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A FOCUS GROUP STUDY ON TELEPRESENCE ROBOTS IN EDUCATION

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Abstract

Recently, there is an intensive interest regarding Telepresence Robots (TR). A TR enables audio and visual interaction between its remote driver and persons around the TR. The remote driver feels like be present physically and socially at the location where the TR is moving around. TR have been used in education at all levels. Various communities of stakeholders such as teachers, students, administrators, and support staff are involved in the introduction and adoption of TR in education. In order to effectively integrate TR in education, the views and perspectives of different stakeholders should be taken into account. For this reason, the partners of an Erasmus+ project "TRinE: Telepresence Robots in Education" conducted 13 focus groups discussions across five countries (Austria, Germany, Greece, Iceland, and Malta). A total of 77 persons in schools and universities gave their perspectives regarding TR in education. Each focus group lasted for about 90 minutes. Initially, the participants provided their demographics and their consent to be videorecorded. Then the moderator guided and stimulated the discussions through a series of 25 questions. Participants pointed out mainly the mobility as a strength of TR; the improved remote access, participation, and sense of presence as opportunities for TR in education; the lack of kinesthetics as a weakness of TR; the lack of WiFi everywhere and participants' consent as challenges of TR in education. Then, they made several recommendations such as equip TR with hand-like actuators and sensors for kinesthetics. The results of this study could inform the development of educational policies about the use of TR in education; the required infrastructure in educational institutes; the various educational options for integrating TR in the teaching practice; the required functionalities of TR for successful users' acceptance, and more.

Keywords: Focus Group, Human Computer Interaction, Mobility, Privacy, Remote Learning, Remote Teaching, Sense of Presence, Telepresence Robot.

1 INTRODUCTION

Telepresence robots (TR) are videoconferencing devices on wheels with wireless connectivity that are controlled remotely via a computer, tablet or smartphone. They are equipped with screen, cameras, speakers, microphones, wheels, battery, software, sensors, wireless connectivity, and more. They provide two-way video and audio communication between their remote drivers and the environment around them. The remote driver can control the TR movement, camera and microphone as well as view, listen, and talk with people close to TR.

TR have been used in various environments such as education, elderly and patient healthcare, offices, and factories. More specifically in education, TR have been used at all educational levels: i) Pre-Kindergarten [1]; ii) Elementary/primary school [2,3]; iii) Secondary/high school [4]; iv) University [5,6]. Various communities of stakeholders such as teachers, students, administrators, support staff, manufacturers of robots and others are involved in the introduction and adoption of TR in education. In order to effectively integrate TR in education, the views and perspectives of different stakeholders should be taken into account. However, previous studies examined discrete cases of introducing TR in a specific class or school. For example, each one of the following studies examine a single case of homebound (due to illness) students who use TR in order to attend their class and avoid social isolation [2, 7-13]. In order to overcome this limitation of previous studies, the current study aims at systematically recording the perceptions of various stakeholders at different countries and various educational institutes with regard to the introduction of TR in the teaching practice. Thus, the partners

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of TRinE (Telepresence Robots in Education) Erasmus+ project [14] conducted thirteen focus groups discussions among educators, students, and administration staff of educational institutions (e.g., assistant heads, directors, principals) across Austria, Germany, Greece, Iceland, and Malta.

2 METHODOLOGY

Focus groups are useful tools to capture user viewpoints and perspectives of new technology, especially when this technology is at an exploratory stage and little is still known regarding users' needs and perceptions. Participants in a focus group discussion exchange opinions and viewpoints with may be similar, opposite, diverse or alternative. Through the discussion, they may learn alternative viewpoints of which they are unaware, the advantages of others' viewpoints, and the disadvantages of their own viewpoints. They may ask for clarifications and discuss disagreements. They may question and reflect on their and others' viewpoints, build on others' viewpoints, and develop new insights that they might not have been able to develop independently. In this way more information is created.

There are few previous studies that exploited focus groups as a research method in order to investigate the use of TR in education. Two focus groups (7 to 25 minutes) with 35 classmates of homebound students were investigated in [10]. The authors identified three themes from the analysis of the data: 1) anthropomorphism for social acceptance and normalcy, 2) overcoming isolation to meet socio-emotional needs, and 3) new experiences that generated talk of an academic future. Also, [2] conducted focus groups (5-10 minutes) in two class of 22 students and a homebound child present via a TR. During the focus groups discussions several problems were identified for homebound students (getting attention, participating in class discussions, and moving the TR throughout the school) as well as for classmates (moving the TR in case of lost wireless connectivity or empty battery). Finally, [15] conducted focus group discussions with 15 classmates of children and adolescents with cancer. Sociality was among the themes that emerged from the data analysis. The classmates included the TR as a representative of the child or adolescent with cancer in their social activities. They regarded the TR as if it was a human. Also, they felt that they are supporting the student with cancer when they take care of the TR and they felt her presence when TR is physically placed in the classroom.

This study also employed focus groups to uncover themes concerning the perceptions of educators, students and others with regard to TR in education. We conducted focus group analysis for two primary reasons. TR is a new technology in education and there is not too much experience regarding its use. Although there is a great interest on TR in education, little is known about whether and how TR work in school practice [15,16]. Also, many stakeholders are involved in the introduction of TR in education. So, there is a need for a research method that is suitable investigating a new technology at an exploratory stage and taking into account the viewpoints of many different stakeholders. Note also that in a companion paper [17], TRinE team investigated the views of TR experienced users via interviews in Austria, France, Iceland, and USA.

TRinE project organized thirteen (13) focus groups discussions across five countries. Two authors of this study developed a detailed methodology and a questionnaire to guide the discussions' moderators. They also trained the moderators and explained to them the steps and the questions of the focus group discussions. The focus groups discussions were conducted via videoconferencing during January and February 2022. A total of 77 persons in schools and universities gave their perspectives regarding TR in education. Each focus group discussion lasted for about 90 minutes. The discussion was composed from five distinct phases: 1) Introduction; 2) Short description and examples of TR and TR uses in education; 3) Discussion on the strengths, weaknesses, opportunities, and challenges of TR in education; 4) Discussion on any policies about using TR in education; 5) Conclusions and recommendations.

Initially, all participants were informed about the aim and context of the research study as well as their right to withdraw at any time. Participants signed a consent form and described their profile and demographics data. To ensure confidentiality, their names and other identifying information have been made anonymous while the videorecording was securely saved for a limited time.

Then the moderator gave examples of TR and uses of TR in education. Using PowerPoint presentations with pictures and YouTube videos of TR in education, the moderator gave examples of TR by different manufacturers and various cases of using TR in education. Next, the moderator guided the discussions through a series of 25 questions. These questions were used to stimulate discussion within the focus groups and allowed participants to provide their viewpoints.

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Thematic analysis was used to analyse the focus groups discussions data [18]. Thematic analysis is the process of identifying patterns or themes (patterns of data) that are important or interesting within qualitative data. Data analysis followed the following stages: (1) familiarization with the data following multiple readings of the transcripts, (2) generating initial codes via open coding with the extraction and isolation of verbatim quotes, (3) searching for themes both under the discussion topic and emerging ones based on extracts from the transcripts, (4) reviewing initial codes and identifying any latent themes and then combining into preliminary themes, (5) refining and developing of themes in subsequent iterations, and (6) consolidating further the identified themes under fewer themes.

More specifically, initially, two researchers repeatedly read the discussions' transcripts and assigned codes to sections of the text. Each researcher created a list of codes for the first transcript and then continuously revised it while systematically working on the rest transcripts. Then the two researchers discussed their lists of codes and came to an agreement. During searching for themes, each researcher combined codes into sub-themes and themes creating a hierarchy both within and across all transcripts. Then again, they discussed the hierarchy of themes and sub-themes and came to an agreement. During reviewing themes, they examined the hierarchy of themes and sub-themes against transcripts looking for latent ones or similar ones. During defining and naming themes, they discussed any differences and conflicts in theme generation, and reached to a consensus. Finally, during consolidation of themes, they combined similar themes or sub-themes to the final ones. Based on repeated revisions, some sub-themes were merged while others were split. Similarly, some themes were also merged while others were split.

3 DEMOGRAPHICS

A total of 13 focus groups were held across various educational institutions in Austria, Germany, Greece, Iceland, and Malta (Table 1). These focus groups involved a total of 77 participants, 42.9% of whom identified as male, 42.9% as female, and 14.3% as other. The participants' level of education varied, with 29.9% holding a Bachelor's degree, 41.6% holding a Master's, and 6.5% having a Ph.D. Meanwhile, 20.8% fell in other categories (e.g., secondary level students) and in 1.3 % of cases (1 respondent) the level of education was unknown. Most respondents were under 50.

Each focus group included participants from a range of roles. Professors made up 10.4% of the respondents, with teachers making up 36.4%, and other roles (e.g., managerial staff in education) including a total of 26% of respondents. Over a quarter of the respondents (27%) were students. When asked to self-assess their digital skills, 15.6% reported a low level, 49.4% described their digital skills as medium and 33.8% described them as high.

Table 1. Demographics of the participants.

Country		Austria	Germany	Greece	Iceland	Malta
Gender	Female	7	3	9	5	9
	Male	6	10	0	3	14
	Other	0	0	0	11	0
Level of Education	B.Sc.	4	3	2	6	8
	M.Sc.	5	5	6	10	6
	Ph.D.	0	2	0	2	1
	Other	4	3	1	0	8
	Unknown	0	0	0	1	0
Average Age		n/a	36-49	36-49	n/a	28
Occupation	Professor	0	5	0	0	3
	Teacher	8	0	0	14	6
	Student	0	6	1	4	10
	Administrator	5	2	8	1	4

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Digital Skills	Low	1	0	6	5	0
	Medium	11	4	3	12	8
	High	1	9	0	1	15
	unknown	-	-	-	1	-

4 RESULTS & DISCUSSION

There was a large degree of overlap in the points raised by educators and students as well as in the importance they gave to each point (Table 2). In fact, all groups mentioned similar strengths (mainly ease of use and mobility) and weaknesses (generally being lack of kinesthetics and hand-like actuators, internet connectivity inefficiencies, and cost). More specifically, all three stakeholder groups (educators, students, and administrators) agreed on important TR weaknesses such as dependency on Internet connectivity, lack of kinesthetics, and high cost; on important TR obstacles such as lack of WiFi connectivity in buildings, lack of support, and consent issues; as well as on important recommendations such as give device hand-like actuators and implement sensors for kinesthetics. Furthermore, educators and students agreed on additional important TR strengths such as ease of set up and use and mobility of TR; TR opportunities such as improved access to remote educators and students, improved active participation, increased sense of presence, and increased equality of opportunities; TR weaknesses such as lack of hand-like actuators, inability to physically interact with environment, and poor sound quality; TR obstacles such as reduced human contact and noise in the environment. The differences among the stakeholder groups emerged more in the implications of these strengths and weaknesses for the opportunities and obstacles experienced and envisioned by the participants.

Because TR allows increased mobility, both educators and teachers groups tended to regard TR as a better option to remote teaching and learning than traditional setups including Zoom etc. for flipped classroom experiences, group work, and teacher demonstrations of practical tasks. However, both groups felt that TR was less amenable to frontal teaching as the sharing of whiteboard content and digital presentations would be more feasible using traditional videoconferencing.

Both educators and students highlighted the importance of the ‘increased sense of presence’ offered by TR with participants saying that TR helped make it less easy to ‘forget’ the online learner. However, they felt that the use of TR should be limited to necessity. While acknowledging that TR offered more equal opportunities for people who are physically indisposed due to distance, illness or ill-weather, participants were largely concerned that TR would be ‘overused’, voicing beliefs that the TR experience does not equate to the face-to-face one, at the detriment of the social element as well as the psychological and pedagogical advantages of ‘being able to look into each other’s eyes’. Experienced students also voiced concern that if many learners were online, it would take the humanity away from the learning environment and lead educators to lose motivation.

Table 2. Views of educators, students and administrators.

Themes	Educators’ views	Students’ views	Administrators’ views
Experiences with TR in education	Not familiar with TR; Familiar with, not used TR; <2 years; 2-5 years; 5+ years.	Not familiar with TR; Familiar with, not used TR; <2 years; 2-5 years; 5+ years.	Not familiar with TR; Familiar with, not used TR; <2 years.
Strengths of TR in education	Ease of setup and use; Mobility of device; Ubiquity of tech at remote site.	Ease of setup and use; Moving camera; Mobility of device.	Interactivity; Immediacy.

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Opportunities of TR in education	Improved access to remote educators and students; Improved active participation; Increased sense of presence; Increased equality of opportunities; Facilitates virtual visits from experts; May facilitate a rethinking of education.	Improved access to remote educators and students; Improved active participation; Increased sense of presence; Increased equality of opportunities; Improved grades for online learners.	Increased sense of presence; Flexibility; Increased equality of opportunities; Admin can remotely observe lesson; Improved remote psychological support.
Weaknesses of TR in education	Lack of kinesthetics; Dependency on Internet connectivity; Lack of hand-like actuators; Inability to physically interact with environment; High cost; Poor sound quality.	Dependency on Internet connectivity; Lack of kinesthetics; Lack of hand-like actuators; Inability to physically interact with environment; High cost; Poor sound quality.	Dependency on Internet connectivity; Lighting quality; Lack of kinesthetics; High cost.
Obstacles & challenges of TR in education	Lack of support and information; Navigability Issues; Lack of WiFi connectivity; Limited availability of devices; Noise in the environment; May be disruptive; Reduced human contact; Consent issues; Device vulnerability; Psychological impact.	May be disruptive; Lack of WiFi connectivity; Consent issues; Reduced human contact; Overuse; Lack of support; Resistance to change; Noise in the environment; Infrastructural challenge; Illicit recording is possible; Limited availability of devices; Device vulnerability; Delays in procurement of replacement parts.	Lack of WiFi connectivity; Need user training; Proper lighting; Lack of technical support; Resistance to change; Consent issues; Lack of funding.
Recommen-dations for TR in education	Limit use to necessity; Implement suited methodology; Have clear strategies in place before implementing; Prioritise the human element;	Give device hand-like actuators; Implement sensors for kinesthetics; 3D sound; Facial detection (to disallow the recording of faces);	Implement sensors for kinesthetics; Device needs arm-like appendages; Additional lighting; Seek funding; Educate all involved in

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	Make TR more visible; Assess and act on psychological issues; Implement sensors for kinesthetics; Lower cost; Give device hand-like actuators; Plan the right infrastructure; Meet in-person beforehand.	Not recommended for lecture structure; Implement 'raise hands' functionality; Notification if device is recording/ battery low etc.	adopting institutions.

Table 3 presents the participants' views across the five EU countries. Participants in all countries agreed that TR improves access to remote educators and students. Participants by at least three countries agreed on the importance of TR interactivity and easiness to set up and use as strengths, improved active participation as weaknesses, high cost, lack of kinesthetics and hand-like actuators as weaknesses, as well as limited availability, navigability, and privacy as obstacles.

Table 3. Views of participants in five EU countries.

Themes	Austria	Germany	Greece	Iceland	Malta
Experiences with TR in education	Familiar with, not used TR; <1 year.	<2 years; Familiar with, not used TR.	Not familiar with TR; Familiar with, not used TR.	2-5 years; 5+ years; Familiar with, not used TR.	Not familiar with TR; Familiar with, not used TR.
Strengths of TR in education		Mobility; Interactivity and orientation; Easy to set up and use.	Immediacy; Interactivity.	Ease of setup and use; Interactivity; Mobility.	Ease of use; Student tech needed is ubiquitous.
Opportunities of TR in education	Improved access to remote educators and students; Improved active participation; Allows virtual visits.	Improved access to remote educators and students; Improved active participation.	Improved access to remote educators and students; Flexibility Increased equality of opportunities; Psychological support.	Increased sense of presence; Improved access to remote educators and students; Navigability; Improved active participation; Increases equality of opportunities; Improved grades for online learners.	Improved access to remote educators and students; Allows active participation; Allows remote presence of administrator; Improved active participation; Improved demonstration in practical sessions.

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Weaknesses of TR in education	Lack of haptics; Cost.	Subject to Internet connectivity; Lack of kinesthetics; No hand-like actuators.	Dependency on Internet connectivity; Cost; Need lighting quality; Lack of kinesthetics.	Subject to Internet connectivity; Lack of kinesthetics; Sound quality; No hand-like actuators; Cost; Charging issues.	Cost; No hand-like actuators; Lack of kinesthetics.
Obstacles & challenges of TR in education	Navigability Issues; Limited availability of devices; Larger groups; Device management; Privacy Issues.	Infrastructural challenges; Illicit recordings; Device vulnerability; Navigability Issues.	Lack of funding; Internet connectivity; Limited availability of devices; Proper lighting; Training and technical support; Resistance to change; Consent issues.	Lack of support and information; Class noise; Inability to physically interact with environment; Internet connectivity; Navigability Issues; Limited availability of devices; Overuse.	Limited availability of devices; Students need a physical presence; Consent issues; Device vulnerability; May be disruptive; Psychological impact; Inability to raise hands; Resistance to change; Overuse.
Recommen-dations for TR in education	Limit use to necessity; Implement suited methodology; Keep the human element; Make TR visible; Have a consent strategy; Incorporate AR goggles.	Collision detection; 3D sound; Facial detection (to disallow the recording of faces); Implement with suited methodology.	Implement sensors for kinesthetics; Address lack of 'hands'; Lighting on the robot; Seek funding; Educate all members in adopting institution.	Limit use to necessity; Give device hand-like actuators; Have a booking strategy; Software to be available on all platforms; Educate all members in adopting institution; Meet in-person beforehand; 360^{o}camera tilting.	Have the right strategies in place; Assess and act on psychological issues; Make TR visible; Lower cost; Limit use to necessity; Implement sensors for kinesthetics; Give device hand-like actuators; Implement 'raise hands' functionality; Implement notification if

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	device is recording/ battery low etc.

Experienced students mentioned that moving from traditional remote learning to TR had earned them better grades. Similarly, we can see a slight difference in the feedback from Iceland and, to an extent, Germany, the countries with the highest experience of TR, with more respondents emphasising the impact of sound quality especially in a noisy environment, and the intricacies of manoeuvring the device. Respondents from these countries focussed on practical issues of navigability including detailed considerations like the evenness of the floor etc. Experienced participants also markedly reported having few concerns. This discrepancy between experienced and inexperienced participants, leads one to consider the possibility that some more important points which emerge with experience, are lower down in our list than they deserve to be.

Both educators and students who had experienced TR, mentioned the importance of support, however this was reflected in the concerns and recommendations of inexperienced educators as well. Participants recommended clear strategies for device booking, maintenance, charging and technical support to be in place. Maltese groups mentioned the importance of unions being on board and personnel officially being assigned duties related to device management. Participants also highlighted the importance of the right infrastructure being in place prior to the introduction of TR: including a good internet connection and a classroom set up that allows manoeuvrability.

Educators highlighted the importance of prior training of staff, students, and parents. Educators and students in St Margaret College (Malta), the educational institution with the youngest student demographic, were among those who focused most on issues relating to liability in case of damage and misbehaviour. Respondents from this school also focused on the importance of preparing parents and children for the TR experience psychologically, considering the possible impact on the rest of the class of having a very ill peer join the class regularly.

All groups made similar recommendations about the device itself, mainly involving increasing kinesthetics, giving the device 'hands' and improving sound quality. One group of experienced users also mentioned improving viewing angles. The groups also came up with recommendations regarding obtaining consent for the use of the device, an area in which educators had particularly predicted obstacles. They felt that making TR more visible can increase its acceptability and reduce public concerns about the online educator being less effective and online students having the ability to record the classroom or being less diligent (issues reported by experienced students and teachers in particular).

Educators focused a lot on TR methodology. Most educators emphasised that when TR is implemented, the human element should be emphasised with one group noting for instance that avatars on TR should not be allowed as they reduce human element. Some groups felt TR would not be suitable for young children who need the physicality of the classroom more. Many felt that TR in itself does not solve the fundamental problems of education, however participants appreciated its utility in flexible, student-centred remote teaching. One Maltese respondent insisted that TR can help redefine education, as online schooling becomes an option for all who would opt for it.

5 PRACTICAL IMPLICATIONS

Based on the empirical data obtained in the (semi-) structured interviews and the focus groups we identified the following beneficial use cases for TR in educational settings:

- Seamless virtual and physical access to education:

  The feedback received from the focus groups and interviews showed that many participants believe that TR mainly can facilitate students, teachers, and experts to participate in a class from distance. As advantages of the technology itself, educators and students mainly mentioned the possibility to bridge long distances, for example, when academic chairs are located in other cities or countries, or when one wants to spontaneously switch between two locations. In this respect, telepresence robots cut travel time to a minimum.

- Better inclusion for ill or otherwise disabled students:

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Moving around the room and having a much more present avatar compared to normal screens gives participants a sense of immersion and takes away the feeling of not being part of a social group. However, participants see this as an advantage not only for themselves as users; it was often mentioned that especially children who have the limitation of not being able to leave the house could be part of a class community again through the robots. This also applies to temporary illnesses and absences. Limitations such as bad audio and video quality, a narrow point of view as well as instable WIFI signals need to be taken into consideration when implementing this use case.

- Improved demonstration in practical sessions and/or in laboratory settings:

  Another interesting point was that telepresence robots have a high potential to make it much easier to work in laboratories and to collaborate in hands-on workshops for (distant) students. This setting would however require a telepresence robot to have more capabilities to perform gestures and to have a much more enhanced manoeuvrability to navigate around obstacles.

It can be assumed that future telepresence robots will therefore differ significantly from those of today. In addition to changes to the robot's appearance to give it a more human look and thus to make it more immersive and to prevent vandalism, work is also being done on mechanisms that will enable TR to open doors and to operate elevators. General improvements of the audio and video quality, as well as the integration of interfaces for videoconferencing providers further simplifies the interaction with the telepresence robot for the user. Future developments could also include software that can translate simultaneously. The main actors regarding the use of TR can be categorised into two main categories: technology users and technology providers next to special roles (see Figure 1):

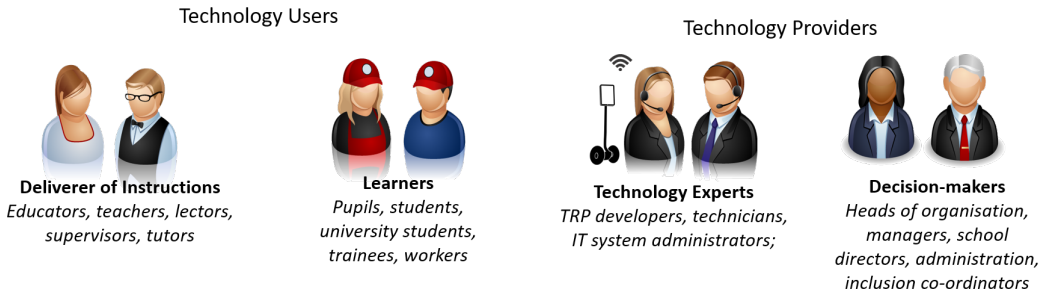

Figure 1. Main actors in the context of the educational use of TR

6 CONCLUSIONS

Overall, the widespread deployment of telepresence robots still requires some changes to the technology and appropriate preparation of the subsequent environment. However, the general attitude toward TR emerged through the focus groups and interviews as primarily positive and confident, indicating that the integration of telepresence robots in the teaching environment is being observed with curiosity and is generally seen as useful. The results of our study should serve as an encouragement for future research on this technology.

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