Mobile Robotic Telepresence Between Hospital and School: Lessons Learned

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Abstract. If a pupil falls seriously ill, it is not only a shock for the pupil himself or herself, but also for his or her family and classmates. The project "Virtual Classroom" of the Heilbronn University in cooperation with the foundation "Big Help for Little Heroes" therefore tries to maintain the daily school routine and thus the contact with friends as far as possible with the help of mobile telepresence robots in the classroom from home or from the hospital. Here there are both technical and human factors that contribute to success or failure. Based on a systematic literature research and practical experience, these factors are identified, discussed and weighted in this paper. If the mobile telepresence robot is used successfully, this pays off twice for the pupils affected: It has been shown that pupils can progress socially as well as in school, even if attendance at school is not possible for a long time.

Keywords. telemedicine, education, augmented reality, mobile applications, user-computer interface

1. Introduction

If a pupil falls chronically or seriously ill (e.g. leukemia), he or she will be absent from the everyday life of his or her fellow human beings. The highest priority is then of course the treatment of the illness and thus recovery, but one's own life as well as the lives of others continues. Especially when a pupil is absent for a longer period and cannot attend classes, he or she is missing an essential part, which is 4-8 hours of the regular daily routine [1]. This can lead to a change in the group of friends, a reintegration after overcoming the illness can be difficult. Through the concept of telepresence [2][3] the perceived absence can be reduced, so that the absence can have far less effect on the student's life.

Due to these facts, the project "Virtual Classroom" of the foundation "Große Hilfe für kleine Helden" (German for: big help for little heroes) was founded in 2011 at the SLK Hospital Heilbronn in cooperation with the Heilbronn University of Applied Sciences. This project gives a student who cannot attend classes for a longer period of time due to a chronic or protracted illness the opportunity to visit school from the hospital or from home with the help of a mobile robotic telepresence (MRP) setting [4]. The project is particularly interesting because it takes place at the interface between healthcare, education and technology and has to be supervised by experts from all

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disciplines. In addition, especially in everyday school life, innovation rarely comes from outside the educational system; as a rule, it is the school or the ministry of education and cultural affairs that dictates the innovation. This results in a natural rejection of innovations from outside [5].

However, the project is clearly distinguishable from the virtual classroom, which is familiar from e-learning. Here, the term usually describes software that is used for synchronous e-learning (e.g. webinars). In this typical scenario, the virtual classroom is a virtual room in which any number of participants meet and, with the help of communication tools (webcam, chat, Voice-over-IP, etc.), a classroom event is simulated [6]. A better term for the project would probably be "Augmented Classroom", since the sick pupil is present in the real classroom with the help of computer-generated content (image and sound).

The primary goal is not to follow the lessons, but rather the social component. On the private level of the sick child, a stay in hospital is always an extremely stressful situation, where distraction from the pain and the examinations is beneficial. At the level of friends and classmates, friendships develop quickly at this age and reintegration into everyday life with friends and classmates can be difficult if you have been absent for several months.

The project started with two laptops and a Skype connection [4], in the meantime the technology has been further developed and evaluated by several final theses, so that it is currently real telepresence [7] with the help of a robot from the company double robotics, which the sick pupil can control remotely with the help of an iPad [8]. Furthermore, with the help of upgraded audio hardware it is possible not only to talk to his classmates but also to follow the frontal teaching.

Despite all these technical advances, however, it is not certain that the use of the telepresence robot, even if it is desired by school and pupils and accepted by the hospital, will be successful. Therefore, this paper lists the success factors from an empirical point of view as well as an accompanying literature research, on which the successful application depends and presents possible solutions to meet these factors.

2. Methods

To determine the success factors, a systematic literature search in the PubMed and IEEE Xplore databases and also with Google Scholar was carried out to check what has led to success or failure in other projects and applications of MRP systems. These factors will then be compared and discussed with the experience of our own deployments. The result is a list of knock-out criteria and other helpful criteria that contribute to the success of such a project.

It is important to note that the points described here are merely descriptive science. For a relational or even experimental approach, the number of cases is far too small and the setting is not suitable.

The experiences described here were shown in the context of three assignments (sick pupils) at three different schools with a total assignment period of 18 months. The last assignment is currently still running successfully. Of the completed assignments, one was successful and one was unsuccessful.

To gather information on the success factors, interviews were conducted with three teachers, a principal, three sick pupils, five classmates, a senior physician of the treating clinic and a pair of parents.

3. Results

3.1. Related Work

Due to the further development of Mobile Robotic Presence systems, these robots, while typically used in office applications [9][10], are increasingly penetrating medical and educational areas.

Newhart et al. [1] and Gallon et al. [11] pursue the same goals as described in this paper, namely virtual inclusion, as the authors call it. Unfortunately, Newhart et al.'s results are very descriptive and not really tangible; they focus more on the children's behavior towards the technology or interview practices than on success factors. The authors describe anthropomorphism, the ability to have human-like characteristics, as only key factor. Interaction with classmates must be possible. In Gallon et al. the preparation of the sick children as well as their parents and teachers are described above all. These are of course key factors, but they are not the only ones.

Other areas of application of MRP systems in medicine relate primarily to the ageing society and the problems associated with it. Michaud et al. [12] investigated the impact of telepresence systems on the care of elderly people living at home, while Koceski and Koceska [13] and Tsai et al. [14] followed similar approaches. Other papers deal with the connection of dementia patients in homes with their family members [15] and the use of MRP systems by users with special needs [16][17].

In the educational context, telepresence robots are described, for example, for learning foreign languages with educators sitting at distant locations [18].

Further applications up to the year 2013, regardless of the use case, are summarized briefly in Annica Kristoffersson's review [7]. In addition, the "Essential Features of Telepresence Robots" named by Desai et al. were critically compared [19].

3.2. Success Factors

The success factors are grouped according to their influence on a successful deployment. At the beginning, the knockout criteria are listed, without a successful mission is not possible. In chapter 3.2. further criteria are listed, which considerably increase the probability of a successful mission.

3.2.1. Knockout Criteria

- Interest and acceptance of the sick student

  The most important factor, of course, is that the diseased student is interested in using the avatar, and his or her condition allows this. Both interest and acceptance increase with user experience, i.e. the more universal the avatar is, the higher the chance that it will be used. In a non-scientifically analyzed comparison between a mobile avatar and one that can only turn its head when fixed in place, the student chose the mobile avatar despite the slightly worse camera.

- Interest and acceptance of the hospital and school

  An interest of the participating institutions, both the hospital and the school (especially the headmaster and the teachers) is of course also obligatory. The use of the robot must not disturb the treatment, it will inevitably change or even disturb the lessons. This happens through interruptions, because the robot may arrive delayed or there may be questions from the sick student, which may also be delayed. Also, setting up the avatar when changing classrooms can take a short time and thus delay the start of the lesson. Acceptance is therefore absolutely necessary.

- Internet connection in school, hospital and at home

  A fast internet connection (> 16Mbit) is required to transmit picture and sound in sufficient quality. In Germany, the problem in many schools and hospitals is that there is no sufficient broadband connection. In rural areas this problem also exists in private households. The digitization of schools promoted by the Federal Government is progressing only slowly, as is the expansion of the network. For this reason, it has always been necessary to provide two 4G LTE routers. These must be positioned differently for each classroom/patient room/children's room, so that optimum reception of the 4G signal is ensured. It is very worthwhile to really scout out these locations and place the LTE routers accordingly. A poor signal and the resulting reduction in UX will most likely prevent the pupil from using the system. A high video and audio quality – which can only be assured with an adequate high-speed internet connection – are also the primary key factors according to Desai et al. [19]. However, it is not so much the quality of the video, but the delay, because the robot is controlled via the video. Since it is normal that the quality of the connection varies over time, a graceful degradation of the provided video and audio streams are essential. It is better to provide a (slightly) worse stream than risk aborts. It should also be noted that the two SIM cards required will incur additional monthly costs.

- Available contact person at home and at school

  It is important that someone is in charge of the technical side of the project and can respond immediately to questions. These questions can be manifold. They range from switching the avatar on and off, regular overnight loading, transport of the avatar to technical support in case of malfunctions (e.g. missing internet connection). Good experiences were made with a WhatsApp group, consisting of 2-4 classmates who take care of the robot in the school. At home the student is dependent on himself or a family member with technical experience. It was rarely the case that the university had to intervene.

- Quality of the avatar/hardware

  Of course, the quality of the hardware also has an impact on acceptance and can become a killer criterion. In addition to the operating noise, this includes

stability/roughness and the ability to receive and send data. A test with an exclusively LTE-capable robot, which was to be assigned the student's fixed place in the classroom, failed because there was insufficient LTE reception at this place. Even positioning the robot closer to the window did not result in any improvement. A connection via WLAN with a better positioned LTE router directly at the window was not possible due to the hardware installed. Therefore, the use of this avatar is not possible. Desai et al. [19] also state that the speed of driving should be approximately that of a person walking slowly. This assumption can be confirmed after the experiences made. Multiple cameras are also helpful, you need at least two: one pointing down to drive and one to talk.

3.2.2. Other criteria that improve the chance of success

- Interest and acceptance by classmates

  Due to the sensitive signal transmission, it is necessary that all classmates switch their smartphones off or into flight mode. This should be possible without checking and it turned out that this was a matter of course after a short period of acclimatization. Further it needs 2-4 students who actively take care of the avatar (switching on/off, loading, transport, etc.).

- Microphone and camera quality

  Good microphone and camera quality are important, but not knockout criteria as has been shown. With poor reception and pixelized images, the pupils were able to show their notes to the sick student to give him an understanding of the blackboard image. Even if the sound quality suffered, the microphone was simply turned off. The pupil nevertheless took part in the lesson and was present, even if somewhat more distanced. But the quality must be very good, at least in parts, otherwise the use will probably be stopped from the beginning as stated above.

- Avatar weight/portability

  It is helpful if the avatar can be easily transported by students of lower grades. This can be achieved if the system can be disassembled and reassembled quickly and easily. Often it also helps if the heavy battery can be carried separately. In the case of systems that cannot be separated, such as the Double [8], a wheelbarrow was used to help out creatively.

- Output on screen selectable as livestream or photo display

  Depending on their state of health, their physical condition or clinical picture (e.g. operations affecting the face) a student may not want to be seen. However, it has been shown that switching off the camera completely is not very personal. Therefore, it helps here if a photo is displayed instead of the live image. This way the student is present but can only be heard, not seen.

- Emoticons

  The pupils wish to communicate with emoticons. These should be easy to display using the keyboard, similar to currently popular apps. Emoticons are a modern form of communication among pupils and are part of everyday life, so this wish is understandable.

- LEDs/instructions for retreat possibility and signaling

  It is important to provide the pupil with an opportunity to rest and to indicate this to the class and the teacher. It was often the case that the student wanted to follow the lessons but was not fit enough to participate. This can be implemented with the help of an LED or a hint in the avatar. This LED or hint then indicates: "I am here, I am following the lesson, but I don't want to be addressed and will not participate". On the contrary, the student must be given the opportunity to respond. This can also be done with the help of an LED or a hint on the avatar.

4. Discussion

Experience to date shows that the project is very well accepted and is constantly growing. Currently, two additional robots are being procured so that several pupils can be supervised at the same time. This makes it all the more important, of course, that the on-site supervision in the schools works. The technical knockout criteria are usually easy to meet, even if they require some effort and cost. The human factors are problematic. A project stands and falls with the communication between the technical contact person, pupils and the responsible persons in the school.

The project is successful above all on a social level, the pupil does not leave his circle of friends completely, so reintegration is much easier as shown. Also, the changed appearance, e.g. with leukemia, is already known to the classmates, through the presence of the pupil the process of change is comprehensible and the result is not so surprising. When the pupil comes back to class, experience shows that it was almost as if he had not left. With good technology a high degree of anthropomorphism can be produced. The effects described by Newhart et al. [1] have also been shown to work here: The fellow students do not differentiate between the student and the robot - the robot is the student. They greet the robot with the name of the student.

Furthermore, one family reported that the good days were school days, as there was much less thought given to the illness than on weekends and holidays. These days were the bad days. This was also reflected in the intake of painkillers: on school days the pupil apparently needed considerably less painkillers. Of course, further research would be interesting here, but due to the very small number of cases, this is currently not possible.

However, the project is very effectual on the social level and also successful from a teaching point of view, even if this is not the primary objective. One pupil has managed to transfer to the upper school despite nine months of abstinence at school. The effects of home schooling play an important role here, of course, but some things may have been taken away from the lessons.

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