Lessons Learned 5, 2 (2025)
Submitted: October 1, 2025
Accepted: November 25, 2025

DOI: https://doi.org/10.25369/ll.v5i2.107
ISSN: 2749-1307

Distance learning – local participation: Telepresence systems in medical education

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Abstract

Telepresence robots (TPR) allow students to participate actively in medical education despite physical absence. Compared to purely online teaching, they enhance social presence by enabling controlled mobility and interaction in discussions and group work.
Within the virTUos project, TPR were used at the Medical Interprofessional Training Center (MITZ) of the Dresden Faculty of Medicine in seminars and compulsory courses. Students valued the independent control and direct interaction with teachers and peers. However, technical issues such as unstable Wi-Fi, limited fields of view, and audio-video delays occurred.
As a complementary solution, a pan-tilt-zoom (PTZ) camera system was developed. Although not mobile, it proved to be more stable and cost-effective.
Overall, telepresence systems support equal opportunities and are particularly suitable for practice-oriented learning. Their effective use depends on reliable infrastructure, clear guidance, and active support from teachers and students. TPR therefore represent an inclusive tool with potential beyond medical education.

Telepräsenzroboter (TPR) ermöglichen Studierenden eine aktive Teilnahme an der medizinischen Lehre trotz physischer Abwesenheit. Im Vergleich zur reinen Online-Lehre erhöhen sie die soziale Präsenz durch steuerbare Mobilität und Interaktion in Diskussionen und Gruppenarbeiten.
Im Projekt virTUos wurden TPR am Medizinischen Interprofessionellen Trainingszentrum (MITZ) der Medizinischen Fakultät Dresden in Seminaren und Pflichtveranstaltungen eingesetzt. Geschätzt wurden die selbstständige Steuerung sowie der direkte Kontakt zu Lehrenden und Mitstudierenden. Gleichzeitig traten technische Probleme wie instabile WLAN-Verbindungen, eingeschränkte Sichtfelder und Ton-Bild-Verzögerungen auf.
Ergänzend wurde ein Pan-Tilt-Zoom-(PTZ)-Kamerasystem entwickelt, das zwar nicht mobil, aber stabiler und kostengünstiger ist.
Insgesamt fördern Telepräsenzsysteme die Chancengleichheit und eignen sich besonders für praxisnahe Lehrformate. Voraussetzung sind eine zuverlässige Infrastruktur, klare Einweisungen und die aktive Unterstützung durch Lehrende und Studierende. TPR sind damit auch über die medizinische Ausbildung hinaus ein inklusives Instrument.

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1. Background

Attending classes is a central part of studying—both for acquiring specialist knowledge and for building social contacts. However, students cannot always be physically present for various reasons, e.g., acute or chronic illness, maternity leave, childcare, or limited mobility. Longer or repeated absences can delay the course of study. Universities are therefore faced with the challenge of integrating learners into everyday student life despite physical distance and enabling social and academic participation. Purely digital distance learning only partially meets these requirements: although it provides access to content, it reduces social presence and can thus weaken learning outcomes and the mental well-being of students. This problem became particularly apparent during the coronavirus pandemic: almost 80% of students said they missed personal interaction with fellow students, and 63% reported a lack of contact with teachers [1]. Restrictions on everyday university life not only affected academic aspects, but also social identity, mental health, and quality of life [2].

Fig. 1: Telepresence robot (TPR) at the Medical Interprofessional Training Center (MITZ).

This is where telepresence robots (TPR) come in. They represent a promising technological advancement over traditional video conferencing systems: mobile devices equipped with a webcam, microphone, speaker, and screen that can be controlled remotely by another person. This allows students to not only follow the content despite their physical absence, but also to actively and interactively participate in class [3]. Unlike conventional systems, TPR enable a higher level of social presence: thanks to their mobility and visibility, the remote operators are more closely involved in the teaching situation and can participate in the action independently, albeit to a limited extent. This creates a more intense feeling of "being there" and participation, which is particularly relevant for longer periods of absence. A key advantage is self-control: students can navigate the robot themselves in the room and decide where to focus their attention. This promotes autonomy and interaction beyond the mere reception of content. Particularly valuable is the ability to move around in discussion groups, make eye contact, and participate in informal exchanges with fellow students—aspects that traditional video conferencing can hardly replicate.

Research confirms the potential of this technology. University staff and students rate its use as overwhelmingly positive, especially in terms of inclusion, interactivity, and social presence [3, 4]. Positive experiences with TPR can also be observed in other areas of education: for example, children with cancer were able to continue attending classes during their treatment and avoid social isolation with the help of these devices [5]. Chronically ill, homebound children in the US were also able to actively participate in school life in this way [6].

These examples illustrate that TPR can make a valuable contribution when participation is not possible. Against this background, the Medical Interprofessional Training Center (MITZ) of the Carl Gustav Carus Faculty of Medicine (MFD) investigated the extent to which this technology can also be used in university teaching—especially in medical education—as part of the virTUos project at the Carus Teaching Center (CarL).

2. Project development

Relevance of the manufacturer for the selection of the TPR

Trust in the technical solution played a central role in the selection of the robot model used. A paper by "Hu" and colleagues emphasizes that this is a basic prerequisite for the acceptance of TPR in university teaching [7]. It is particularly relevant because sensitive data such as audio and video transmissions are processed during use. Compliance with data protection regulations was therefore a mandatory criterion for our institution. Specifically, this meant that server service providers had to be subject to the GDPR or, alternatively, end-to-end encryption of all transmitted data had to be guaranteed. Only providers who could ensure these framework conditions technically and organizationally were considered for use.

Model selection and technical specifications

We decided to use the UBBO Expert from AXYN Robotique because it meets data protection and security requirements and also impresses with its technical features.

The UBBO Expert as a TPR (approx. 1.60 m high, 21 kg weight) is equipped with:

- 13.3-inch HD touchscreen
- Movable camera with large pan/tilt range
- LED panel for nonverbal signals
- Stereo speakers and microphone for bidirectional interaction
- Three wheels (two motorized), cornering and turning on the spot
- Browser-based control (PC, tablet, smart-phone), no additional software required
- Speed: up to 1 m/s, battery life approx. 8 hours
- Step and collision sensors
- 4G-enabled for independent operation of Wi-Fi

Close contact with the manufacturer proved to be crucial for successful deployment. Technical problems could be quickly resolved on site and questions answered directly. This not only increased availability in teaching operations, but also strengthened confidence in the data security and reliability of the solution.

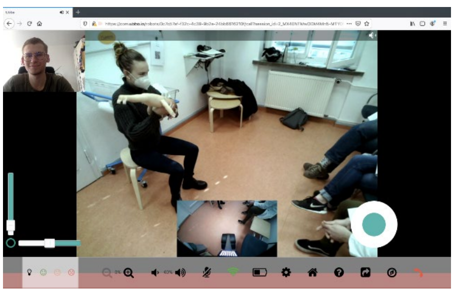

Fig. 2: Screen view of a participant

Integration into various learning scenarios

UBBO Expert was first used in peer teaching formats in rotation training at MITZ, including practical and communication stations. The training comprised full-day sessions in several rooms and on several floors, allowing students to experience different learning environments. In small groups of about six people, the robot was used specifically for students who were unable to participate physically or organizationally – for example, due to mobility restrictions, illness, pregnancy, or childcare.

Fig. 3: TPR in the practical teaching unit on transfusion at MITZ.

In addition, TPR was tested in seminars, internships, and compulsory courses in human medicine, including anatomy, physiology, virology, nuclear medicine, radiation therapy, and communication seminars. In these settings, the robot enabled the remote-controlling students to actively participate in discussions, group work, and practical exercises, to work on learning content, and to ask direct questions. This also facilitated spontaneous conversation between students in small groups.

Particular challenges arose with larger groups, room changes, and floor transitions, as the robot has a limited field of vision. There were also difficulties in overcoming small thresholds. Technical problems such as audio/video latency, Wi-Fi disconnections, and limited zoom and camera resolution were observed, but these were partially offset by targeted support, alternative streaming solutions (e.g., Zoom), and the use of mobile data connections.

Fig. 4: TPR in the virology lab practical.

Briefing participants, attendees, and lecturers using TPR

To ensure the smooth use of TPR, participants received specific instruction in advance. Basic information was provided by email and included:

- Quick start guide for dialing in and operating TPR
- Technical requirements
- Tips for effective communication via TPR
- Schedule information
- Alternative communication channel in case of TPR failure (e.g., the TU-hosted chat platform Matrix Elements)

A brief introductory meeting was held before the start of the course. Technical functions were tested, volume was adjusted, and participants were familiarized with the driving dynamics of the TPR.

Attendees and instructors were also informed about the use of the TPR. Special attention was paid to changing rooms and floors, as this often causes problems: the robot's limited field of vision makes orientation difficult, and the connection can be interrupted when changing Wi-Fi access points or using the elevator. Those present were trained to actively support the TPR, e.g., by avoiding collisions or facilitating elevator use. At the same time, communication, helpfulness, and inclusion were discussed. The tutors received additional tips on integrating the TPR into lessons, particularly on task distribution and active involvement in discussions.

Intensive support and observation protocols

During the pilot phase, individual support for each participant was necessary due to a lack of reliable data on technical reliability. Systematic observation protocols were kept during this phase. Important findings included the following:

- The LED display of the TPR was rarely used.
- The TPR shows difficulties in overcoming thresholds.
- The limited response time due to latency restricts interaction in teaching scenarios with fast question/answer rhythms.
- Students position the TPR specifically to keep tutors and relevant points of interest optimally visible.
- Frequent queries about transmission quality were observed.

PTZ system as a supplement

Based on these observations, an alternative system was developed that is based on a PTZ (pan-tilt-zoom) camera. In combination with a Windows laptop, the "Zoom" video conferencing software, a compact conference audio system, and two power banks, the system functions as a mobile video conferencing setup. Mounted on a rollable table, the system remains flexible in terms of location, while the autonomous driving function is omitted in favor of technical stability. The remote-controlled axis alignment can be used by participants via the "Zoom" feature "far-end Camera Control."

Fig. 5: Setting up a PTZ system on a mobile table.

The PTZ system uses inexpensive standard components that can be flexibly exchanged or expanded. It can be easily adapted to different teaching and room configurations. The manufacturer-independent design in terms of hardware and software facilitates further development and avoids dependencies on individual suppliers.

3. Evaluation results

Evaluation of TPR use

The use of TPR was evaluated in all participating groups – students, lecturers, and participants in external events. Participation was rated positively by the majority: around 79% of participants rated the opportunity as "good" to "very good." The main reasons for use were illness, quarantine/isolation, physical distance, or childcare responsibilities. The TPR was found to be intuitive to use; short test runs or briefings in advance were rated as helpful.

Fig. 6: LEGO® ramp for overcoming thresholds.

Technical problems occurred in about one-third of cases, in particular Wi-Fi disconnections, sound problems (reverberation, echo, motor noise), image quality issues, and control delays. These could usually be resolved by restarting the system or with support from teachers/technical staff. Those present reported that communication worked well for the most part, especially in small groups or quiet conversation situations. Challenges arose when several people spoke at the same time. Barriers such as small thresholds or steps were overcome by specially made LEGO® ramps, which were individually adjusted to the height of the respective steps.

The use of TPR enabled students to actively participate in discussions, group work, and exercises, work on learning content, and ask direct questions despite their physical absence. Suggestions for improvement related to sound/video quality, (optical) camera zoom, more stable Wi-Fi connections, more sensitive controls, and short test runs before the event.

Advantages and disadvantages of the systems used

As part of the evaluation, the characteristics of the TPR/PTZ systems were compared. This revealed different strengths and weaknesses that should be taken into account when choosing the appropriate system for teaching courses. Table 1 in the appendix provides a compact overview of the most important advantages and disadvantages of both systems.

Handouts for TPR/PTZ in OER

During the pilot phase, instructions for using the systems were created. These include step-by-step instructions for preparing, setting up, operating, and maintaining the systems, including information on technical configuration and the use of mobile connections. The materials are designed to be practical in order to support teachers and students in their use. All instructions are available on the OER platform Twillo and can be freely accessed, downloaded, and adapted for your own teaching.

Fig. 7: QR code for the Twillo telepresence collection.

Exchange with the Veterinary Medicine Department in Leipzig

As part of the dissemination process, an interdisciplinary exchange took place with the Faculty of Veterinary Medicine at the University of Leipzig.

Fig. 8: TPR in veterinary medicine in Leipzig.

TPR was used in the slaughterhouse, sausage factory, and seminar rooms. Students rated their participation via TPR as predominantly positive; image and sound quality were rated as good, and communication was largely equivalent to face-to-face situations. Limitations arose in particular with navigation and dealing with hygiene requirements.

Conference contributions

The experiences were systematically documented, published, and disseminated via specialist networks. The publication "Practical teaching goes digital – are we all on board?" [10] shows that telepresence not only enables digital teaching formats, but also specifically promotes equal opportunities and participation. The results were presented in several lectures, poster contributions, and on e-teaching.org, which enabled interdisciplinary exchange and practical implementation in various departments.

The results were also presented in several national and international lectures. These include "Lessons Learned 2021" [11], the 2022 annual conference of the Society for Medical Education (GMA) [12], and the 2024 Human and Computer Conference under the title "Telepresence in Medical Education – From the Path of Participation for the Disadvantaged to the Benefit for All." A poster presentation at the 64th Working Conference of the DVG's "Food Safety and Consumer Protection" working group in 2024 dealt with the use of TPR specifically in the veterinary context and highlighted its practical implementation and evaluation.

In addition, the findings were published on the e-teaching.org platform under the title "Hybrid Teaching Concepts with Telepresence Robots" [13]. As part of the "Digital Inclusion Network Meeting," an interdisciplinary exchange took place in which the participation of different departments in teaching through telepresence systems was discussed. This variety of formats not only promoted scientific discussion, but also strengthened the direct practical relevance: teachers gained insights into possible applications, technical requirements, and didactic integration, while students benefited from improved access to teaching.

4. Discussion

The evaluation of the use of TPR in medical teaching shows a mixed picture: on the one hand, experience confirms the great potential of the technology, but on the other hand, significant technical and organizational challenges are becoming apparent.

Limitations of the evaluation

Our evaluation is not without limitations: the sample was limited, participation was voluntary, and the feedback may have been influenced by positive expectations of the innovative technology. In addition, long-term effects and the sustainability of the use were only indirectly recorded.

Proven and less proven aspects of the TPR system

The use of the TPR system showed both clear advantages and some challenges. Particularly positive is the participant satisfaction: students who used the TPR rated their experiences as 100% positive, and 57.1% also found its use to be a relief. Despite physical separation, a sense of involvement was also successfully conveyed, as users reported being actively involved in the proceedings. Another success factor was didactic integration: targeted training and embedding of the technology in the teaching processes proved to be crucial for learning success.

Some technical and organizational aspects were less convincing. Over 75% of TPR users and 83% of those physically present reported technical problems, such as poor sound quality, connection interruptions, or operating difficulties. In addition, acceptance among those present was rather reserved. They found the technology disruptive. Finally, the PTZ system proved to be a very good alternative to a mobile TPR despite its limited mobility, thanks to its excellent image and sound quality, especially for teaching situations where mobility is less crucial.

Comparison with the literature

Our observations are largely consistent with the existing literature. As Ahumada-Newhart and Olson (2019) [6] report, they also encountered technical problems, including unstable Wi-Fi connections, connection interruptions, and difficulties with navigation, control, and interaction. Participants and teachers sometimes had to intervene to provide support.

In addition, our evaluation results confirm the statements of Trittin & Blumenthal (2024) [8]: TPR increase social presence, enable the participation of students with limited mobility, and promote interaction compared to video conferencing, but still lag behind face-to-face teaching. Stable technology, the active involvement of remote participants, and didactic measures such as clear objectives and hybrid group work are crucial for successful implementation.

The training and preparation of teachers and students proves to be a critical interface between potential and practical implementation. Leoste et al. (2022) [9] show that although TPR is predominantly rated positively in terms of social presence, inclusion, and interactivity, there are also hurdles such as high costs, technical problems, and lack of experience. Targeted training, investment in infrastructure, and further research are necessary to fully exploit the potential of TPR in a higher education context.

5. Conclusion

The use of TPR enables students to actively experience medical education despite their physical absence. This principle of hybrid participation can be transferred to many other degree programs, especially those that focus on practical exercises or group work. Another key aspect is the do-it-yourself approach with freely selectable software: the use and further development of freely accessible systems, such as the PTZ system via Zoom, allows even smaller institutions to introduce hybrid teaching formats without the need for high investments in proprietary systems. Finally, the project demonstrates clear transferability to other subjects: initial experiences with telepresence systems in mechanical engineering show that the concept is relevant far beyond medicine and can be adapted for laboratories, practical training, or practical exams, for example.

It should be particularly emphasized that the willingness of lecturers and students to participate already plays a significant role in the success of such projects and is of great importance for the successful implementation of hybrid teaching formats. Overall, experience shows that telepresence systems are a sustainable, inclusive, and practical tool that can increase equal opportunities in medical education and effectively support innovative teaching formats.

Technology alone does not create participation – didactic concepts, technical support, and the conscious use of hybrid attendance are crucial.

Acknowledgements

We would like to express our special thanks to our former colleague Anne Röhle, whose commitment, expertise, and valuable intellectual contributions have contributed significantly to the success of the project. We would also like to thank Gustavo Barrios Berlioz for his valuable support.

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Appendix

Table 1 Comparison of the TPR and PTZ systems based on various criteria

Criteria	Telepresence Robot (TPR) (Modell: Ubbo von Axyn Robotique)	PTZ-System
Mobility	Autonomous; students can move independently in the room; limited navigation when obstacles are present	No autonomous movement; mobile only via a rolling cart
Interaction	High level of interaction and informal exchange	Limited interaction; high degree of informal exchange
Operation	Intuitive, often "one-click"; short introduction required	Setup required; active configuration necessary
Technical Stability	Dependent on WiFi; audio/video latency possible	Technically stable; fewer connectivity issues
Audio /Video Quality	Good; insufficient for highly detailed visualization	Very good; very well suited for detailed visualization
Flexibility /Customization	No custom modifications possible due to closed system	Modular, manufacturer-independent, easily expandable
Support Effort	High (training, technical support)	Lower
Data Protection	European servers, compliant	Local control, compliant
Costs	Higher; specialized system	More affordable; standard hardware usable
Practical Exercises	Limited comparability to in-person presence	Not mobile; therefore, limited direct participation in exercises
Special Features	All-in-one software incl. control; limited multi-user support	Remotely controllable camera ("far-end control"); individually replaceable components