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Over the past 10 years we have witnessed major changes to the medical education landscape in response to advances in digital technologies. Couple this with the disruptions imposed by the COVID-19 pandemic and we have what could be described as a ‘perfect storm.’ Rather than hunker down and wait for it to pass, we took it as an opportunity to re-evaluate how we practice surgical education in the fourth year of our 6 year medical programme. In this article, we describe the formation of 6 core principles that function as pivot points in developing a new perspective centered on the importance of engaging and empowering our students as emerging clinicians. From these 6 principles, we designed and developed 3 interventions. Each intervention is discussed in regard to its purpose, operation and overall integration into the program. (J Surg Ed 80:159–165. © 2022 Published by Elsevier Inc. on behalf of Association of Program Directors in Surgery.)

KEY WORDS: surgical education, virtual surgical education, virtual curriculum, Professionalism, video-based education

COMPETENCIES: Patient Care, Systems-Based Practice, Medical Knowledge, Interpersonal and Communication Skills, Practice-Based Learning and Improvement

BACKGROUND

Exposure to the operating theatre is an essential part of medical students’ surgical placement. However, due to COVID-19 restrictions our students have found access to the operating theatre significantly limited and at times withdrawn. This is not unique to our institution, but reflects a situation that has been reported by surgical departments internationally. The resulting void of experience for our students has acted as a catalyst for us to explore alternative solutions, particularly the potential of emerging digital technologies of virtual learning and videoconferencing. This of course comes with some significant challenges. Firstly, there is the substantial body of research highlighting the prevailing struggles and anxiety experienced by students entering the operating theatre. Unless thoughtfully designed, the layering of further complexity is likely to confound this situation even further. Secondly, due to the exigencies surrounding COVID-19, access to surgical theatres to undertake research and development is likely to be met with resistance. And lastly, there is always a degree of trepidation when promoting reform through a separate set of educational assertions that may appear different from the status quo. That said, we side with those eager to push the boundaries of what is possible in the hope that we can contribute theoretically and practically to a new appreciation of what is possible in surgical education.

We envisage surgical education as integrated and experiential, where students’ learning becomes part of the patient’s journey as it intertwines with surgical communities, so that students can truly ‘practice’ being doctors. However, our experience has revealed that while students are eager to be engaged, they are often thwarted and alienated as a result of restricted access to many systems and practices. This in turn can lead to students feeling alienated and disenfranchised. Our aim is to tackle this issue by developing a legitimate but peripheral environment that mirrors particular clinical systems and practices that encourage participation without risk.

OUR SOLUTION

We started this project by appreciating that our fourth year medical students have grown up in a socially
integrated world of technology and practice. We know from experience they are proficient in and value opportunities to engage with digital technology, particularly in regard to collaborative environments. We also knew students appear more motivated and engaged when skills, information, and instruction are situated within socially meaningful activities. For this reason, we adopted an experiential mindset, that allowed us to situate learning within meaningful, shared endeavors. It also allowed us to address learning across cognitive, psychomotor, affective and social dimensions. To achieve this, we developed a set of elements (listed below) that we felt were essential in the formation of a peripheral, but legitimate environment where our students could participate, not as students, but as emerging clinicians within clinical communities of practice.

1. A patient-centric approach to learning, motivated by social relations where trainees are paired with patients from admission to discharge – creating continuity and responsibility of care.
2. A stronger focus on creating cycles of learning embedded within meaningful clinical practices as opposed to discrete formal learning episodes outside of clinical practice.
3. Exposure to the ill-structured complexities of real time | real life experiences, maximizing the opportunities for students to engage in legitimate meaningful clinical practice and decision-making.
4. The deployment of digital technology to craft team-based unified virtual communities aimed at preserving legitimate clinical practices as the central vehicle for learning.
5. The use of Point of View (POV) as a learning method to augment operating theatre experiences.
6. A focus on reframing of clinical training as professional development as opposed to traditional instructional apprenticeship or didactic classroom activities.

**OUR INTERVENTIONS**

We explored various clinical scenarios to ascertain how these 6 core elements could be realized through specific activities and contexts within the surgical community. An essential part of this process involved working with our students to ascertain their views on the value of our project and to invite contributions. We achieve this by backing a student-led project that examined student opinions and perspectives on the intervention elements, including our rationale for change. This data was generated by students meeting in groups and recording their discussions on the 6 core elements and screenshots of the various interventions. The overwhelming response was supportive, with student feedback adding valuable points concerning their perceptions of the project’s relevance and applicability to their learning and aspirations. There was clear that the students felt ‘stuck’ in a reactive, teacher-centric, information orientated, classroom-based model of learning. The project team, acknowledging the burden associated with change and the unrelenting stress of Covid-19, was committed to promote a more proactive, experiential approach that was grounded in a seamless coupling between our applied learning model and clinical practice. It was felt this approach was more practitioner orientated and reflected a better sustainable and fit-for-purpose model that was in line with the strategic goals of medical education.

With these results in mind, we developed 3 interventions to capture the 6 core elements (Figure 1). Firstly, to foster the clinical experiences of our students as a patient-centric endeavor. Secondly, to promote information capture to support understanding and informed decision making. And thirdly, to leverage the capability of video to augment learning from surgical practice in the operating theatre. We have included the table below to help clarify the relationship between the 6 core principles and the 3 interventions Table 1.

What follows is a breakdown of each intervention.

**ASSIGNING PATIENTS TO STUDENTS**

We began with what we felt offered the strongest sense of legitimate purpose: the patient – practitioner relationship. It was through these sustained patient relationships that students would come to experience the impact of clinical actions and management decisions on patients. However, for students, developing these relationships can be very difficult. Student-patient relations often become abstract observer ships when they are not an integral part of the patient journey. It is not uncommon for students to review patients in clinic or on admission but never have further meaningful contact. This lack of student responsibility for care and continuity often results in a lack of motivation to engage and can lead to feelings of alienation. Unfortunately, this is not often realized, with students instead, remarking on their invisible presence and awkwardness and lack of opportunity to engage in some sort of legitimate practice. For many students, it appears as if they are excluded from real medical practice, destined instead to hover in the shadows as an observer.

To address this, students are assigned a number of patients that they manage from admission to discharge. This practice is supported by a series of simulated, but authentic activities managed by the wider surgical team.
This includes participating in the operative discussions and procedures, experimenting with situation awareness and leadership, engaging in teamwork. The student-patient relationship will include admitting a patient, creating patient records, completing pre-operative preparation tasks, facilitator-guided live operating sessions, debriefing and post-operative documentation, including discharge paperwork and patient information.

**DIGITAL RECORDS PLATFORM**

The initial challenge in fabricating a digital presence for students was to devise a concept that would allow us to combine a succession of legitimate clinical practices. It was particularly important to the project team to focus on activities that mimicked rather than conflicted with standard hospital practices. With the increasing deployment of technology within health care, we felt an Electronic Medical Records (EMR) platform offered a more legitimate means for managing clinical data than the existing informal assortment of Word documents and notebooks. This supported the general awareness within the medical education sector that the ability to document clinical encounters and maintain medical records is a fundamental clinical skill that should be part of medical training. Unfortunately, many institutions restrict student access to hospital record keeping systems on the grounds that (1) it increases undue liability and (2) that student notes cannot be used to populate patient records. It is for this reason, that we decided to create a separate student based online EMR platform that imitated a clinical health records environment. Students would maintain patient information (Fig. 1), daily clinical schedules and clinical interactions with colleagues and clinical teachers in a protected environment. It offers students a private and secure place to capture, monitor and review their various clinical activities.

To create the collaborative EMR, we deployed the freely available opensource general practice software OpenEMR as our code base. This was then customized in accordance with the following 4 features:

1. Workflow: Classifications & calendar scheduling for clinical and professional development.
2. Communications: Internal communication between colleagues and clinical staff within their community.
3. Patients: Records of patient details and patient encounters.
4. Professional Development: Record of professional development with related notes/reflections.

While these represent what we believed to be the core features, the system continues to be developed as our understanding and aspirations evolve.

**REAL-TIME, REAL-LIFE VIDEO**

An ongoing dilemma for us as surgical educators is how to capitalize on our students’ experiences of the operating theatre. This is worsened by student access to theatres being limited both in numbers of students able to attend and the frequency of these opportunities. Our students also pointed
out that after a couple of times, their desire to attend theatre sessions often diminishes. The reason for this was due to the limited view and constricted space — you had to be vigilant, not on learning, but on trying not to get in the way. This can be exacerbated by the operating surgeon’s difficulty in being simultaneously practitioner and teacher. As a result, many of our students are left feeling detached from the activity with little to no awareness of any learning. They frequently report their frustration of (1) not being able to see what was happening (2) confusion over the purpose, (3) feeling awkward, anxious and at times demeaned. These are not unique. Two recent systematic reviews of student experiences of operating theatre learning,\textsuperscript{21,22} reinforced our accounts by noting stress, anxiety, confusion over relevance and intimidation as continuing significant factors impacting student’s theatre experience. A common thread in both studies, is the acknowledgment of operating theatres as fast moving, highly unpredictable places charged with the potential for calamity.

One promising way to meet this challenge, is via live streaming of the surgery. While still in its infancy, it is now possible to stream live video footage from surgical theatres to adjoining rooms where students and staff can view the surgery while engaging in open discussion. Our intention was to create a rotating hybrid approach that continued to include theatre exposure, while simultaneously adding a seminar room experiences for those not in theatre. These sessions are run under the mentorship of a facilitating surgeon. The facilitating surgeon has two-way audio access to the procedural surgeon. Their role is to engage the students in open and informal discussion associated with the procedure, guiding the students through the operation, punctuated by group questions for the procedural surgeon. The video feeds are sent to two 70" monitors situated in an adjoining seminar room where students can view the live streams. One screen presents the 360-degree view of the theatre and the other for either the surgical head camera or the laparoscopic camera.

To achieve this, we have created an infrastructure that deploys 3 high-definition cameras (Fig. 2), allowing real-time streaming of theatre operations over a private high-speed network. The laparoscopic feed and the 360-degree camera (positioned against a wall and above head height) had no impact on the normal operations of the theatre. However, there was brief input to ensure that the light and video were correctly aligned with the surgical field.

The 360-degree camera gives a view of the whole operating theatre and observation of the surgical team in their “natural environment” allowing us to make professional skills an explicit part of the surgical curriculum.

The surgical head camera and microphone offer a ‘surgeons-eye’ view allowing students to clearly see the open or external surgical field.
The Laparoscopic camera footage providing the internal operative view during laparoscopic procedures.

Unlike pre-recorded video, live surgery situates the student within the known context (theatre and patient). By combining the familiar context with live streaming (absence of the known) will are more likely to see elevated emotional states and increased engagement.

The downside to live streaming of surgery is the multiplicity of technical layers required for successful implementation. However, once implemented, live streaming is more cost effective and rapid than the traditional asynchronized system that requires highly skilled personnel to undertake the filming and editing process. Two recent systematic reviews on the use of video streaming in surgery\textsuperscript{23,24} found that the use of video streaming for educational purposes was not widespread. One of the reasons raised for this was the lack of clarity regarding the software, hardware and configurations required to generate a turnkey approach. Part of this project is to do exactly that by identifying low-cost devices and workable configurations. Figure 3 presents a schematic of the configuration (including hardware & software) used to implement the laparoscope live stream from the surgical theatre to a seminar room (>1 second latency).

**FIGURE 2.** Cameras employed from left to right: Insta360 Pro 2 camera, Xenosys Lookscam 2 surgical head camera, and Stryker laparoscopic camera.

**FIGURE 3.** Schematic of the live-stream video configuration for the deployment of the laparoscopic video stream.
THE CHALLENGES

The initial ‘honeymoon’ phase returned promising results as we developed the core points, tested various devices and talked through our ideas with students. However, as we moved to integrate the elements into a single system we were met with many unforeseen challenges. For example, the Opensource Electronic Medical Records (EMR) platform we deployed for our Digital Records needed extensive programming changes to meet our brief. We had to develop various procedures to ensure privacy for both video streaming and access to the digital records platform. We found that the digital networks were not as reliable as anticipated, particularly in regard to data transfer between university and hospital networks. We had underestimated a number of essential factors needed for continuous HD quality video streaming. Cameras were not performing as the marketing brochures implied. By the time we had addressed many of these, we had accumulated a rather large ‘kit’ of hardware that was impractical to configure quickly. As a result, we have had to develop a purpose-built mobile trolley equipped with the various video elements. While this created delays in the project, it has resulted in a more efficient process, reducing the amount of setup time and eliminating the theatre bench clutter of devices and cables.

SUMMARY

In this article, we presented a set of principles, supported by a series of interventions that we believe contributes to the continuing momentum for reform within medical education. At the heart of this project, is our belief in the importance of engaging and empowering our students as emerging clinicians. We set out 6 core principles that we believe can function as pivot points with the teaching and clinical teams. We then showed how we were able to address each of these within 3 interventions focused on (1) Assigned patients, (2) Digital records platform and (3) the deployment of real-life and real-time video technologies to augment and extend operating theatre experience.

Our intention is to blend these elements in such a way as to create a meaningful context whereby students have the opportunity to “practice” being doctors in a safe legitimate, parallel environment. This is of course predicated on our belief that practices are best learnt by allowing students to engage more fully and professionally with patients and staff in an authentic manner. Operating like a clinical portfolio, it seamlessly facilitates the capture of clinical events across patient journeys, promoting intentional and purposeful patient relationships, and acting as the catalyst for engaged discussions with the teaching and clinical teams.

Finally, we are cognizant that what we have presented in this article is only part of the story. We continue to press on, reassured by our appraisals and interactions with students, that we are heading in the right direction. A further paper assessing the impact of our intervention will follow after our launch of the project in 2022. If there are aspects of our approach that you are deploying or if you are interested in developing something similar, please do not hesitate to contact us, we would love to collaborate.

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