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Are we underinvesting in education?

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Surgical education used to be simple. 'See one, do one, teach one' was Halsted's (1852–1922) philosophy and for the better parts of the 19th and 20th centuries that was to be the way forward (1). Back in the day, students of surgery would actually pay the master for the educational expertise he dispensed. Surgery was generally a low-tech affair using instrumentation straight out of the forge or the workshop with no accreditations or bureaucratic approval processes needed. Surgical intervention was such that a so-inclined individual could learn by observation and then train, in the best of cases under the eye of a mentor, and then rapidly become a solo operator. The gamut of possible procedures could be mastered by a single surgeon, the dream of present-day administrators, although even then, some were more skilled at amputation and others at hernia repair. Economically all of this made sound sense and with this type of educational system hospitals did not have much to invest in the education of future surgeons.

Then things started to evolve and new techniques arrived. Anesthesiology allowed deep ingress into the human anatomy. Roentgen's discovery of the X-ray in 1895 burst into the medical world and incredibly in the absence of modern communications, within a year of its publication, it became a household word. Blood transfusion and antibiotics followed suit entailing more and more complex procedures. CT and MRI revolutionized the diagnostic process so that a third-year medical student could now diagnose conditions only the professors could guess at before. Even so up to the 80s, Halsted's principles stood the test of time. Then, endoscopy arrived applied to all areas of surgery and specifically to orthopedic surgery. This necessitated new skills to master the novel arthroscopic techniques first essentially diagnostic and evolving into interventional. And finally, surgical assistance technologies and robotics assaulted the operating theaters (2). We as a profession bravely entered the 21st century to find that not only technology had changed practices but also that society was transforming. The work ethic had evolved the individual, and his needs now tended to supersede societal necessities. The weight of economics and administration was brought to bear on medical practice and surgeons were quickly made to realize that health care is priceless... but at a cost.

And so it goes with education. The new technologies necessitate training, repetition and practice. A learner can watch a skilled arthroscopist for hours and still not get the feeling for triangulation and 3D visualization from a flat screen. This needs to be proactively taught using training simulators that are becoming more and more sophisticated and realistic. Delicate open surgery, such as microsurgery, needs also to be learned through practice on adequately prepared pedagogical material or specimens. Complex surgeries need to be planned and executed in the classroom or the cadaver lab before being directly applied to the patient.

Practice is the backbone of success for many professions outside of surgery. Who takes a commercial flight driven by a pilot without his flight simulator hours? And who goes to a play or a concert where the performers have not learned their part beforehand?

Medical schools and hospitals need to invest in the training of their surgical personnel including all those involved in the interventional process. In many countries, working hours have been regulated for surgical trainees and this is a positive societal development (3). However, it leads to less exposure and less case experience. These experience and practice gaps need to be filled if hospital operating rooms are to function at the highest level and if patient care and safety are to be optimal. Simulation centers offering realistic conditions for operative training are necessary so that trainees may benefit from the practice of complex tasks and also so that teachers may benefit from the effort generated by providing useful pedagogy. Developments in artificial intelligence, realistic image rendering and haptic feedback are moving forward at a rapid rate. Augmented and virtual reality will become essential learning tools to teach and to facilitate planning, workflow and techniques. Collaborative teaching projects with engineers have become the norm (4). The neuroergonomy of surgeons while operating is now also under scrutiny with new near-infrared spectroscopy (technology that allows to quantitate the blood flow activity of the prefrontal cortex while operating (5)). This

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tool may allow, in the future, to evaluate surgical attitudes under duress and to practice strategies for diminishing stress and enhancing efficiency while operating.

It is also important that the centers located in teaching hospitals and universities are independent and not tributary to commercial sponsors. The initial investment may be viewed as a burden by the administration, but rapidly the benefits weigh in. Although there is no hard data available yet, logic and common sense would have it that progress is to be expected. The morale of surgical personnel is improved because a well-practiced procedure is less stressful when applied in the operating theater. Also, less time is lost during the procedure because traps and difficulties have been previously identified. All this leads to the conclusion that patient well-being is improved when the team is well-prepared.

Practical skills are essential to a well-functioning surgical team but without solid theoretical knowledge based on current evidence, rational decisions involving patient care are not possible. In that aspect, the transmission of theoretical knowledge has also undergone a revolution in this information age. From the weighty volumes of the Index Medicus, founded in 1879, to the online PubMed database launched in 1996 and containing more than 35 million citations and abstracts of biomedical literature, a profound transformation of information dissemination has come to pass. Open access journals, introduced in the nineties, have brought knowledge closer to the user. There are 119 orthopedic journals listed in 2022, and of those, 40 are Open Access. In the top 20 journals classified by impact factor, 6 journals are gold Open Access which means that the article is permanently and freely available online. Open Access journals have the advantage of a wide distribution at no cost to the reader but have the disadvantage that article publishing charges are borne by the authors and their institutions.

Education is the backbone of excellence and safety in the surgical environment. The scene has changed and the teaching and learning process has become much more diverse and sophisticated. Academics need to be involved in the process and research projects are badly needed to scrutinize, analyze and evaluate the new teaching tools and to integrate the engineers into the training process. Budgets and investments must be tailored to meet the new contingencies and to insure a smooth transfer and ready access to knowledge for the coming generations.

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