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USERS' EXPERIENCES AND PERCEPTIONS ABOUT TELEPRESENCE ROBOTS IN EDUCATION

Maria Perifanou[1], Polina Häfner[2], Anastasios A. Economides[1]

[1]University of Macedonia (GREECE)
[2]Karlsruhe Institute of Technology (GERMANY)

Abstract

Telepresence robots (TR) enable people to be represented by a mobile robot at a distant location and audio-visually interact with people and the environment around the robot. The user of the TR remotely controls and drives the TR in its environment as well as interacts with people using microphones, speakers, cameras, screens, and other facilities of the TR. TR have been exploited in various areas including education. However, most previous studies examined specific cases of introducing TR in education. The current study aims at synthesizing the experiences and perceptions of various TR users at different countries and various institutes. A qualitative research study was implemented with regard to the Erasmus+ project TRinE: Telepresence Robots in education. The team conducted 20 interviewees with experienced users (students, educators, technicians, etc.) in the integration of TR in education across Austria, France, Iceland, and U.S.A. The interviewer interrogated the interviewee employing 28 questions about the interviewee's views, practices and experiences with TR in education. The results shown that the most common use of TR was that of a remote teacher or student participating in a class via a TR. The most frequently mentioned TR strength include the ability of the remote students to feel present, participate, communicate, and socialize with their classmates; TR weaknesses include their weak wireless connectivity, low sound and camera quality, lack of hands and gestures; TR challenges include obstacles in its movement (e.g., elevators, doors, stairs), privacy concerns, lack of WiFi everywhere, risks of misusing TR. The interviewees were not aware of any national or international policies about TR in education. Finally, they made recommendations in a number of issues.

Keywords: Interviews, Remote Learning, Remote Teaching, Telepresence Robots.

1 INTRODUCTION

A telepresence robot (TR) is a remote-controlled device on wheels composed from a screen display, microphones, speakers, cameras, battery, software, and wireless connectivity that is driven by a remote operator via a computer, tablet, or smartphone. The remote operator of the TR can view and hear people and objects around the TR as well be heard and viewed by these people. So, the remote operator feels like been physically present at the TR's location. The operator can drive the TR close to specific people or objects, go around them, and zoom on them. The operator has control and autonomy on how, where, and when to move as well as what to see and speak.

TR have been used in various applications areas such as education, healthcare, eldercare, office, home, and work. More specifically with regard to education, homebound children (e.g., due to illness or disability) can attend school through a TR [1,2] or a remote teacher can teach students by controlling a TR that is located in front of them [3]. Previous studies have shown the potential of TR in various educational subjects such as informatics [4], engineering [5], science [6], special education [7], languages [8], and more. However, further research is needed to understand how TR work in school practice [9,10]. In order to capture a holistic view of TR in education, TR integration in education should be investigated from multiple perspectives. However, each one of the previous studies examined a specific case of introducing TR in education. For example, studies examined specific cases of homebound (due to illness) students who use TR in order to attend classes and avoid social isolation [1,2,11-16]. In order to overcome this limitation of previous studies, the current study aims at systematically recording the experiences and perceptions of TR users (students, educators, technicians, etc.) at different countries and various institutes that used TR in education for various reasons. The current study reports results from interviews conducted by the TRinE (Telepresence Robots in Education) project across Austria, France, Iceland, and U.S.A. TRinE is an Erasmus+ project [17] aiming at facilitating the integration of TR in education. The project's partners conducted 20 interviews with experienced users in the use of TR in education across four countries.

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2 PREVIOUS STUDIES USING INTERVIEWS ON TR IN EDUCATION

Interviews was one of the methods that previous studies have employed in order to investigate the use of TR in education. In a case of 5 homebound children with chronic illness who were attended school using a TR, semi-structured interviews were conducted with the children, 5 parents, 10 teachers, and 6 U.S. school/district administrators [1]. The following three themes were identified: 1) anthropomorphism (participants treated the TR as if it was a human) for social acceptance and normalcy, 2) overcoming isolation (remaining socially connected) to meet socio-emotional needs, and 3) new experiences that generated talk of an academic future.

In foreign language learning using TR, three English learners and a native-speaker of American English participated in a U.S. university campus tour using a TR [18]. Each remote learner controlled the TR during the campus tour guided by the native speaker who introduced the history and culture of the buildings along the tour route. At the end, all three learners and the native speaker were interviewed. Five themes were identified: Emotions; Authentic learning experience; Learner-centered activities; Technical issues; Practical concerns. It was concluded that using TR at real world places provides authentic communicative practices in foreign language learning. In a similar case [8], a remote learner in China was driving the TR at the campus arboretum of a U.S. university, stopping at interesting places and discussing with the language instructor as well other native speakers who happened to pass by. Four native English speakers and eleven learners in China participated in the experiment. The data analysis of all 15 participants' interviews resulted to 24 themes grouped into 3 categories: Strategies for situated learning in real-life places; Strategies for scaffolding the learning process; Strategies for enhancing learner agency.

[19] explored the use of a TR without mobility capability by homebound students diagnosed with cancer to remain academically and socially connected with their classes. They conducted semi-structured interviews with 13 school-aged children and adolescents, 3 parents, and 2 teachers in Denmark. Five themes were identified: Expectations; Sociality; Learning; Spatiality; Technology. Participants experienced the TR as facilitating social intersection processes with classmates and inclusion in learning activities, reducing their sense of loneliness and lacking behind educationally.

The views of students with cancer, parents/guardians, school teachers, and healthcare professionals were investigated via 25 semi-structured interviews [20]. They discussed the benefits, acceptability, barriers, and enablers of utilizing robots in schools. Data analysis revealed six themes: Inconsistency of educational support during and after cancer treatment; Impact of cancer on isolation and wellbeing; Telepresence robots can support adolescents' education and isolation during cancer treatment; Assessing suitability of the robot for a young person; Need for the school to be engaged in the process; Ensuring good user experience with the appropriate technology. Then the authors developed the TRECA (Telepresence Robots to Engage CAncer patients in education) service that enabled enhanced sense of agency and wellbeing to patients. The participants pointed out the importance of stakeholder buy-in and taking an individualized approach to service delivery.

The experiences of 37 homebound children due to illness were investigated via semi-structured interviews in Norway [9]. Four categories of important elements emerged: 1) the child's state of health, 2) the school's approach to the robot, 3) technical aspects of implementation, and 4) the child's informal network of supporters and alliances.

As it becomes clear, each one of the aforementioned previous studies investigated via interviews a single case of using TR in education. The current study investigates multiple cases of TR usage in education across various countries (Austria, France, Iceland, and U.S.A.) and educational institutes by taking into consideration the experiences and views of educators, students, technicians, and others who have used TR in education for various reasons. The interviewees described their experiences, expressed their perceptions, and made recommendations with regard to TR in education. In a companion paper [21], TRinE team investigated the views of participants in thirteen focus groups discussions in Austria, Germany, Greece, Iceland, and Malta.

3 METHODOLOGY

The study employs semi-structured interviews in order to gather the experiences and views of various TR users in education. Carrying out these interviews is essential to gain insights into specific problems and challenges that the interviewees have encountered and specific measures that they have taken or they propose to be taken.

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Initially, a methodology and 28 triggering questions were developed by two researchers with expertise on educational technology. Then ethical approval was obtained by the ethical committee of the project coordinator's university. The project's partners organized 20 interviews with experienced users of TR in education in four countries. The interviews were conducted during January and February 2022. Each interview lasted on average approximately 60 minutes and was conducted via videoconferencing.

The interviewees gave their consent to participate in the interview and be videorecorded. Initially, the interviewees were informed about the project, its goals, and how the information will be used and analysed. The principles of anonymity, confidentiality, and personal data security were also applied. The interviewees were informed that there are no right or wrong answers, but only different points of view; and free expressions and opinions are welcome. Then they were asked questions about their views, practices, and experiences with TR in education. Finally, they made recommendations.

Data were analysed using thematic analysis [22] in order to extract key themes (patterns that are important or interesting) in the interviews' data. Themes emerge as the overarching categories of common data across multiple interviews. Two researchers in the field of Educational Technology agreed on exploring the interviews' data. They followed a six steps methodology [22]: 1) Familiarizing with data; 2) Generating initial codes; 3) Searching for themes; 4) Reviewing themes; 5) Defining and naming themes; 6) Producing the report. So, after the two researchers familiarized themselves with the interviews' data, they assigned codes to segments of the data that were focused around a specific topic. The researchers discussed the codes and in case of disagreements they came to consensus. Finally, they agreed on the themes.

4 DEMOGRAPHICS

Eighteen interviewees come from three European countries while two interviewees come from USA (Table 1). Most of them are middle-aged and highly qualified; most have a Master's degree and a few have a Bachelor's degree, two even have a PhD. They aged 19 to 50+ years old and belong in different occupational groups such as professors, teachers, students, technical and non-technical staff. Their average experience in the field of TR ranges from 3 to 6 years collected in schools, universities or companies for manufacturing of telepresence robots. Nine interviewees reported to have medium digital skills, while in each country there is at least one interviewee with high digital skills and some with low digital skills.

Table 1 Table 1. Demographics of the participants.

Country		Austria	France	Iceland	U.S.
Gender	Female	1	0	0	1
	Male	2	2	1	1
	Other	1	0	11	0
Level of Education	B.Sc.	0	0	3	2
	M.Sc.	1	1	7	0
	Ph.D.	1	0	2	0
	Other	1	1	0	0
Average Age		43	62	45	31
Occupation	Professor	1	1	0	0
	Teacher	1	0	7	0
	Student	0	0	4	0
	Technician/admin	2	1	0	2
	other	0	0	1	0
Digital Skills	Low	0	0	4	0
	Medium	1	1	7	0

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	High	2	1	1	1
Avg. years of TR experience		n/a	6	4.5	2

In the following, we will present in detail the respondents' opinions, perceptions and recommendations on TR according to different categories.

5 RESULTS AND DISCUSSION

The interviews conducted were manifold and covered several professional groups from four countries: Two professors from Austria and France, teachers and students from Iceland and Austria, technicians from educational institutions as well as from companies manufacturing telepresence robots from the U.S and France (Table 2). When asked what they thought the strengths of telepresence robots were, all agreed that TR enhances the feeling of being present and part of the class, although at a distance, compared to video conferencing tools (Tables 2 & 3) as it was also found in [1,10]. The students were happy that they could clearly hear their classmates and teachers via the TR on the remote side. Most importantly, they felt noticed by their teachers and classmates and made to feel included in the lessons and discussions, as opposed to being online via Zoom or MS Teams. Professors and teachers were pleased with the improvement in teamwork between students on and off campus and felt more comfortable using TR. More remote students were able to attend their lectures and they could see the faces and expressions of their classmates using a TR in the class. While being away from the universities and enjoying a vacation break, educators were still able to communicate, attend meetings, deliver lectures, and feel that TR help them and their students to socialize. Technicians stated that it can be easier for anyone to resume to an on-campus routine using TR as compared to returning after an absence. They also believe that one-to-one communication becomes better as engagement increases with a high level of immersion through the use of TR along with the feeling of "being there".

Social anxiety and phobia are issues of huge concern amongst students and adults as well. TR offers a great opportunity to students who find it difficult to socialize as they can interact with their peers and teachers more comfortably. With the use of telepresence robots, students who are sick or abroad wouldn't miss their lectures or group sessions thus in turn increasing attendance which will help them score better grades and perform better at school or university.

Teachers and professors have the advantage that they do not have to fly in or out to meetings in different places to give lectures and can just drop in to check if everything is going well. For example, an art teacher who teaches remotely at one of the interviewed universities in Iceland mentioned that it is convenient for him to use a TR from his studio and teach students abroad. He has all the tools, paints, and required art supplies he needs close at hand whenever he wants to access it and can also move the TR around the class as required to demonstrate certain painting techniques to each student. Technicians see opportunities for more collaboration and the development of cyber classrooms in TR.

Table 2. Views of interviewees from Austria, France, Iceland, and U.SA.

Themes	Austria	France	Iceland	U.S.A.
Experiences/ cases with TR in education	Research projects on TR. TR in the Tech lab at Space21Future. Technical Support for Insurance company for adult education training center. Overseas professors and professors with disabilities gave remote lectures.	TR used by a professor to stay connected on campus while on a holiday. University uses 15 TRs for students who have illness, disabilities or live in remote areas.	Teach Art classes at school using TR. Use of TR via computer and smartphone. University students attend class via TR. Teachers use TR at university to lecture and attend meetings.	Working in a company producing TR.
Strengths of TR in education	Students can be virtually present in the classroom.	Enhances emotional involvement of students as they	Independence to start the class.	One-on-one communication is better enabled

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	Students feel a sense of belonging to the class. Decrease in drop-out rates for remote students. Enabling children who cannot attend school to participate in class. Positive impact on learners during class and peer2peer meetings. Improvement in movements and active interaction of remote students with local students during breaks.	meet their peers after a long time via TR. Remote interaction with students on campus makes the user student happy. Both the remote user and the TR's surroundings can participate. Level of immersion is very high.	Feeling more personal although being at a distance. Pre-defined instructions on how to use TR makes it easy and simple to use. Availability of guidance and support by learning centers. Promotes student teamwork.	between students and teachers remotely. TR gives emotional support to students. More engagement among students by the use of TR.
Opportunities of TR in education	Clear visibility of the blackboard can increase students' engagement. Teachers-in-training can get media trained. Experts can supervise small groups or individuals. Experts from the field can transfer their knowledge. Possibility of role-playing games using TR.	A single teacher can teach in multiple universities at different locations. Integration of a "following-mode" for the TR to move by following tags. Implementing user passwords to maintain the integrity of TR.	Possibility to just drop-in and socialize. Adding arms to the TR can be considered. Equipping TR with more than one iPad. Motivates teachers as attendance does not go low.	Minimizes obstacles that students abroad face. Limitations of seats available for lectures can be avoided. A cyber classroom would make collaboration and online working possible.
Weaknesses of TR n education	Poor WiFi connections. Lack of network and technical training, equipment and setup. TR has limitations on full multimodal interaction. Time required to support or repair any damages by external companies. Integration issues of different TR systems in one school network from a data security perspective. Declining curiosity-curve after the initial period of use. Security risks using third- party devices from unknown manufacturers. Noise by the use of TR.	Poor WiFi connections Risk of TR falling down the stairs or in a hole. Human assistance is required to transport and take care of the TR. Full interaction between student-teacher is a must.	Need for good finance and technical infrastructure. Students on campus hesitate to help the TR move around on the floor or to use an elevator. No connectivity with TR when it is in the elevator. Unstable WiFi connections in different areas on campus. Risk of access to sensitive data via TR.	Difficult to place sensors satisfactorily. Sometimes, TR cannot properly recognize obstacles like tables. TR cannot use elevators or stairs or open doors by themselves. Tough to maintain good and stable network connections.
Obstacles & Challenges of TR	Preparation is necessary for teachers and students to use TR. TR need to be accepted by teachers and students.	Difficulty in one-to-many communication for remote user. Ability to trace the exact TR geolocation.	Lack of policies about TR. Extra time required to turn on the TR during a presentation.	Making the TR affordable makes it difficult to design a high-quality device. Robots can cause fear in children.

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	Danger of misuse of installed permanent cameras by students. Lack of media literacy among children and adults. Shift to a new environment. Lack of gesticulation. Use of outdated encryption algorithms and HDMI frame grabbers.	Consent from every individual to be filmed wouldn't be possible. Adults would perceive a TR to be just only a technical device. France has a law where pictures of public gatherings are not allowed.	Discomfort to some students on campus. Teachers would lose interest in teaching if they use a TR. Charging, sound quality, and connectivity issues of TR.	Risk of robots being hurt or damaged by children.
Recommen-dations for TR in education	A guideline set by every school prior to the use of TR. Setup and follow national rules before using TR. Wait for another 5 years approx. for devices to get cheaper and better. Important developments can be made in the area of foldable displays, spider legs and intelligence and behavioral training of TR.	Make TR to return to charging docks automatically. Provide better GPS, speakers, and microphones. TR should follow the same rules as students on campus. An assistance must accompany each TR. Use of 4G or 5G for better connectivity. Add speech-to-text and translation system.	Provide better high-resolution images. Provide better zoom. Functionality for only stream video but no recording, especially for students. Make TR compatible with iOS. Enable quick authorization by the teachers to use TR in their classes. Make user-friendly app for using TR.	Automatic translation from one language to another.

Poor WiFi connection is recognized as the most common weakness with TR by interviewees from all countries and occupational groups (Tables 2 & 3) as it was also pointed out in [2,8,12-16,19]. The students feel that there are certain limitations for them to interact with their peers while using a TR. For example, in case the remote students want to ask for help to get the TR into an elevator, they need to wait until someone comes close to the TR or is willing to help them. Connectivity is lost when the TR is in the elevator and hence it leads to freezing issues which can cause inconvenience to the remote student to locate his/her telepresence robot. During group discussions, when everyone is talking, the noise makes it difficult for the remote student to understand and communicate or catch up with his/her peers. Also, it is difficult for remote students to ask or answer questions due to the noise made by the TR or the peers. According to the students interviewed, the TR sometimes stands in front of them and block their views during lectures.

Teachers are more concerned about the elevator access issues than the students are. They are aware of the damage that can be caused to the TR if it falls down the stairs or in the elevators and also that human intervention is required. Although the professors and teachers can see the students attending via TR, they feel the interaction initiated by the students still needs more improvements and so does the TR wireless connectivity in different parts of the campus.

Professors and teachers fear privacy issues more than students and technicians. They are afraid that anyone using TR could gain access to private data and some of them are not comfortable being recorded or video streamed [2,7,12,14-16,18]. This can be considered as one of the major TR challenges. Educators in Iceland pointed out the need for a better financial and technical infrastructure to use TR efficiently and effectively. The technicians from TR manufacturers consider their major hurdle to be the construction of advanced TR at lower and affordable prices.

Teachers and administrators in Austria found it difficult to adapt to changes in their environment. They felt a lack of media literacy among students and teachers along with the fear of misuse by students. Use of outdated encryption algorithms and HDMI frame grabbers was also pointed out as a weakness in TR by the technicians. One of the interviewees mentioned that in France, there is a general rule that

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prohibits people from recording or taking videos of any public event or gathering. Thus, compliance with different policies and regulations must be considered while designing features of a TR and also before buying and using a TR which is in itself a huge obstacle for TR manufacturers and distributors.

The technicians and members from the financial and admin department in the TR company in the U.S find it challenging to integrate the sensors being used satisfactorily and they foresee issues with the obstacle detection. For example, the gaps below a table are not recognized accurately by the TR which can cause the telepresence robot to hit the table and cause damage. They are skeptical about the use of TR for children as it can induce fear within small and younger kids. Among the weaknesses are included the use of third-party devices from a data security point of view and the noise pollution caused by the telepresence robot. Similarly, from the same perspective, integrating different telepresence robots on the same campus for one single location is challenging. One problem can be the lack of technical support and training that should be provided by learning centers or manufacturers or resellers. For example, there may be delays in repairing damage or defects to TR, which can hinder the progress of a person's activities using it.

Telepresence robots seem to be an interesting device to the students in the initial days of its introduction, however there is a decline in curiosity over a period of time in certain places. Not everyone on campus would be comfortable and accepting the TR technology and hence a few hesitate to help the remote students driving TR for using the elevator and guiding the TR safely. Students interviewed in Iceland mentioned facing battery life issues quite frequently while attending their semester abroad lectures through a TR. Students recommended using a first-come-first-serve scheduling to book and use a TR at their universities and mentioned that they would be more comfortable to use it if the robot had arms. TR experienced students also felt a need for more telepresence robots to be made available for use. Some professors and teachers found the user interface of the TR and its app a little difficult to use and suggested that a simpler user design could be considered for ease of use.

Table 3. Views of students, professors, teachers, technicians and others.

Themes	Students' views	Professors' views	Teachers' views	Technicians' views	Others' views
Strengths of TR in education	Participate even while being away. Hearing lectures is easy. More realistic than zoom calls. Teachers were less likely to forget the students present as TR than on zoom calls. Increases quality of education.	Promotes on-off campus student teamwork. Communication is as good as teaching live. TR creates presence as students cannot turn off the camera unlike in zoom. Students can interact remotely.	TR helps to socialize. Move around while giving class to students. Increases mobility. Ill students can attend class from home. Avoid dropout of students who attend remotely.	Children who are not well can attend class. Remote experts can participate. TR can be used for peer-to-peer meetings.	Easier to come back or resume in-person classes or meetings. People are not absent but 'there'. Level of immersion is too high. One-on-one communication is better enabled. More engaged remote person.
Opportunities of TR in education	Use in teacher training programs Possible to form friendships. Help students with anxiety and social phobia. Improving grades by attending via TR.	Run courses despite the location. Convenient for group work.	Possibility of just dropping in.	Experts can supervise and teachers can observe.	Students are more attentive in class with TR than other tools. Single teacher can teach at multiple places. Use of 4G or 5G. Cyber-classrooms and collaborations.

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Weaknesses of TR in education	Losing connectivity in elevators. Limited battery life. Slow turning movements of TR Few TR available at the university. Lack of human facial and hand gestures for communication.	Internet connectivity. Charging of TR. Sound Quality. More difficult to use TR than Zoom calls. TR requires extra work than Zoom calls.	Low resolution images. Inefficient zoom. Weak WiFi signal. Charging port for the TR. Difficult to follow conversations of different students.	Teachers and students have to adapt to the new technology Technical equipment and network are hurdles. Hardware failure. Best sensors require extra expenses.	Cannot use stairs or elevators. Needs an assistance. Unstable internet connectivity. Young children get afraid of TR TR could get damaged by students.
Obstacles & challenges of TR in education	Elevator mobility problem. Risk of misuse of TR. Risk of TR being taken as an excuse.	TR is not embodied. Location tracing. Feeling disabled due to lack of freedom of movement. Problems due to noisy environment. TR freezing.	Technology has its limits.	Privacy issues. Use of third-party devices in the manufacturing. Component replacement poses to be a challenge. External entities are responsible for the maintenance.	TR is perceived only as a technical device and not as a student. Teachers might not want to be filmed. Need of sensors everywhere. Hard to design a low-cost TR. Lack of data protection.
Recommen-dations for TR in education	First come First serve facility to book TR for students. Add hands to the TR.	Make TR more visible. Enhance accessibility. Improve TR reservation process.	Ensure that the device is user friendly.	Develop better sensors. Ensure that service is top notch. Less moving parts. Easy to replace broken parts. Use parts from reliable manufacturers.	Add speech-to-text sw. Add translation sw. Provide automatic following mode. Enable user passwords. Add noise canceling sw.

Technicians from universities and TR companies suggested that the use of 4G/5G over WiFi can provide stable and improved connectivity with TR.. They also expect the technology to become more advanced, especially in the area of noise cancellation. The technicians recommend installing better sensors in TR to increase accuracy. They also suggested increasing the budget to invest in high quality sensors. Telepresence robot components can be planned and produced in such a way that they are easy and quick to repair and replace. One of the suggested solutions is to buy components from a reliable and trusted source after running several compatibility tests. As TR is also to be used by people with disabilities, it is extremely beneficial to include a speech-to-text system. Around the globe, we have multiple languages and not everyone can learn a language. Hence, an integrated translation system will make TR an extremely desirable technology not only in the education sector but open gateways in several other fields. Since educators in particular have concerns about data security and privacy, the addition of a user password will reduce the fear of data compromise among them and allow them to accept the technology with an open-minded perspective. There were recommendations from students and teachers for high-resolution images and video quality, as well as a function to choose whether the video should only be streamed or also recorded. This could also help the TR acceptance since people may feel safe and protected. Better zoom in and zoom out function, compatibility with iOS devices, adding high quality GPS, speaker and microphones devices, and an auto-return feature to charging docks could enhance TR.

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6 CONCLUSIONS

This study conducted 20 interviews about TR in education with students, professors, teachers, technician, and others in Austria, France, Iceland, and U.S.A. The interviewees admitted that TR may provide remote learning, teaching, advising, communication, collaboration, and participation in education. The remote user of the TR feels like being present and belonging to the class. However, the introduction of TR in education faces several problems such as the TR cost, inability to use elevators and stairs, short battery life, need for support staff, long delays in repairing, as well as the inadequate WiFi coverage of schools, noisy environments, privacy concerns, and data security. They made several recommendations such as equipping TR with 4G/5G capabilities, easy-of-use, extra sensors, arms and gesticulation, high-quality microphones, speakers, video recording, displays, zoom in and out, software for obstacle detection, noise cancelation, speech-to-text, translation, auto-navigation, passwords, and compatibility. Users training

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