Abstract
Extended school absence during K-12 education can have a negative impact on both the educational and social development of a child. Mobile Remote Presence (MRP) can help enable continued access to K-12 education for children with health challenges. However, most MRP platforms are targeted towards adult users in domains such as the workplace. The importance of social interaction and engagement in K-12 education creates a unique set of needs and challenges for an MRP platform. In this work, we discuss the benefits of MRP usage for K-12 education, ongoing challenges for MRP across domains, and the requirements of an MRP platform for the classroom.

Introduction
According to the 2012 National Survey of Childrens Health, approximately 3 million children in the U.S. have health challenges that cause them to miss significant amounts of school. Causes for extended school absence include recovery from health interventions (e.g., complex surgeries and physical challenges) and isolation due to compromised immune systems caused by a variety of conditions (e.g., cancer, autoimmune disorders).

Being away from the school environment causes students to miss both educational and social experiences. Various solutions exist for addressing the educational experiences through home schooling, individualized tutoring, online learning, and other specialized instructional interventions, but the absence of cognitively stimulating peer-mediated educational experiences can have serious effects both in terms of social and cognitive development (Bransford, Brown, and Cocking 1999; Mayer 2003).

To enable continued access to K-12 education, we explore the use of mobile remote presence (MRP) robots. A MRP robot is a type of telepresence system characterized by its physical embodiment and mobility in the remote environment. MRP robots provide representation of and communication with a remotely located human operator, enabling interaction with people co-located with the system. In particular, it allows the operator to engage in dynamic, spontaneous interactions that naturally arise when co-located together.

Prior work has explored the use of MRPs in diverse real-world environments including hospitals (Nestel et al. 2007), the workplace (Tsui et al. 2011a; 2011b), and rehabilitation centers (Tsui et al. 2011a). Although there has been limited usage of MRP in the classroom, a few cases have shown that such systems are a powerful gateway for minimizing the effects of physical separation from school (Brown 2013). The goal of this work is to utilize an MRP system such that a child with significant health challenges can continue to be physically present in their normal classroom (Fig.1).

The most significant challenge for employing MRP systems in K-12 education is that commercially available systems are not targeted towards the needs of the classroom and target population. In this paper, we present some of the capabilities required for MRP systems to be used in K-12 education. Furthermore, we discuss other requirements and features that will make an MRP safe, adoptable, scalable, and beneficial to a student’s educational experience.

By meeting these needs, we can enable students to belong, conduct real-time participation in school routines with peers, continue learning, feel less isolated, and establish an identity beyond illness, isolation, and separateness.

Prior Work
Past work in MRP targeted a diverse set of real-world users, including professionals in the workplace (Desai et al. 2011; Guizzo 2010; Tsui et al. 2011b), people with special needs (Beer and Takayama 2011; Tsui et al. 2011a), and patients in hospitals (Nestel et al. 2007). MRP usage significantly increases the presence of the operator in the remote environment (Kristoffersson, Coradeschi, and Loutfi 2013;
Lee and Takayama 2011) and also creates the opportunity for spontaneous, casual interactions in the workplace (Lee and Takayama 2011). Other works have also identified additional settings such as the home and classroom where social interaction via MRP can be beneficial to learning, aging in place, and collaboration (Kristoffersson, Eklundh, and Loufﬁ 2013).

As MRP is a relatively new technology, there are ongoing challenges for designing MRP systems that are effective across multiple users and domains. One of the most significant challenges in utilizing MRP is the difﬁculty controlling (navigating and positioning) a MRP robot. This issue is cited as one of the greatest factors contributing to negative experiences using such platforms, for both the operator and the people co-located with the MRP (Kristoffersson, Eklundh, and Loufﬁ 2013; Tsui et al. 2011a).

Accurately navigating and positioning an MRP robot requires a great deal of cognitive effort and remote users often are aware when they fail to control the robot (Beer and Takayama 2011). During interactions, operators must also dedicate a signiﬁcant amount of their time to positioning the MRP to maintain visibility. These issues negatively affect interactions with remote users and point to a shortcoming in both the capabilities and interface of current MRP platforms. Although prior work has suggested autonomous behaviors and greater feedback to address these challenges, there are few commercially available platforms that possess or support these features.

Another significant issue found with MRP platforms is the lack of features supporting social behaviors. Several works have found that the violation of social etiquette was the primary concern of adult MRP users (Beer and Takayama 2011; Morris, Lundell, and Dishman 2004), but few platforms have focused on providing features to mitigate this issue. The main challenge is that social norms for MRP behavior have yet to be established, leading to confusion for both MRP operators and people co-located to the robot (Tsui et al. 2011a; 2011b).

Some of these issues arise because MRP users tend to feel a disconnect from their remote embodiment. Operators often feel discomfort after long use which cause many to withdraw from social interactions (Lee, Park, and Nam 2007; Weiss et al. 2001). Others desire to see a better representation of the MRP’s physical embodiment in order to understand how they are perceived by their peers (Mehrabian 1977; Ekman and Friesen 1969; Kendon 2004).

Moreover, as MRPs are uniform in appearance and meant to be used by a variety of operators, there is little sense of a particular person. The lack of personalization, combined with the inability to generate normal social behaviors, such as gesturing, can make it harder to interact with, operate, and accept an MRP. This is an even greater problem in the classroom as interactions with peers contribute signiﬁcantly to the learning of lifelong social behaviors. Hence, the challenge of our work is overcoming the shortcomings of commercially available MRP platforms in order to utilize an MRP robot as an effective educational tool.

Although there are a variety of commercially available MRP systems, their designs, functionalities, and cost are often suited to speciﬁc applications or domains. Available platforms include the QB, Suitable Beam, VGo, Double, and iRobot Ava. Many of these platforms target primarily the ofﬁce, while few such as the Ava are designed for alternative applications such as telemedicine. The functionalities and target users of these MRP platforms give rise to varying price ranges from $2000-$2500, for Beam+ and Double, $7000-$10000, for VGo and QB, and $20000+, for Ava and Beam Pro. Although MRPs systems can be used outside of their intended applications, some of the physical limitations such as large platform bases, connectivity, or the height of the MRP can affect its usability in other applications.

For the intended purpose of supporting K-12 education using MRP systems, many of these general limitations of MRPs must be addressed. Furthermore, we must understand the challenges that prevent MRP system adoption in the classroom and explore how to overcome these challenges using currently available MRP platforms.

**MRP Platform Requirements**

Although MRP offers great potential for K-12 education, there are few MRP platforms that target the needs of the classroom. We have identiﬁed three general categories of requirements for using MRP to enable continued access to K-12 education in the classroom.

**Classroom Requirements**

Traditionally, MRP platforms have targeted adult users in orderly environments such as the ofﬁce. As MRP usage spreads to other domains, platforms must incorporate the requirements of different environments and a diverse set of users. Focusing on K-12 education, we have identiﬁed a basic set of requirements that an MRP platform must address in order to operate within the classroom environment.

MRP platforms in the classroom must ensure the safety of both its users and bystanders. Unlike the ofﬁce, classrooms contain considerably more clutter and movement. Prior work has already shown that it is difﬁcult for even adult operators to reliably navigate and control MRP platforms (Beer and Takayama 2011). Hence, younger operators may have increased difﬁculty safely operating an MRP platform, especially in a packed and messy environment like the classroom. As the majority of people co-located with the robot are children, there is also greater potential for accidents to occur. Hence, an MRP platform for the classroom should ensure safety by minimizing the chance of collision with the environment or co-located humans.

Autonomous or semi-autonomous navigation have long been a goal for MRP platforms as it can lower cognitive load, improve the robots path, and increase safety (Desai et al. 2011). However, few commercially available MRP platforms currently offer this feature as it requires extra sensors and computing, increasing cost. Moreover, in the case of failure, liability is shifted from the human operator to the robot. A simpler method of increasing safety is enabling the robot to intervene only when the human operator is about to hit something in the environment. This minimizes the danger of autonomous actions but still requires additional sensing features.
capabilities. Other methods focus on augmenting the operators abilities to safely control the platform using tools such as virtual fixtures.

The form and appearance of an MRP platform must also be considered in a K-12 classroom. Classrooms are often crowded, messy, and scaled down in size. The size of the robot should be limited such that it is able to utilize the available pathways, does not block the view of other students, and can be charged in the classroom. Moreover, the robot should be covered such that no wires or components can be pulled out by items in the environment or other people. A compact form and clean appearance is not only necessary for safety but also for acceptability.

Lastly, a large concern of MRP adoption in the classroom is cost. MRP platforms are designed to act as the remote body of one student. As most schools are limited in budget and several MRP platforms may be needed for each school, the cost of each individual platform should be low (<$5,000). Moreover, the platforms should not require large amounts of additional maintenance and repair.

Usability Requirements

One of the main concerns for MRP usage across domains is usability. Prior work has often identified two elements of an MRP platform that significantly affect the robots usability and the users experiences: autonomy and interface (Desai et al. 2011; Kaber et al. 2000).

Controlling an MRP platform is often rated as the most difficult aspect of using an MRP robot (Desai et al. 2011). Without any additional support, reliably navigating the platform requires a significant amount of cognitive load. As previously mentioned, autonomous or semi-autonomous navigation not only offers greater safety, but can remove the burden of control from the user. Instead, they can focus on communicating and interacting with others in the environment.

However, navigating the robot is not the only difficulty of controlling an MRP robot. The user must also accurately position both themselves and the robot such that there are no visibility issues affecting the interaction. Hence, it is important for a platform to offer an interface with features that make it easier for the operator to do all of these things. For instance, offering a point and click feature that simplifies the task of positioning the robot can reduce the operators time and cognitive load. Notifying the user that their image is obscured or dark can improve their interactions. A poor interface has already been shown to be detrimental to not only the users experience but their acceptance of the robot as well (Kaber et al. 2000).

Although these challenges are issues for MRP usage across domains, they can be exacerbated with our target population, K-12 students with significant health challenges. Thus, for their MRP experience to be beneficial, it is important to address these usability needs.

Social Requirements

MRP usage in the classroom is beneficial to the child in several ways. Research has shown that social interaction in the classroom is an integral component of cognitively stimulating peer-mediated educational experiences (Bransford, Brown, and Cocking 1999; Mayer 2003). These peer interactions are essential for language, cognitive, and social development. Moreover, long periods of isolation from their peers can be detrimental to a child’s emotional well being. Hence, there is a need to support the social interactions between peers in the classroom.

One of the fundamental shortcomings of MRP platforms is their lack of social expressiveness. Humans utilize nonverbal behaviors, such as gaze and gesture, to provide necessary cues for socializing. However, most MRP platforms focus on communication and mobility and thus, do not provide any way to replicate or generate these important cues. This limits the ability of the MRP operator to fully engage in a social interaction.

Although the MRP platform acts as the operators remote body, from first glance, it is difficult to differentiate one MRP platform from another. An important component of social interactions is individual identity (Miller 1962). Thus, allowing personalization of an MRP platform enables the operator to truly utilize the robot as a remote body. Furthermore, it makes it easier for co-located peers to identify the robot as the operator on both a practical and social level.

Enabling an MRP platform to be more interactive and engageable requires both expressiveness and personalization. Although prior work with telepresence has identified these issues, no commercially available platforms support these capabilities (Beer and Takayama 2011).

Future Work

We presented three sets of requirements for utilizing an MRP in a K-12 classroom. As there exists no commercially available platform that meets these requirements, we plan to augment a low cost platform with additional sensing and signaling capabilities.

We also plan to create a custom interface that allows us to implement various levels of autonomous positioning and semi-autonomous movement. This custom interface will allow users to augment the robot’s communication capabilities with various signaling tools such as LEDs or a signaling arm. Plans for these modifications are still in progress.

Conclusion

In this work, we have presented the challenges of utilizing MRP for continued access to K-12 education in the classroom. Most commercially available platforms have yet to address the unique needs for children MRP users. Hence, it is important to keep these issues in mind when utilizing any available MRP system in the classroom.

Acknowledgments

This work was supported by NSF NRI IIS-1528121 and a NASA Space and Technology Research Fellowship.

References


