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# CONTENT

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# REVIEW OF THE USAGE OF TELEPRESENCE ROBOTS IN EDUCATION

Aleksandar Velinov, Saso Koceski, Natasa Koceska

**Abstract.** The usage of telepresence robots can have a huge positive impact on education. They can provide remote access to classrooms. This would be really helpful for students who are absent from school. It was especially noticeable during this period of the Covid-19 pandemic. This technology can complement online teaching with displaying classroom boards, performing laboratory exercises that require better view and movement, and so on. Here, we show the usage of telepresence robots in education and cases when robots can be used for remote learning. The main goal of this paper is to provide a comprehensive review of studies related to the application of telepresence robots in education in the last 4 years.

## 1. Introduction

The term "telepresence" is often used in the latest technological advances. It is especially propagated during this period of the Covid-19 pandemic. We live in a time when grouping is banned in almost every country in the world. Protection measures have been introduced to restrict movement and reduce contact between people. Many places are inaccessible to people or are accessible according to special protocols that need to be followed. This is why telepresence came to the fore.

There are several definitions of telepresence in the literature. Draper et al. in [1] define telepresence as a perception of presence within a remote or simulated location. Held and Durlach mention that the term "telepresence" is often used in discussions for teleoperation. According to Mair in [3], telepresence is the experience of being present at a remote world location directly from one's own environment. Here we can only add that although users using telepresence technologies can be virtually in a remote environment, they can control the movement, receive data from the environment etc.

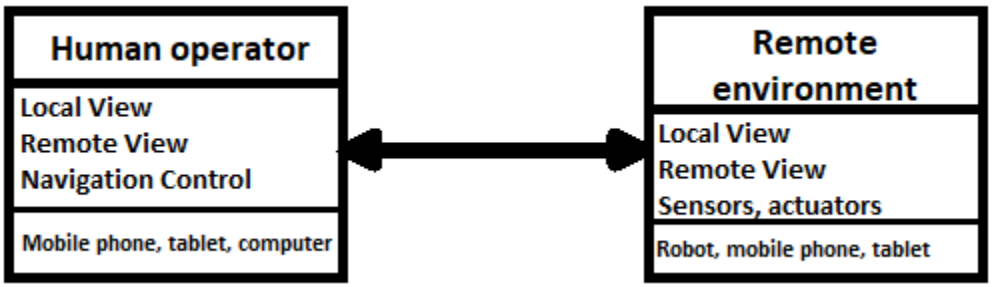


Figure 1. *Telepresence communication*

Basically, all telepresence communication takes place as presented in Figure 1. On one side is a human operator. Using the Internet, he accesses the remote environment via mobile phone, tablet, or computer. Using the device's own camera, the user can access the local environment (Local View). This is often not recommended as the local user's priority is to access the remote environment (Remote View). This is only good for your own view. The user may also have an option for navigation control. When telepresence robot is on the remote side, the user can control it through his device. This allows movement in a remote environment. In addition, the data from the remote site such as sensor data, object data, etc., can be sent to the user side.

On the other side is the remote environment. Often there is a robot and a mobile phone or tablet on this side. The robot is used to move in a distant environment. In addition, the robot may have sensors that generate data or actuators. This data can be sent to the human operator. The mobile phone or tablet is used for telepresence. Using their camera, the user can get an overview of the local site (Local View).

The user also has an overview of the human operator environment. This is made possible by the use of telepresence technology.

There are a lot of areas in which telepresence technology can be applied. Koceska et al. in [26] present a design and validation of telepresence robot that can help the elderly and their caregivers in carrying out their daily activities. They conducted experiments in a private elderly care center in which the participants were elderly people and caregivers. According to the results of semi-structured interviews, the users positively evaluated the robotic system. 73% of the participants expressed a desire to use the robot in everyday life. 80% of the caregivers said that the robot would help them perform daily tasks. According to this research, if most of the elderly accept the robot for telepresence, then we could expect even greater acceptance if it is used in education. The reason for this is the tendency of young people to use new technologies. In this context, Cha et al. in [19] present an interactive game that allows players to control a telepresence robot in a virtual classroom. The purpose of the game is to motivate young children to use this technology. The use of robotic kits in education could also help to acquire new skills and apply them [50].

Telepresence technology is quite current and applicable. As mentioned earlier, this is especially true during this period of the Covid-19 pandemic. One of the areas most affected by this pandemic is education. Many students had to attend classes online. This required development of new telepresence technologies for educational purposes. One such technology is a telepresence robot which is increasingly used in classrooms.

There is still no paper that reviews the advanced studies of the usage of this technology in education. This imposed the need for this type of research that we present here.

Our paper is structured as follows. In Section 2, we present the use of telepresence robots in education. Section 3 is a review of studies. The last Section 4 concludes our work.

## 2. Telepresence robots in education

Telepresence robots are used in education by people who cannot physically attend classrooms. These may be people who are out of school for a short period of time due to illness or injury. According to [4], in 2015, 19% of the fourth-graders in the US were absent from school for three or more days in the last month. About 13% missed 3-4 days of school. About 5% missed 5-10 days (between a quarter and half of the month) and less than 2% missed more than 10 days of school, or half or more of the monthly school days[1]. Henderson et al. in [5] define the term chronic absence. It means missing 10% or more school days in a year for any reason. It is nearly one month of the school year. Balfanz and Byrnes in [6] mention that 5 to 7.5 million students are chronically absent. They also gave an example for Maryland. In 58 elementary schools there are 50 or more chronically absent students. It is around two classrooms of students who are absent more than a month of the school year. According to [6], the chronic absence in high school is higher. In 61 schools, there are 250 or more students who miss a month or more of the school year. Given this, telepresence technology could be used extensively by these students. This way, they will use the technology when they need it.

Telepresence robots can also be used by people who have been prevented from attending classes for a long time. These are students that live with chronic diseases such as cancer, asthma, anemia, etc. [7] [8]. Due to the seriousness of such diseases, these students are completely prevented from being able to physically attend classes in the classrooms [9].

According to [10], studies that use the National Health Interview Survey, assume that 6.5% of American children have chronic illness that can affect their physical health.

According to [11], 10-15% of children in the United States are affected by at least one chronic disease. Shaw et al. in [12] mention that approximately 17% of all students under age 18 suffer from a chronic illness. More than 40% of children diagnosed with cancer are absent from school when they are undergoing treatment [13]. The use of a telepresence robot can significantly help these children in the

[1] Student absenteeism, https://www.epi.org/publication/student-absenteeism-who-misses-school-and-how-missing-school-matters-for-performance/

educational process, the process of socialization and in the communication with their peers and teachers. Weibel et al. in [13] present a qualitative pilot study about how telepresence robots can help school-aged children and adolescents with cancer to remain socially and academically connected with their school classes during treatment. Based on the results in [13], telepresence robots can significantly improve the everyday hospital life of children and adolescents with cancer. It can increase their inclusion in learning activities and reduce the sense of loneliness.

Telepresence robots can also be used by students who have been suspended from school. The most common reason for suspension is inappropriate behavior[2]. According to [15], the proportion of all students in US suspended from school at least once during the year decreased from 5.6% to 4.7%, between 2012 and 2016. The number of students suspended in high schools is higher. The percentage decreased from 9.6 to 7.6, between 2012 and 2016. With the use of telepresence robots, suspended students can attend classes and stay in touch with their peers. This can have a positive effect on them. They will not miss classes just because they are physically separated from their peers, but they can work on their behavior to get back into the classroom.

In this period of the Covid-19 pandemic, telepresence robots can be very useful in continuing the educational process. At the beginning of the pandemic, half of the world's student population did not attend school[3]. More than 850 million children and youth had to stay away from schools and universities [14]. During this period, a number of organizations such as UNESCO launched an initiative to develop distance learning solutions [14]. Most schools have started online classes. Although there were many tools that could facilitate online teaching [49], there were still situations where online teaching could not completely replace teaching with physical presence. For example, writing on a school board was difficult to replace. Working on experiments that required movement in the laboratory was also difficult to replace with online teaching. These are some of the educational processes where telepresence robots can be used to help teaching in this period of pandemic.

Telepresence robots can also help in reducing the number of children who do not attend school (out-of-school children). According to UNESCO, 258 million children and youth were out of school for the school year ending in 2018. This includes 59 million children of primary school age, 62 million of lower secondary school, and 138 million of upper secondary age[4]. The most common reason why children cannot go to school is poverty [16]. If states invest in telepresence robots and devices for children, then the number of out-of-school children will decrease.

All previous usage cases confirm the enormous importance that telepresence robots can have in education.

## 3. Review

### A. Research questions

With this review we want to discover new directions in which we could explore the usage of telepresence robots in education.

The main research questions that lead us to this review are the following:

- How many of the studies use telepresence robots in primary, secondary or higher education?
- How many of the studies in addition to telepresence technology also use virtual reality (VR), augmented reality (AR) or other technologies?
- How many of the studies use telepresence robots to monitor laboratory exercises or practical work?
- What are the most common technologies for transmitting video or messages?
- What are the most common students', teachers' and parents' comments?

[2] What Kinds of Behavior Can Lead to Suspension From School?, https://www.lawyers.com/legal-info/research/education-law/what-kinds-of-behavior-can-lead-to-suspension-from-school.html

[3] UNESCO, https://en.unesco.org/news/half-worlds-student-population-not-attending-school-unesco-launches-global-coalition-accelerate

[4] Out-of-School Children and Youth, http://uis.unesco.org/en/topic/out-school-children-and-youth

**B. Selection of studies**

The purpose of this paper is to review the latest research on the usage of telepresence robots in education in the last 4 years. We used Google Scholar as a source to search for studies. We selected the studies according to the following criteria:

- It should not be older than 4 years
- It should show the application of telepresence robots in education
- It should show results obtained from the research
- Using other technologies such as VR or AR along with telepresence robots (TR)

We excluded studies according to the following criteria:

- It is a thesis, dissertation, or review paper
- Studies with informal context
- Studies that provide only an introduction to telepresence
- Studies that include the use of robots in education but do not apply telepresence technologies

According to the above criteria, we selected a total of 28 studies. Selected studies can be seen in Appendix A at the end of the paper.

**C. Results**

- How many of the studies use telepresence robots in primary, secondary or higher education?

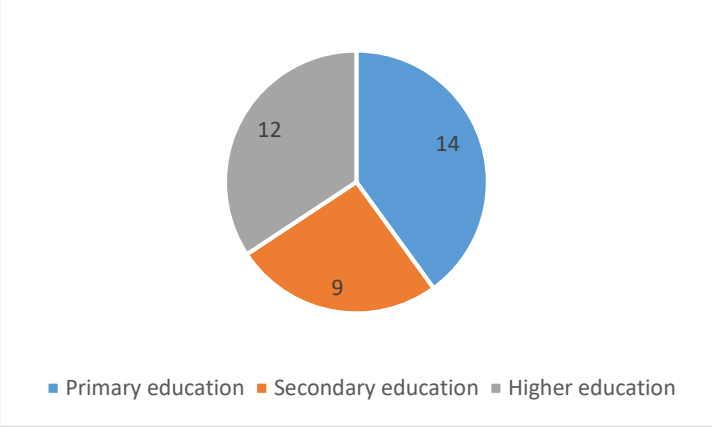


Figure 2. *Target groups for the usage of telepresence in education*

According to our research for target groups, 14 studies cover the usage of telepresence robots in primary education, 9 in secondary education and 12 in higher education (Fig. 2). Some of the studies mention application in several groups of education. Our opinion is that telepresence robots can be applied to all target groups.

- How many of the studies in addition to telepresence technology also use virtual reality (VR), augmented reality (AR) or other technologies?

As can be seen in Fig. 3, most of the studies (22) apply only TR without other technologies. The use of technologies such as VR and AR could make a great contribution to education [48], especially if these technologies are used with telepresence technologies.

From the reviewed papers, other technologies used in conjunction with TR are:

- VR – 2 studies [34, 44]
- AR – 1 study [43]
- Computer Vision – 1 study [21]
- Computer Vision and Speech Recognition – 1 study [38]
- Holographic Projections – 1 study [35]

From the data obtained, we can see that a small number of studies use TR along with other technologies. These technologies could enhance the user experience. Only two of the studies that apply additional technologies are used in primary education. Although these are small children, the usage of these technologies could help them a lot in education.

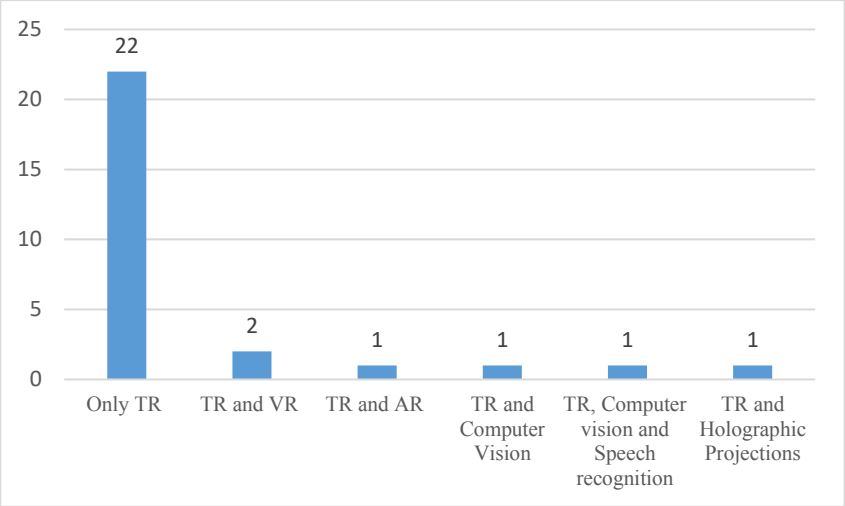


Figure 3. *The usage of TR and other technologies*

Given the fact that nowadays children have an affinity for new technologies, this could be interesting for them and could improve their success. The same is also true for secondary and higher education.

- How many of the studies use telepresence robots to monitor laboratory exercises or practical work?

In 12 of all studies, telepresence robots are used to perform laboratory exercises or practical work. This is especially useful in higher education. This is evident in this period of pandemic when doing practical work is a challenge due to the restrictive measures. There are not many studies that present in detail the methods and technologies for creating remote labs and using TR. Only Xie et al. in [43] present such a remote laboratory. We believe that despite the methods in this paper, in the future it is necessary to do more research on this in order to create laboratories that could help in the educational process.

- What are the most common technologies for transmitting video or messages?

The ways in which communication takes place between students acting as operators and robots are mentioned in 16 studies. In some cases, web applications are used, while in others these are mobile applications. Some of the studies use the default applications from the manufacturers, while others present their own developed applications. Most of the studies do not mention which technology is used for communication. The most commonly mentioned is WebRTC technology used for real-time communication. The communication process is very important in telepresence platforms. It is important to use technology that enables the transmission of video, audio, and messages without major delays on the receiving side. We believe that it is necessary to do more research in this area in order to enable smooth communication and thus increase the acceptance of this technology in education.

- What are the most common students', teachers' and parents' comments?

Comments are an important part of creating robots and telepresence applications. They could help in the initial acceptance of TR as well as in their improvement. From the reviewed papers, we extracted the comments of the participants in scenarios. Although at first we only wanted to select comments

from students, teachers and parents, looking at the papers we found that some of them also offered comments from other participants such as principals [18] and healthcare professionals [47]. Comments from students are filtered into two groups: students-operators (who operate the robot remotely) and students-peers (students in the classroom). It is also worth noting that in some of the studies [32, 36, 39, 45] teachers appear as operators. Comments are classified as positive, negative and suggestions, in order to be easier to follow. The most common students', teachers' and parents' comments are shown in Table 1.

Table 1. *Comments from students, teachers, and parents*

| Participants | Positive comments | Negative comments | Suggestions |
|---|---|---|---|
| Students (operators) | - A sense of being able to control a given body or see, hear, and be in a particular space<br>- It looks like physical presence in the classroom<br>- Intuitive and easy to use | - Having difficulty hearing people across the distance of the classroom<br>- Struggled to see materials presented by both the teacher and nearby students<br>- The driving interface was distracting | - The ability to go between "sitting" and "standing"<br>- Minimized driving interface when the robot was in "stationary mode."<br>- Chat interface for private communication |
| Teachers | - The ability to ask questions in real time and look at each other<br>- Positive attitude towards technology acceptance<br>- "excited," "thrilled," and "happy," that the child would be able to attend school via robot | - Not having any control over the robot's operation<br>- Wi-Fi connectivity was often lost<br>- It was difficult to include the homebound student in the exercise | - The ability to fax material back and forth would be a welcome addition<br>- Lights or other salient signaling to indicate each robot user's state<br>- The ability to call remote students |
| Parents | -agreed to cover the costs for the tool<br>- They would like to implement this solution, because of the benefits that their children would have when they miss school<br>- The robot can provide something social and educational | / | / |

## 4. Conclusion

There are great opportunities to use telepresence robots in education. They provide access to a remote classroom. This is especially important for students who are absent from school fora short or long time. With their help they will be able to follow teaching remotely. This contributes to better socialization, integration, and collaboration with their peers. This will also have a positive effect on student success. The review in this paper opens new research directions for the application of telepresence robots in education.

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**APPENDIX A: Summary of all selected papers**

| No | Year | Reference | Title of paper | Education | Technology | Laboratory, experimental or practical work | Technologies for video and messages transmitting |
|---|---|---|---|---|---|---|---|
| 1 | 2017 | [17] | Designing telepresence robots for K-12 education | Primary and secondary education | TR | Yes | / |
| 2 | 2017 | [18] | My Student is a Robot: How Schools Manage Telepresence Experiences for Students | Primary education | TR | No | / |
| 3 | 2017 | [28] | Qualitative exploration on children's interactions in telepresence robot assisted language learning | Primary education | TR | No | / |
| 4 | 2017 | [29] | Telepresence Robot: Process of Appropriation through the Evolution of the Modalities of Presence | Higher education | TR | Yes | Own application for audio/video communication |
| 5 | 2017 | [30] | Hybrid Learning in Higher Education: The Potential of Teaching and Learning with Robot-Mediated Communication. | Higher education | TR | No | / |
| 6 | 2017 | [31] | Integrating Telepresence Robots into Nursing Simulation | Higher education | TR | Yes | Web applications for audio/video communication |
| 7 | 2017 | [32] | Development of a Peer Tutor Support System for Disabled Students Using a Telepresence Robot in South Korea | Primary education | TR | No | Web applications with two-way audio/video communication based on WebRTC protocol |
| 8 | 2018 | [20] | Evaluating the effects of personalized appearance on telepresence robots for education | Primary education | TR | Yes | / |

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| 9 | 2018 | [22] | Telepresence Robots in the Classroom: The State-of-the-Art and a Proposal for a Telepresence Service for Higher Education | Higher education | TR | No | Own Android, IOS apps, Windows or OSX apps (according to the support of robot type) |
| 10 | 2018 | [21] | Development of telepresence teaching robots with social capabilities | / | TR and Computer Vision | No | Own Android and IOS apps based on WebRTC protocol |
| 11 | 2018 | [33] | Development of telepresence technology during the teaching process at Subotica Tech | / | TR | No | Video and audio communication using Viber |
| 12 | 2018 | [34] | A Study to design VI classrooms using Virtual Reality aided Telepresence | Higher education | TR and VR | No | Video and audio communication using VR-compatible Android applications |
| 13 | 2018 | [35] | Professor AVATAR: telepresence model | Primary education, Secondary education, and Higher education | TR and Holographic Projections | Yes | Holographic telepresence system is used for video and audio communication |
| 14 | 2019 | [23] | Dedicated applications of telepresence robots for education | Secondary education | TR | Yes | Video and audio communication using application like Skype, Messenger, or own application |
| 15 | 2019 | [24] | Increasing student compliance with teacher instructions using telepresence robot problem-solving teleconsultation | Primary education | TR | Yes | Own default iOS applications |
| 16 | 2019 | [36] | Convergence Technologies by a Long-term Case Study on Telepresence Robot-assisted Learning | Primary education | TR | No | Own developed Android applications |
| 17 | 2019 | [37] | Using a Telepresence robot in an educational context | Higher education | TR | Yes | / |

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| 18 | 2019 | [38] | Using the Engagement Profile to Design an Engaging Robotic Teaching Assistant for Students | Higher education | TR, Computer Vision and Speech recognition | Yes | / |
| 19 | 2019 | [39] | Analysis on Acceptance and Use of Technology for Elementary School Teachers in Telepresence Robot-assisted Learning | Primary education | TR | No | / |
| 20 | 2019 | [40] | Broadening Participation for Remote Communities: Situated Distance Telepresence | Secondary education and Higher education | TR | Yes | / |
| 21 | 2019 | [41] | Around the state from your couch: using telepresence robotics to facilitate field-based internships in teacher preparation | Primary education, Secondary education, and Higher education | TR | Yes | / |
| 22 | 2020 | [25] | Telepresence Technological Model Applied to Primary Education | Primary education | TR | No | Own web apps based on WebRTC protocol |
| 23 | 2020 | [42] | Are We There Yet? Comparing Remote Learning Technologies in the University Classroom | Higher education | TR | No | / |
| 24 | 2020 | [43] | Engaging Students in Distance Learning of Science with Remote Labs 2.0 | Secondary education and Higher Education | TR, AR | Yes | Mobile application, Cloud server application and own developed web application |
| 25 | 2020 | [44] | Immersive Telepresence Framework for Remote Educational Scenarios | Primary and secondary education | TR, VR | No | Unity-ROS interface |
| 26 | 2020 | [45] | Multiple Device Controlled Design for Implementing Telepresence Robot in Schools | Secondary education | TR | No | Own developed web application and mobile application |

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| 27 | 2020 | [46] | Meaningful engagement via robotic telepresence: an exploratory case study | Primary education | TR | No | Web application and mobile application |
| 28 | 2020 | [47] | Back to school with telepresence robot technology: A qualitative pilot study about how telepresence robots help school-aged children and adolescents with cancer to remain socially and academically connected with their school classes during treatment | Primary and secondary education | TR | No | / |