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# Head-Mounted Cameras in Virtual Clinical Learning

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## ABSTRACT

**Background:** Clinical workplace learning was severely disrupted during the COVID-19 pandemic because of social distancing measures. In response, we developed a Virtual Clinic using head-mounted cameras to preserve authentic patient contact and clinical team interaction for medical students. Our aim was to create virtual teaching activities that allowed participation in real-time patient care and facilitated peer learning and feedback.

**Approach:** The Virtual Clinic was established in a separate space with live video connections to the hospital ward. Students rotated between wearing head-mounted cameras during rounds, teaching visits and consultations, whereas peers observed remotely in small groups. Educational design was informed by principles of authentic and active learning strategies. Remote students contributed through discussion, documentation tasks and peer feedback.

**Evaluation:** Twenty-seven medical students participated in the Virtual Clinic during their internal medicine clerkship. Data were collected through 37 Likert-scale items and 13 open-ended questions. Students reported that Virtual Patient Rounds and Virtual Teaching Visits were both engaging and intellectually stimulating. Despite remote engagement, students reported a strong sense of integration within the medical team. Limitations included occasional connectivity issues.

**Implications:** This innovation supported continued clinical education during pandemic restrictions while fostering student autonomy and team integration. The approach is transferable to other disciplines and contexts, such as interprofessional or global health education. Key lessons include the potential for virtual bedside learning beyond COVID-19.

## 1 | Background

Clinical workplace learning involves teaching and learning in a clinical environment focused on patients and their problems [1]. Traditionally, the final stages of medical training for students occur in the workplace where learning activities are directly related to patient care and interprofessional collaboration with nurses and physicians. However, the COVID-19 pandemic disrupted clinical medical training, as distancing measures limited physical interaction with patients, physicians and fellow medical students. All over the world, institutions rapidly adopted videoconferencing, online case-based discussions, telesimulation and teleconsultations to replace in-person clinical education. Although these ensured educational continuity, they often lacked immersion, direct patient interaction and meaningful engagement with the healthcare team [2, 3]. Some institutions experimented with 'virtual clinics' using static cameras or remote access to clinical environments, but these were typically focused on procedural training, limited to preclinical or postgraduate education or lacked interactive components [4–6]. A promising but still underutilized strategy involves real-time point-of-view (POV) streaming through wearable cameras to simulate authentic bedside experiences for remote learners [7, 8].

In an attempt to preserve authentic patient contact and clinical team interaction for medical students, we developed a Virtual Clinic using head-mounted cameras to livestream clinical

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encounters from a first-person perspective [9]. Our aim was to create virtual teaching activities that allowed participation in real-time patient care and facilitated peer learning and feedback to recreate the key aspects of clinical learning: exposure to real patient encounters, interprofessional collaboration and structured peer feedback. Through the head-mounted cameras, we were able to simulate the bedside experience and allow students to participate remotely in clinical encounters.

> "*We developed a Virtual Clinic using head-mounted cameras to livestream clinical encounters from a first-person perspective.*"

## 2 | Approach

Authentic and active learning strategies were integrated in the design of the learning activities to foster learner engagement and effective clinical training. The Virtual Clinical creates a realistic educational environment that combines technology with an authentic learning approach. Such an authentic learning environment not only promotes students' knowledge and skills but can also support the effective transfer of skills to the clinical workplace [10]. Discussion of problems and differentials is made possible by an interactive connection between the on-ward students and their peers. This enables an active and constructive learning experience that can improve student motivation, knowledge, critical thinking and problem-solving skills [8, 11, 12].

To replicate authentic bedside learning during physical distancing, first-person POV live streaming was used through head-mounted cameras (Image 1). One or two students participated in clinical care on the ward while wearing the camera, and peers joined remotely from the Virtual Clinic via a live stream, with two-way audio enabling interaction with patients and the medical team. The ward-based student engaged autonomously in patient care, whereas peers learned through observation, reflection and peer feedback.

**IMAGE 1** | Medical student interacting with a patient while wearing a head-mounted camera, enabling remote viewers to observe the clinical encounter.

> "*Students participated in clinical care on the ward while wearing the camera and peers joined remotely.*"

Three virtual teaching formats were developed:

- Virtual rounds: One student of the group wearing a head-mounted camera participates in the patient rounds together with the nursing staff and a clinical teacher, whereas the remote students fulfil administrative tasks such as patient debriefing, ordering laboratory and radiological exams, and peer consultation of other specialties if needed. The students who were remotely present have the possibility to ask questions to the patient or the medical team on the ward.
- Virtual teaching visit: One or two students take a patient history and perform a physical exam while being observed by a supervisor and their remote peers. The remote students have the possibility to ask additional questions to the patient or the medical staff present. Afterwards, the on-site students reflect on their clinical skills and receive feedback from their supervisor and peers.
- Virtual consultation: After reading the electronic medical records, one student visits a patient on the ward and performs a consultation. The supervising doctor watches the consultation remotely through a live stream but does not interfere. Afterwards, the student and supervisor discuss the case, and the student receives feedback.

## 3 | Evaluation

To evaluate the innovative learning activities using head-mounted cameras, a paper-based questionnaire was filled out by the students at the end of their clerkship. A 37-item questionnaire—including Likert-scale questions (1 = completely disagree to 5 = completely agree)—assessed satisfaction, educational and technical value, perceived challenge and involvement in the treatment team during the Internal Medicine clerkship and the Virtual Clinic. It also included items on the potential of virtual learning as an alternative to in-person clerkships. All participants provided written informed consent before taking part in the study. The protocol of this study was approved by the Educational Research Review Board of the [anonymized] on 12-05-2021 (reference number: OEC/ERRB/20210511/1).

All 27 clerkship students who participated in the Internal Medicine Virtual Clinic between May 2021 and July 2021 completed the questionnaire. Not every student participated in each learning activity, and some students participated in more than one learning activity. The number of evaluations received per learning activity is depicted in Figure 1.

### 3.1 | Virtual Patient Rounds

During the Virtual Patient Rounds, students found the experience to be satisfactory and challenging (Figure 2). Scores for the technical aspect were lower because of connectivity issues. In their

written feedback, students expressed appreciation for the virtual format despite COVID-19 measures and provided a more accessible and alternative way to practice patient rounds. Suggestions for improvement included increasing interaction and involvement: 'sometimes there was little interaction if you joined virtually, try to make it more interactive' and 'ask the student more challenging questions so they would feel more involved'.

### 3.2 | Virtual Teaching Visits

For the Virtual Teaching Visits, students reported feeling satisfied and appreciated the educational value of the activity (Figure 3). Most students felt part of the medical team despite being remote. From narrative responses, we learned that students thought the virtual teaching visit to be a good alternative to a regular teaching visit, in which they could observe and provide feedback to each other and discuss the patient case extensively. Positive feedback highlighted the opportunity to ask questions, the interactivity, immersion in a patient and their illness, active participation in clinical reasoning, receiving one-on-one feedback from a consultant and learning from each other by observing and providing feedback.

> "*Most students felt part of the medical team despite being remote.*"

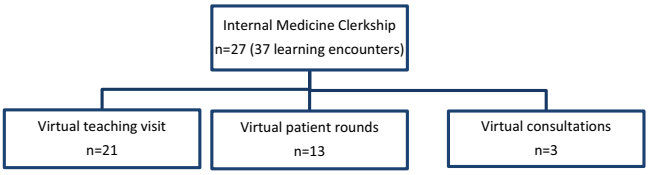


**FIGURE 1** | Flowchart of study participants with number of evaluations per learning activity.

### 3.3 | Virtual Consultations

Because of scheduling issues, only three students participated in Virtual Consultations with a patient. This feature turned out to be very dependent on the commitment of the supervisor. Students who participated shared feedback such as 'increased exposure to new and interesting cases'. Again, technical and connectivity issues were mentioned as points of improvement.

### 3.4 | Overall Scores on the Virtual Clinic and the Clerkship

Students generally expressed high satisfaction with the Virtual Clinic, appreciating its educational value and the level of challenge it offered (Figure 4). Although the Virtual Clinic was seen as a

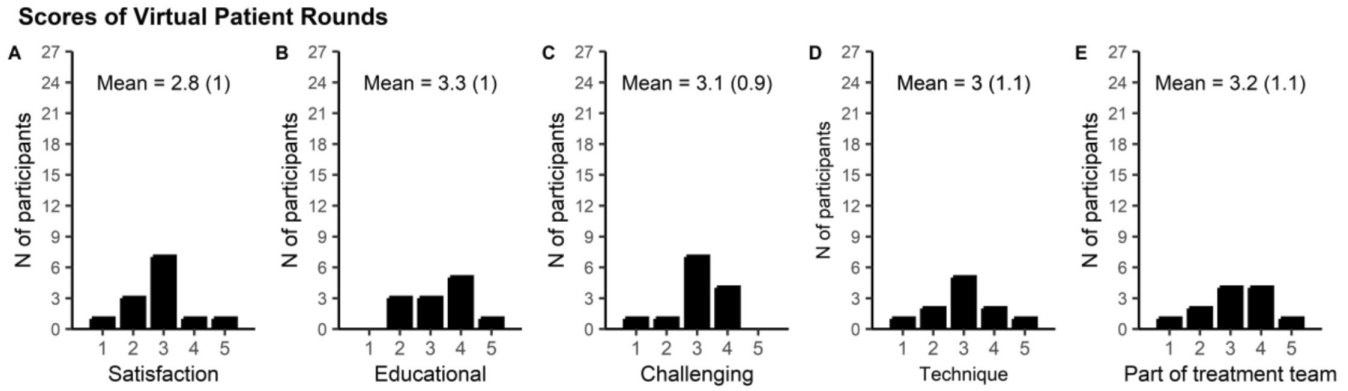


**FIGURE 2** | Evaluation of virtual patient rounds. The y-axis depicts the number of participants. The X-axis shows Likert scale scores ranging from 1 (*completely disagree*) to 5 (*completely agree*) for different domains mentioned in Tables A, B, C, D and E, respectively. Mean scores are reported including standard deviation in brackets.

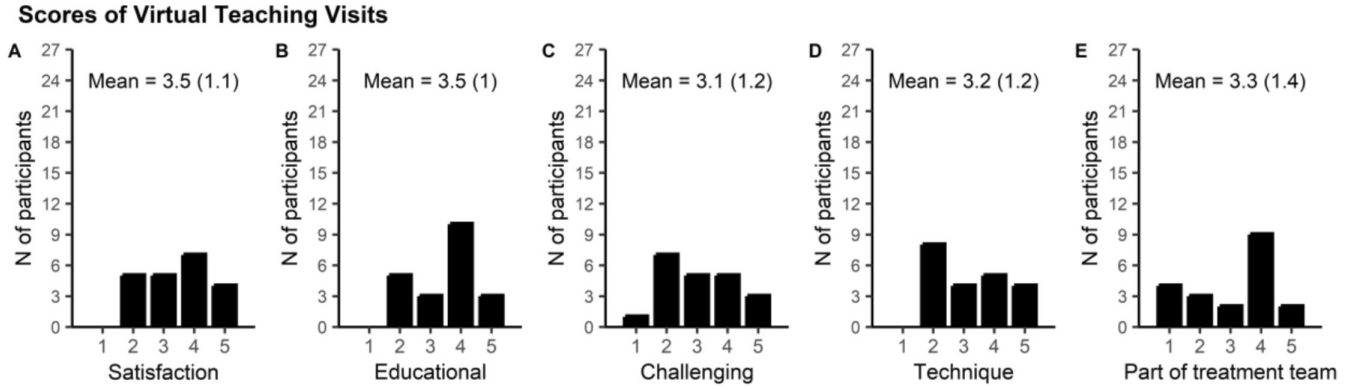


**FIGURE 3** | Evaluation of virtual teaching visits. The y-axis depicts the number of participants. The X-axis shows Likert scale scores ranging from 1 (*completely disagree*) to 5 (*completely agree*) for different domains mentioned in Tables A, B, C, D and E, respectively. Mean scores are reported including standard deviation in brackets.

valuable addition, students remained neutral about its potential to fully replace in-person clerkship experiences (Figure 5). Opinions were divided on whether the format contributed sufficiently to their learning goals and opportunities for feedback. Although face-to-face interaction remained the preferred mode of learning, students noted clear advantages to the virtual teaching visits, such as the opportunity for focused feedback, a quieter and safer environment for patients and more time for post-encounter discussion.

## 4 | Implications

Our evaluation shows that head-mounted cameras can successfully preserve authentic patient contact and clinical team interaction for medical students in virtual clinical settings. Although originally implemented in response to COVID-19-related restrictions, this innovation remains highly relevant for current clinical education.

The approach supports safe and scalable patient-based learning, particularly in situations where bedside teaching is difficult to organize, such as in large groups, interprofessional contexts or settings with limited teaching capacity. It ensures access to meaningful clinical experiences for all students, regardless of location or rotation schedules. Key lessons from our implementation include the need for reliable technical support and stable network connectivity, which are essential for maintaining interaction quality between students, teachers and patients.

> "*The approach supports safe and scalable patient-based learning, particularly in situations where bedside teaching is difficult to organize.*"

Although bedside teaching remains the preferred method of clinical education because of its hands-on nature and direct patient interaction, the use of head-mounted cameras provides a valuable alternative in situations where bedside teaching is not feasible. Importantly, this model is not merely a workaround for exceptional circumstances. It adds lasting value to the clinical teacher's toolkit, enabling new forms of engagement, flexibility and inclusion. Specific applications currently being explored include the following:

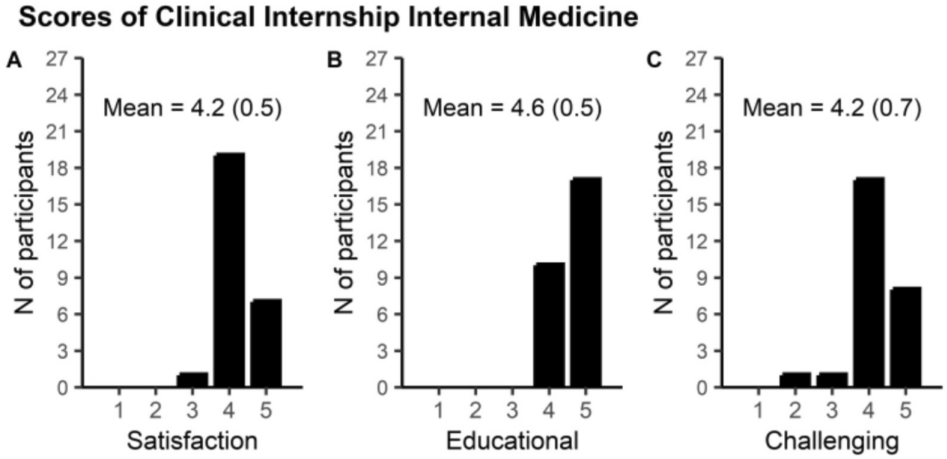


**FIGURE 4** | Evaluation of clinical internship in internal medicine. The y-axis depicts the number of participants. The X-axis shows Likert scale scores ranging from 1 (*completely disagree*) to 5 (*completely agree*) for different domains mentioned in Tables A, B and C, respectively. Mean scores are reported including standard deviation in brackets.

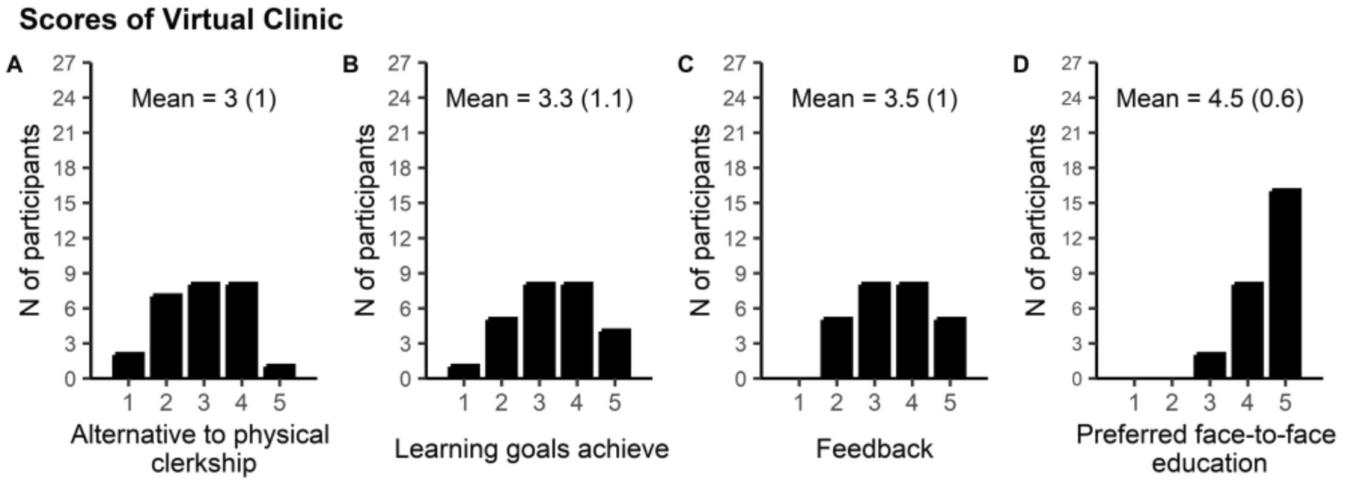


**FIGURE 5** | Evaluation of the virtual clinic. The y-axis depicts the number of participants. The X-axis shows Likert scale scores ranging from 1 (*completely disagree*) to 5 (*completely agree*) for different domains mentioned in Tables A, B, C and D, respectively. Mean scores are reported including standard deviation in brackets.

- Large group sessions: Virtual sessions allow more students to access consistent, high-quality patient encounters simultaneously.
- Interprofessional education: Virtual rounds that include nursing and allied health students alongside medical students promote a more collaborative, team-based approach to learning.
- Cross-institutional learning: Remote teaching visits enable clinical training across different hospitals and institutions, fostering collaboration and exchange of expertise between healthcare settings.
- Global health education: The model is being expanded to allow live participation in international clinical settings, offering students exposure to diverse healthcare environments and practices.

By expanding the Virtual Clinic model beyond its initial use during the pandemic, we can offer flexible, inclusive clinical training opportunities that support diverse learner needs. We are committed to further research on the long-term impact on learning outcomes and the integration of this model into regular curricula, particularly as it complements traditional bedside teaching in medical education.

## 5 | Curriculum Context

In the Master's program in Medicine at Leiden University Medical FdCenter (LUMC), students begin their clinical training with an introductory clerkship, followed by a clerkship in internal medicine and related specialties. This internal medicine clerkship serves as the first substantive clinical placement in the curriculum. The learning objectives include developing core skills in clinical reasoning, patient communication and physical examination within the context of hospital-based care.

### Author Contributions

**Tessa A. Mulder:** investigation, conceptualization, formal analysis, writing – review and editing, writing – original draft. **Soufian Meziyerh:** investigation, conceptualization, formal analysis, writing – review and editing, writing – original draft. **Argho Ray:** writing – review and editing, supervision. **Arianne D. Pieterse:** writing – review and editing, supervision. **Johannes W. de Fijter:** writing – review and editing, supervision. **Peter G. M. de Jong:** writing – review and editing, methodology, supervision, conceptualization. **Floris M. van Blankenstein:** writing – review and editing, methodology, supervision, conceptualization. **Esther C. Hamoen:** writing – review and editing, methodology, supervision, conceptualization.

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The authors have nothing to report.

### Conflicts of Interest

The authors of this manuscript declare that they have no conflicts of interest to disclose. They have no financial, personal, or professional affiliations that could be perceived as having influenced the content or conclusions presented in this work.

### Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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