadband. In the last decade, the use of MRT has also grown, although some versions of MRT have been deployed since the late 1990s. With the increased availability and reduced cost of systems and broadband/high-speed Internet connectivity, this sector is expected to increase more than eight-fold from $42 million in 2014 to $372 million in 2019. MRT systems consist of an LCD screen, a web camera, a microphone, and speakers, generally on a mobile base (although one solution is a fixed base).

Various companies have responded to the need for these systems by producing a range of MRT products (see Kristoffersson et al. for a more complete list). The systems allow for remote control by the user through a web-based interface, usually using a device such as a smartphone or tablet, often over wireless networks.

The use of MRT in healthcare has involved the telepresence of consultants in intensive care units, and in emergency departments (for example, in stroke care), and for bedside rounding for postoperative patients. MRT is ideal for the assessment of patients when visualization is a key component of the examination, such as in the areas of neurology, mental health, and dermatology/wound care, among others. The advantage of MRT over traditional telehealth is that the user can move the unit autonomously, unlike fixed systems that have no mobility, or “carts” that need an individual to serve as facilitator to move the equipment.

The use of MRT in education began mostly in institutions of higher learning, as students became more adept at using technology for social connections and learning. The use of MRT to connect homebound children to their schools for instruction and inclusive social experiences has increased. Although the first study of homebound children’s use of MRT in education was only published in 2016, there is likely to be a steady focus on this burgeoning field in terms of attitudes, acceptance, technical issues, and outcomes for children using MRT. For hospitalized children, MRT was first used in 1999 in Canada to connect to schools in a pilot project that initially involved three case studies. A smattering of single cases and a few uses in children’s hospitals have been noted around the US, but no systematic deployment of MRT for education has been previously published, to our knowledge.

The key barriers to the deployment of MRT programs for hospitalized children are cultural, technical, and fiscal. Culturally, it is unusual for hospital staff and systems to think about or deploy education-related activities in the healthcare environment. Traditionally, medicine and education have maintained
their own respective silos, and practitioners have been generally respectful, but mutually exclusive, of each other’s domains and expertise. At times, this separation has been fostered by an inaccurate interpretation of the laws that govern privacy, namely the Health Insurance Portability and Accountability Act (HIPAA) and the Family Educational Rights and Privacy Act (FERPA) for healthcare and education, respectively. Moreover, many inpatient settings have operational protocols ranging from infection control to visitation that make policy deviations difficult. Most importantly, there are barriers related to personnel time and role constraints, especially when the introduction of a novel program is considered.

On the technical side, generally the hospital does not deploy the robot but supports a user interface that can remotely control the robot, typically through a tablet device. Although hospitals are moving toward increased acceptance and support of “bring your own device” (BYOD) policies for staff and patients, there are concerns around privacy, HIPAA compliance, and security that necessitate policies and personnel to support and enforce the policies, as well as health information technology (IT) staff to support the end users. Additional concerns center around bandwidth (especially if numerous end users are connecting via a variety of devices and streaming large amounts of data) and (less concerning recently) electromagnetic interference with medical devices.

The primary fiscal barriers to deploying an MRT program from a hospital are similar to the barriers encountered by schools: the cost of capital acquisition of the technology and the cost of operations and support (in terms of staff time and effort, as well as maintenance contracts). For a hospital administrator, these costs might be offset by a corresponding input, but educational activities are not billable, which makes it hard for such a program to gain institutional support in terms of sustainability.

Methods

We launched this project to test the feasibility of using MRT with hospital-bound pediatric patients so that we could objectively identify the strengths and weaknesses of the deployment and the resources required to make the project successful. The project was launched in July 2015 for a one-year period, at a children’s hospital-within-a-hospital in a rural, integrated healthcare system in the northeastern United States. The project was deemed to be exempt from review by the organization’s Institutional Review Board. Given the interprofessional collaborative nature of the endeavor (healthcare and education), an ESA that serves the 17 school districts in the geographic area around the hospital was engaged as the education partner. Preliminary funding was secured from two foundation grants (one institutional and one community) of $20,000 each to secure the technology and to fund the personnel time to conduct the project.

Prior to the project, the education partner elicited feedback from prospective school personnel regarding the deployment of MRT technology in classrooms. The main concerns revolved around the privacy of the observed personnel, liability related to the mobility of the robot and whether it would be an obstacle to students and equipment in the classroom, the cost to schools for purchase (and maintenance) of the device, and time needed to train staff on operations and for teachers to accommodate the needs of the student using the MRT (assignments, environmental sound/light modifications).

In the first six months of the program, several key programmatic steps were implemented. The second six months included recruitment of student patients and feasibility testing of the equipment (see Table 1). The child life specialists provide opportunities to engage children and adolescents in coping strategies and other modalities to minimize the stresses of hospitalization, and are key to program management. The hospital IT team provided guidance on device configuration and policies regarding security and privacy within the hospital system. The school champions helped engage the ESA’s administrative leader, who facilitated conversations with principals and key IT personnel who would be responsible for robot operations.

Materials were developed on topics ranging from staff and patient/family engagement to operations and data collection. (See Table 2.) Also, materials for prospective families were developed to provide details on privacy and attendance implications. The development of infection control protocols (wipe-
down of tablets, use of disposable earpieces) was essential because the tablet devices in the hospital are reused from one patient to the next after discharge and new enrollment.

The team reviewed variables such as age, health status, and expected length of stay to determine which pediatric patients would most likely be able to operate and engage with the MRT system. Generally speaking, extremely ill patients in intensive care settings were not considered because of the nature of their care. Also, we decided to limit participation to patients in public school and those who were not enrolled in special education. Reasons for these limitations were that participation by private-school students would require additional arrangements to be made, and that the delivery of specialized education was considered to be more involved than could be addressed in this feasibility study. Similarly, children younger than five years of age were not considered because they were unlikely to be in school. The initial cutoff for length of stay was three days because of the estimated time required to deploy the program with the school.

The key program personnel reviewed the available technology options, including at least three MRT solutions, based on equipment (and maintenance) cost, compatibility with existing systems, usability in the schools, and the degree of IT intervention required versus end-user operability. Because the school partner had previously had successful experience with the deployment of a home-to-school MRT solution, we proceeded with the same solution at a cost of $3,100 to $3,300. The base robot, charging station, enhanced camera, and audio kit cost $2,800, and the additional tablet controller, depending on size and configuration, was an additional $300 to $500. The charging station, enhanced camera, and audio kit, though not required, were purchased for easier deployment and functionality.

**Results**

Of the 69 patients approached, 6 declined to participate (four families declined, and two schools declined). One parent gave “not interested” as the reason for not participating; the others did not provide a reason. From the schools, one teacher declined because he or she did not think it was a good match for the student, and one school declined without giving a reason. One patient could not consent to participation because the parents/guardians were not available during the hospitalization.

Of the 62 remaining patients, 5 patients were not eligible because they were in cyberschool, private school, or home school. Seventeen patients had an Individualized Education Program (IEP, a legal document created by the school and family that outlines the child’s learning needs and services provided) and were not eligible for that reason. Two patients’ schools reported that they did not use the technology, and one patient’s school reported that their Internet connection was down the day of implementation. Thirty-three patients were discharged within two to three days of admission, which led to inadequate time for implementation.

Out of the remaining four patients, three patients encountered failed attempts and delays in deployment on the school side and could not complete the connection, leaving one patient who was able to make use of the robot while hospitalized.

No technical failures occurred for the one student who successfully connected twice to her school. Connectivity from the hospital to the school location was generally simple, with occasional connectivity disruptions in certain areas of the school building and hospital (“dead spots”), which were noted. This student continued to use the program for homebound instruction after discharge. Additionally, 8 students (of the 33 who were unable to establish the hospital-to-school connection) elected to continue using the MRT solution after leaving the hospital. They successfully connected to the school from home. The length of these connections ranged from one week to four months. Anecdotal responses from parents and children were generally that this program would benefit the child’s socialization while hospitalized and that they did not perceive the operation of the robot as a problem.
Discussion

The deployment of MRT systems to connect hospitalized children to their schools for the purposes of education and social connectivity is in its infancy in the US, and in this paper we aim to demonstrate the process and feasibility results of our yearlong endeavor to use MRT to connect a rural hospital system to surrounding school districts. In this section, we describe the key lessons learned during feasibility testing.

Eligibility of Patients for the Program

Because of the time required to accomplish the various steps in the process to deploy the MRT system, and the number of eligible patients who could not participate because of the time constraints for deployment, we think that a minimum of four days is needed, which would allow one to two days for MRT connection and instruction after timely robot delivery and setup. Additionally, this wait allows parents a couple of days to adjust to the situation better, considering the challenges that the patients and parents are facing. Therefore, use of the MRT system is more feasible for patients with longer stays (typically children with oncological or chronic renal or cardiac conditions) than for patients with acute/subacute stays, such as for infections or gastrointestinal issues.

Exclusion criteria should be modified to allow for participation of private-school students, but it is appropriate to exclude cyberschool students, who would not have a class setting in school to connect to anyway. Similarly, there would be no rationale to exclude students with special education needs and many children with chronic medical conditions who undergo hospitalization would have an IEP or other support/accommodation plan at school.

Technical Aspects

Connectivity—Within the hospital, the controller tablet device is best maintained on the hospital’s “guest” wireless network. Thus, the tablets are configured similar to BYOD protocols, with content-filtering tools to safeguard both the patient and the institution. The dedicated “guest” network is configured for open access with no encryption because the hospital’s IT department generally has no control over the hardware or software of guest users’ devices, and there is less risk of interference with dedicated, secure hospital IT systems. In situations where Wi-Fi is not readily available, the unit can operate using a tablet equipped with 4G/LTE cellular service.

Battery life—The internal rechargeable lithium ion battery on the robot provides up to eight hours of normal use and recharges to full capacity in two hours. Thus, it is imperative to instruct school personnel to return the unit to the charging station at dismissal for overnight charging.

Durability—Generally, the robots are durable. The tablet is mounted on the robot in a shock-resistant case to minimize damage if the robot is tipped over. The robots have a shock absorption mechanism built into their base to maintain lateral stability while traversing common obstacles in an office or classroom setting, such as cords, bumps, or a surface change at a threshold. Although these devices can be tipped or pushed over by a person, such instances are rare.

Maneuverability—Generally, the robot operates at slow-to-moderate walking speed and is designed for use on most flat, smooth indoor surfaces, such as concrete, commercial carpet, and hardwood floors. It can traverse an Americans with Disabilities Act (ADA)–compliant wheelchair incline. Although it could potentially be used outside on a paved surface while connecting via 4G/LTE service, it is not designed for outdoor use and is not water resistant.

Audio—On the patient side, given the noise levels in the inpatient environment and the need to pay attention to the school-side audio, it was determined to use headphones. For infection control purposes, disposable earbuds were chosen. On the school side, the optional audio kit includes an amplified speaker and a directional microphone. Because classrooms are generally noisy, this optional audio kit is recommended for use in any educational setting. Some other MRT solutions offer a tweeter/woofer setup with 3.5 feet of separation between the speakers (tweeter in the head, woofer in the base), which enhances audio quality.
School Deployment

Delays in school deployment were attributed to the fact that the parent did not engage the school; consequently, a change in the program was made, and parents are asked to initiate engagement with the school district. School districts tend to be more responsive to parents than if initiation is done by hospital systems. To increase the chances of success, because a few schools either declined to participate, were not comfortable with the technology, and/or were unfamiliar with the program and its timing constraints, schools need to be trained in advance either during an orientation or through another avenue. The school ESA partner can help to identify training opportunities and develop appropriate materials. No issues occurred during the deployment phase of the project. The biggest challenges revolved around steering the robot, and these can be overcome through teacher and parent training exercises. Having one or more of the MRT devices in-house in the hospital environment will allow for this type of training in the future. External technological issues such as Internet connectivity were a concern in a couple of districts.

One of the positive outcomes of this project was that the initial process of trying to connect with the schools enabled families to become aware of, and pursue, the program after discharge. This finding demonstrates the use of MRT to facilitate the hospital-home-school transition.

Limitations

This work involved only a single, rural healthcare system working with 12 school districts in the immediate geographical area. Therefore, generalization to other systems and areas will depend on the local relationships, technological infrastructure, and individuals involved. However, in this paper we provide guidance on an overall structure and likely barriers to be addressed. Additionally, the final number of patients who successfully entered the program was only 1 of the 69 patients approached, but because this was a feasibility study and not an outcomes study, we were able to identify variables to be changed in future deployments. Having more pediatric patients and their families complete the program would have strengthened our results. We only anecdotally inquired about the patient/family experience with the MRT system during this project; however, in the future we will use objective surveys and include teacher experience measures to make the process more user-centered.

Areas for Further Study

The significance of this work for generalization and future research includes the following broad categories.

Cultural—Apart from the resistance to a new technology, educators may fear misuse of the MRT system (able-bodied students using it to skip out on school, unauthorized persons hacking into the classroom). The issue of privacy for personnel (both hospital and school) can be addressed through detailed disclosures, agreements, and autonomy of either participant to terminate an encounter. Home/hospital teachers may be concerned that automation or robots might replace or reduce their positions and roles. We have not found that MRT replaces home/hospital teachers; rather, it augments their valuable efforts (particularly by enabling peer social interaction). Telepresence may not fully convey nonverbal cues (also depending on connectivity), such as eye contact, facial expressions, or body language, and this limitation can be disconcerting for some who view it as loss of human interaction.

Legal—One concern is whether the use of MRT violates the Wiretap Act by listening in on conversations without consent. Another is whether the electronic communication (video stream) is being recorded and stored. Both of these are mitigated by full disclosure about what the system can do and the reasons for its use, with appropriate permission obtained in advance. Recording from the MRT devices themselves is not possible, nor is it recommended. There is no difference between using MRT in a classroom and having an observer in the classroom, subject to the school’s rules and regulations.

Operational—A challenge related to the navigation of the MRT device in the school is physical obstacles that require the assistance of a chaperone. Additionally, although the student can be virtually present, an ongoing challenge is posed by classwork, much of which is still done with paper and pencil or on a local network, making it harder for the hospitalized student to keep up. As schools use more virtual networks and online assignments, this challenge might improve over time.
Mobile Robotic Telepresence Solutions for the Education of Hospitalized Children

**Technological**—A challenge is the reliability of Wi-Fi connections, without latencies or high data losses, in both the hospital and the school. Some hospital areas and rooms have “dead spots,” and schools can have inconsistent Wi-Fi service, particularly in rural areas. This limitation can affect the audiovisual quality and the interaction through the system. Further, as new technologies are developed using 4G capability, the wireless networks may need to be upgraded, which can be cost prohibitive for many schools. Many MRT systems are domain specific (e.g., healthcare, education, business), and with less competition in any specific area, the chances of costs going down are lower, thus posing a major barrier to widespread adoption.

**Financial**—Generally, both hospital and school systems face ongoing expenses for the use of MRT (both equipment maintenance and personnel operations). Although the use of MRT may not be a revenue-generating endeavor within a fee-for-service model, in an era of accountable care going forward, the use of data to support the value of such a program can help with value-based reimbursement (VBR). The scientific basis for this type of intervention must be bolstered in the literature, with research questions related to health outcomes, patient experience, and reduction of costs (as in missed school days and expense to schools for home/hospital teaching). Such data would help not only to strengthen the argument to include some of the costs in a VBR model, but would also increase the replicability of such programs in children’s hospitals across the US.

**Conclusion**

The world of MRT is growing rapidly, with substantial direct-to-consumer marketing, and it is incumbent on medical clinicians, IT personnel, educators, and researchers to stay abreast of this technology, while remaining aware of its limitations. It can afford the opportunity for hospitalized children to participate in school programming and maintain social relationships with peers. Our work shows that building a team of stakeholders, identifying eligible patients, selecting technology options, and conducting feasibility testing of the program are key steps that are integral to the deployment and acceptance of MRT systems.

Future directions include conducting further research on MRT implementation, from user experiences to operational strategies, and developing outcome metrics to test hypotheses that these systems are linked to positive academic and socioemotional outcomes. Health information management professionals should be aware of local partners and should partner with clinicians to be champions for these programs. Information learned from deployment of these systems can be disseminated through presentations at regional and scientific conferences and by publishing in scientific journals, as well as in local and regional community media to reach educators and families.

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Geoff Craven is the CEO of Craven Tech in Lewisburg, PA.
Notes


Figure 1

Hospitalized Child Interacting with Mobile Robotic Telepresence in a Hospital

*Source:* Courtesy of Vecna Technologies, Inc.
*Note:* Image is not an actual patient
Figure 2

Example of a Mobile Robotic Telepresence System

Source: Jeffrey Kay

Note: Image is not an actual patient
### Table 1

Timeline of Methods

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Hospital Activities</th>
<th>School Activities</th>
</tr>
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<tbody>
<tr>
<td>0–2 months</td>
<td>Identification of stakeholders: pediatric clinician champion, child life specialists, staff of the hospital information technology team</td>
<td>Identification of stakeholders: technology specialists, administrative leader, principals, and school information technology staff</td>
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<tr>
<td>2–4 months</td>
<td>Stakeholder meetings to address space and time logistics, infection control management, and patient privacy</td>
<td>Providing details to principals; addressing teachers’ and administrators’ concerns around privacy and comfort with the technology, connectivity at the school, and purpose of the program; trial demonstration of robot for school partners</td>
</tr>
<tr>
<td>4–6 months</td>
<td>Development of infection control and operational protocols (see Table 2); determination of patient eligibility; development of materials to provide details to families</td>
<td>Technology acquisition: development and signing of agreements between the hospital and school partners for purchase and maintenance of the robots</td>
</tr>
<tr>
<td>6–12 months</td>
<td>Collection of data on operational/technical obstacles and family experiences</td>
<td>Robot deployment and collection of data on operational/technical obstacles</td>
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Table 2
Mobile Robotic Telepresence Program Protocols

<table>
<thead>
<tr>
<th>Hospital</th>
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<tr>
<td>• Develop and provide appropriate signage for the program, and adhere to all infection control and procedural guidelines.</td>
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<tr>
<td>• Work with inpatient staff to identify students eligible to participate in program (based on the district involved and the approximate length of stay).</td>
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<tr>
<td>• Approach families/patients about participation with a description of the program; obtain necessary enrollment information and consent forms from family (if research is conducted).</td>
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<tr>
<td>• Orient patient and family to the use of the tablet controller and the system in general.</td>
</tr>
<tr>
<td>• Once the student is enrolled, communicate with the appropriate school personnel (see below) to deploy the classroom robot.</td>
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<tr>
<td>• Connect with information technology (IT) staff for troubleshooting, with inpatient staff to answer any questions, and with families to gauge satisfaction and concerns.</td>
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<tr>
<td>• Log information on technical failures/concerns and any participant or staff questions/concerns.</td>
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<th>School</th>
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<tr>
<td>• Upon receiving a referral from hospital staff, record data (student name, teacher name/homeroom, approximate length of stay).</td>
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<tr>
<td>• Immediately contact school building staff (including principal, teacher, and technology coordinator/IT personnel) to confirm placement of the robot in the classroom/building.</td>
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<tr>
<td>• Prior to delivery:</td>
</tr>
<tr>
<td>o Reset, test, and charge the robot.</td>
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<tr>
<td>o Update applications (if needed).</td>
</tr>
<tr>
<td>o Log placement date, robot passwords, and logins.</td>
</tr>
<tr>
<td>• Meet staff and IT personnel at the time of delivery, and assist in connecting the robot to their network. Provide basic training on how to use the robot (for first-time users), and provide passwords and contact numbers for technical assistance.</td>
</tr>
<tr>
<td>• Provide instructions to staff regarding robot mobility between classes (assign a “student buddy” to chaperone). Also, allow the robot to leave class early to provide enough time to navigate through hallways without traffic.</td>
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<tr>
<td>• If the student has a regular seat in class, remove the chair and place the robot in the student’s place. Review the classroom layout to allow the robot to be able to move freely through aisles, past tables, and so on. Be mindful of classroom/building carpeting or uneven flooring that may prevent the robot from going into certain areas. Be aware that the Wi-Fi connection may not be strong enough in certain areas within the building and the robot may not work properly.</td>
</tr>
<tr>
<td>• Review procedures with teachers, and review how to control the height and volume of the robot. Also review the importance of charging the robot at the end of the day.</td>
</tr>
<tr>
<td>• Be sure to provide a contact phone number and/or e-mail address for technical assistance with the robot.</td>
</tr>
<tr>
<td>• Contact hospital staff to share connection information and to test the connection from the hospitalized student’s tablet device.</td>
</tr>
<tr>
<td>• After the robot is returned, reset and clean the robot.</td>
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