self

Surgical Education
Learners Forum

The future of surgical training

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The future of surgical training must challenge the age-old apprenticeship model of *'see one, do one, teach one.'*

This classical model simply cannot scale to meet current and future demand. Although many clinicians already learn a great deal through reading and online videos, the next leap is in complementing this knowledge acquisition with psychomotor skills acquisition.

The SELF: Surgical Education Learners Forum aims to expand global surgical training by scaling skills acquisition using self-assessed progression through learning new surgical psychomotor skills. Our ambition is not only to develop a surgical workforce with competent skills, but also to empower them to advance their capabilities in response to local needs. We seek to reframe that old surgical education mantra to instead be: *'see one, teach yourself one, do one.'*

Contents

Surgery is a cornerstone of global public health. Yet most of the world's population cannot receive surgical care when they need it. This often has disastrous results for the health and well-being of populations.

In addition to the avoidable disfigurement and disability, more than 10 million people every year die from lack of access to surgical care. This is comparable to the 10 million people a year dying from cancer, and the additional four million people a year who die from HIV, TB, and malaria (combined).

As the world's population increases past eight billion, we are challenged to find solutions to this deficit of care. Many groups are attempting to address this problem with different approaches, from working with governments on central planning to mission-based delivery of essential surgical services.

An increase in infrastructure, facilities, and medical equipment is needed, but alone it does not address the critical lack of trained surgical practitioners who will need to work in these communities. We need to increase capacity by training significantly more surgeons and surgical practitioners at a far faster rate than we can with the existing global capacity of our classical, centralized medical education.

SELF: The Surgical Education Learners Forum is a new initiative that has evolved from the Global Surgical Training Challenge (GSTC). SELF aims to sustainably change the paradigm of surgical training, dramatically increasing access in low and middle income countries. Our goal is to empower any clinician to learn independently and self-assess specific skill sets. They will do this by means of open source training modules that are freely available.

The initial Challenge was developed in response to the question, *"How might we bring increased surgical training to low resource settings?"* Among the parameters set forth were the need for surgical practitioners to be able to independently learn and practice their psychomotor surgical skills. They would do this through surgical simulators they could build using low-cost and readily available materials. The training needed to be open-source access. Most importantly, learners needed to have the ability to self-assess their skills so that they could learn outside of the traditional education pathways.

Hundreds of innovators around the world stepped up to the GSTC in 2020, which was launched and jointly executed by Challenge Works (formerly Nesta Challenges) and MIT Solve. In the middle of a global pandemic, teams of health care workers, innovators, entrepreneurs, and engineers formed across countries, time zones, cultures, and languages. These teams developed and iterated upon training modules that address urgent needs spanning a wide variety of surgical specialties.

Our intention has been to build and launch a community and a platform upon which other innovators and makers can design and create their own modules to serve the millions of people in need of safe, competent surgical care. This platform will also allow organizations to create integrated courses consisting of a curated set of high quality training modules that meet the needs of that organization.

It's a complex challenge that will require all of us to work together to solve it. I hope you will join us in this innovative and bold endeavor.

Dr Catherine Mohr, President, Intuitive Foundation

What are we trying to do?

We are focusing on surgical training as a means to upskill surgical practitioners of all kinds to increase access to life-altering and life-saving surgeries across the globe.

The SELF: Surgical Education Learners Forum is a community platform that seeks to deliver comprehensive surgical self-training programmes for learners at any point in their career.

This programme is being created with the support of the Intuitive Foundation. It will build on the work done in the GSTC. Initiated in 2020, the Global Surgical Training Challenge was an initiative funded by the Intuitive Foundation and run in partnership with Challenge Works, MIT Solve, the Royal College of Surgeons in Ireland (RCSI), and Appropedia, a site for original research on sustainable development where users can develop and share collaborative solutions. The goal was the creation of didactic and simulation based learning modules with rigorous self-assessment tools.

The Challenge aimed to stimulate the creation of, and to test in a clinical application, novel self assessment methods for practitioners to learn and perfect new skills. As the follow-on program, SELF will fund development and evaluation of future modules with new global teams to expand upon the original set.

Who are surgical training modules for?

The surgical training modules address the needs of a variety of learners, depending on the context and local patient needs. The modules can be used by nurse practitioners, family practice doctors, surgeons, and any clinical and medical officers who are surgery practitioners. For example, a general surgeon, nurse, midwife, or medical officer can learn to perform external tibial fracture fixation when they find themselves to be the only ones in the community providing orthopedic care. In other cases, surgery practitioners who perform only open surgeries can add laparoscopic surgery to their set of skills without leaving their active practice.

How is this surgical training approach unique?

Many organizations are trying to address the shortage of surgeons around the world through infrastructure development and training. However, it is accepted as a fundamental truth in the surgical training world that, during training, skills practice must be overseen by a master surgeon who observes the trainee and gives them targeted feedback so that they can improve. We seek to challenge that model at a fundamental level, asserting that the learner can practice psychomotor skills to mastery on their own by receiving targeted feedback from the simulator rather than a human mentor.

The SELF initiative is unique in that it takes free online learning two steps beyond video or reading based education. It gives learners an opportunity to develop hands-on skills with high-fidelity, build-it-yourself simulators, and it allows them to monitor and hone the progress of their skills as they practice, and determine when they have reached a competency level that is safe to move to the operating room.

When we seek to solve the global problem of insufficient surgical practitioners, only an approach like this, which decentralizes and scales surgical training beyond large, urban medical centers, can safely produce the staggering number of skilled surgical practitioners necessary to meet global patient needs.

Components of the training modules

The training modules are hosted on the open source platform Appropedia, and are freely available to learners. Each training module, regardless of the surgical specialty or procedure, has three primary elements:

Knowledge Learning

A fairly traditional didactic segment provides background on disease, epidemiology, pathophysiology, and anatomy. Additional topics may include pre- and post-surgical management, and follow-up care. Learners can download the elements to their mobile devices and follow the curriculum at their own pace outside of any structured training programme.

Simulation Training

Where the novelty comes in is in one of the most challenging elements of the design of the modules – building self-assessment into the simulators so that the learner receives real-time feedback that they are practicing the skills correctly. Designed to be used without the benefit of a teacher, the simulators have incorporated feedback elements so that the learner can immediately see what they were doing incorrectly, and take that into the next practice session.

In addition, these simulators need to be designed such that they could be built using locally accessible materials anywhere in the world. A further challenge was creating sufficiently detailed instructions that would allow non-technical learners to build these simulators for themselves. Materials selected by the teams ranged from cardboard boxes and string to basic medical supplies such as clamps and gauze, the critical aspect being that the material chosen must have sufficient fidelity to actual surgical practice that the learner would not need to 'unlearn' any aspect of the technique they were practicing once they got into the OR.

Self-Assessment

Self-assessment is not just about the adaptive and focused skills practice that is necessary to develop competence. It is also essential for the development of confidence on the part of the surgical practitioner, so that they can safely, effectively, and ethically care for their patient.

One of the unique components of the GSTC-sponsored training modules is the ability for learners to know when they have successfully acquired skills to be able to safely progress to the operating room for their first clinical cases on their own. This is done through a combination of different self-assessment methods. In the didactic segment, there are pre-and post-learning quizzes. In the simulation segment, learners may use different forms of self-assessment in addition to the physical feedback from the simulator such as verification checklists, artificial intelligence, and/or peer community feedback to help them determine when they are truly ready.

Existing modules

The following modules are by the Global Surgical Training Challenge finalists and represent examples of what is possible.

Laparoscopic surgical skills

Initially developed as a training module for the diagnosis and laparoscopic treatment of ectopic pregnancy, this platform has expanded to include a variety of laparoscopic surgical procedures, including for the treatment of appendicitis as well as important techniques for abdominal surgery like suturing at odd angles and running the small bowel.

In high income countries, patients with a wide variety of abdominal and pelvic pathologies are primarily treated with minimally-invasive (MIS), or laparoscopic, procedures. But in low- and middle-income countries, particularly sub-Saharan Africa, when surgeons are available, they mostly rely on classical open procedures. These result in increased blood loss, longer hospital stays, and slower recoveries which disproportionately impact patients in low resource environments without safety nets. While open surgery is preferable to no surgery, increasing access to MIS in parallel with increasing access to surgery would go a long way to address the high rates of morbidity and mortality.

The ALL-SAFE team designed and developed a platform to help surgeons who already perform open surgery to become competent and confident in performing all aspects of patient care in the laparoscopic treatment of many of these procedures.

Users of the each of the modules follow a similar process:

- Users first create an account on the platform, after which they can visit any of the modules.
- Each module requires the learner to take a brief knowledge pre-test.
- After the pre-test they begin with a case study, during which they go through an interactive clinical case. As the learner answers each question, the platform presents more detailed information about topics such as pathophysiology.
- Upon completion of the cognitive aspect of the module, they can move on to the psychomotor technical skills. These are videos of expert surgeons demonstrating the use of the simulator.
- The learners then download the instructions for building their simulator, including the materials and tools necessary to build it.
- Using a connection between their mobile phone and a laptop computer with the cardboard box simulator, the learner can mimic a scope and monitor set-up.
- After practicing, learners access a Verification of Proficiency, which serves as a checklist of important elements for competent performance of the procedure. It will also be used in the peer assessment process.
- Once they feel confident of their acquisition of skills, they can record their performance and upload it to the platform.
- The learner gets immediate AI generated feedback on the essential steps.
- Following that, the learner will be assigned peer videos to review while three peers review their video and complete the same Verification of Proficiency checklist assessment.
- The educational portion of this step is two-fold – the learner receives feedback from peers as well as learning from assessing the other's videos.
- This video review may be performed as many times as needed for the learner to feel confident in their skills.

Each module is designed to teach specific laparoscopic skills, each adding to a repertoire of skills that are widely applicable to other laparoscopic procedures.

- **Ectopic pregnancy**

  Ectopic pregnancy is a leading cause of maternal death in low income countries.[1] The World Health Organization has prioritized preventable maternal death at the top of its global agenda. The module emphasizes the techniques of incision, evacuation, and closure of the affected Fallopian tube.

- **Acute appendicitis**

  Expanding upon the initial module for ectopic pregnancy, the ALL-SAFE team created one for acute appendicitis – a common and growing pathology in LICs.[2] A laparoscopic appendectomy is also an operation which encompasses many basic laparoscopic skills such as retraction, dissection, and suture ligature that can be applied broadly to other laparoscopic operations.

- **Small Bowel Handling (Meckel's diverticulum)**

  This module teaches the general technique for systematic laparoscopic bowel exploration ('running the bowel') with the simulation goal being identification of pathology of Meckel's diverticulum. This essential skill set is applicable to any laparoscopic case in which the small intestine is manipulated and/or searched for injury or pathology.

- **Penetrating Thoracoabdominal/Traumatic Diaphragmatic Injury**

  Penetrating injuries to the thoracoabdominal region are complex and challenging for surgeons. Most patients in the low-resource setting are treated through exploratory laparotomy. While this module addresses the specific surgical management of a diaphragmatic injury laparoscopically, the technical principles taught in this case (diagnostic laparoscopy, retraction, exposure, intracorporeal suturing at extreme angles and knot tying) are general and widely applicable towards laparoscopy and a surgical practitioner's laparoscopic toolkit.

1. Kirk E, Condous G, Bourne T. Ectopic pregnancy deaths: what should we be doing? *Hosp Med.* 2004 Nov;65(11):657-60. doi: 10.12968/hosp.2004.65.11.17044. PMID: 15566057.
2. Wickramasinghe DP, Xavier C, Samarasekera DN. The Worldwide Epidemiology of Acute Appendicitis: An Analysis of the Global Health Data Exchange Dataset. *World J Surg.* 2021 Jul;45(7):1999-2008 (Epub 2021 Mar 23). doi:10.1007/s00268-021-06077-5.

External fixation of fractures

Traumas represent an enormous public health burden around the world. In 2019, there were 300 million reported fractures of the patella, tibia or fibula, or ankle.[3] Many of these cases resulted in lifelong disability and pain for patients who are unable to access the few orthopaedic surgeons in low income countries. Beyond the huge burden of lower limb fractures from traffic accidents, these injuries often occur in conflict zones or as a result of natural disasters, where access to orthopaedists is even more of a challenge.

This team aimed to teach non-orthopaedic clinicians the fundamentals of fracture fixation using high fidelity 3D printed bones that can be delivered to the learner. As 3D printers have become more widely available, these bone models have been made all over Africa and Latin America. For learners who do not have access to a 3D printer, the module offers resources for ordering the models.

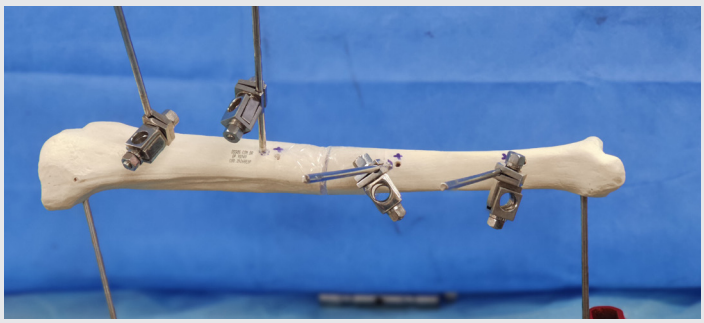
The modules have five phases:

- Pre-learning clinical confidence assessment
- Knowledge review
- Building the simulator
- Skills practice
- Self-assessment

The didactic, or knowledge, portion of the module reviews anatomy of nerves, blood vessels and other structures. Learners identify indications for specific approaches, including how to identify cases in which a referral to a specialist is appropriate or necessary.

For simulation training, the modules include instructions for 3D printing of models that accurately simulate bone length and diameter, external contour, cross-sectional shape, hardness and porosity for a variety of types of patients.

A step-by-step self-assessment framework guides learners to measure things like pin, fixator and bone positions to compare their results against clearly labeled metrics.



3. Wu, Ai-Min et al. Global, regional, and national burden of bone fractures in 204 countries and territories, 1990–2019: a systematic analysis from the Global Burden of Disease Study 2019. *Lancet Healthy Longevity*. 2021 Aug;2(9):E580-E592 (Epub 2021 Sep 1). doi:10.1016/S2666-7568(21)00172-0.

Tibial Fracture Fixation

During the knowledge-building phase of this module, learners learn the principles of surgical care and management for open tibial shaft fractures. This includes gaining familiarity with the anatomy, blood supply, and nerves that surround the tibia. Learners will understand the indications for modular external fixation, and will learn when it's more appropriate to refer a patient to a specialist or tertiary care facility. In addition to learning the structures and classifications of fractures, users will also learn about antibiotics to prevent infection.

The module provides detailed instructions for 3D printing tibial bone models. Learners place the bone model on a basic vice clamp to position it to mimic a patient in supine position. They can use real drills to learn the audible cues, gain the psychomotor skills and gain the muscle memory of applied pressure, direction, and other requisites for these procedures. Step-by-step instructions guide the learner through the procedure for modular external fixators as well as uniplanar fixators.

A training logbook accompanies the module so that users can self-assess their performance. The self-assessment framework allows the learner to evaluate and iterate upon their own success in alignment and position of screws and pins, as well as the trajectory of the drilling.

Pediatric Distal Forearm Fractures

This module is designed for traditional bone setters rather than surgical practitioners, which provide much of the primary fracture care in many sub-Saharan African countries. This extends the reach beyond the team's earlier module, but it also includes material relevant to prehospital providers, clinical officers, nurses, nurse practitioners, and medical officers.

The primary objective is to teach first point-of-care providers to become confident and competent in performing ultrasound diagnostic imaging. An estimated two-thirds of the world's population lacks access to any diagnostic imaging. Handheld ultrasound devices can provide diagnostic imaging at the point-of-care for almost any musculoskeletal injury in resource-constrained settings. Children, in particular, can benefit from the use of ultrasound to rule out the presence of a pediatric distal forearm fracture and distinguish between buckle (torus) fractures and cortical break fractures as there is significant downside to over treating a suspected fracture.

Similar to the tibial fracture fixation module, learners start with a pre-assessment before moving on to the knowledge-building phase. Here they learn about anatomy and how to distinguish among different distal forearm fracture types with ultrasound of standardized models. They learn how to conduct a clinical assessment to determine if an ultrasound is appropriate.

Using a handheld ultrasound, users learn basic skills for scanning a pediatric distal forearm. Upon making a diagnosis, the user can learn how to properly apply a splint or utilize other nonsurgical management techniques for other non-fracture injuries. Users also learn the indications for referrals to surgical specialists.

Humeral Fracture Fixation

This module is designed for medical officers and surgeons who are not orthopedic specialists to become confident and competent in irrigation and debridement, powered and manual drilling, positioning and correctly inserting Schanz screws, and constructing the rod-to-rod modular frame as part of external fixation procedures for open humeral shaft fractures performed in regions without specialist coverage.

Similar to the tibial fracture fixation module, learners will go through phases of knowledge review, building a simulator, psychomotor skills practice, and a self-assessment.

Prehospital hemorrhage control

This Guatemala-based team focused their efforts on non-surgeons. Their training module teaches ambulance drivers, volunteer firefighters, and other first responders how to manage bleeding from trauma during transportation of a patient to a hospital.

As in many low- or middle income countries, Guatemala lacks an organized trauma care system. Many first responders are, in fact, volunteers with limited formal training beyond basic first aid. A patient who is bleeding profusely may not survive the sometimes long ride to the hospital. First responders have demonstrated their eagerness to learn how to care for patients for the safest transport to regional hospitals.

CrashSavers designed a module that teaches clinical decision-making and technical skills critical to stopping life-threatening bleeding. Using a virtual reality mobile app in combination with a build-it-yourself simulation trainer, learners gain the ability to differentiate among a variety of hemorrhage control techniques, and the instances in which to use them.

Learners learn four techniques for hemorrhage control:

- External pressure to a bleeding superficial wound
- Packing into a bleeding deep wound
- Insertion and deployment of a foley catheter in a deep, narrow wound that is profusely bleeding or in an anatomic junction (i.e. base of neck, axilla, groin)
- Tourniquet application on a bleeding extremity

The CrashSavers module has five primary components:

- An introduction and orientation
- Lectures that review key principles and indications for various forms of hemorrhage control
- App and simulator that include do-it-yourself instructions
- Skills practice that covers a variety of clinical scenarios with real-time efficacy feedback
- Self-assessment to test acquired knowledge and skills

Learners can choose to build a simple or advanced simulation model, depending on their comfort level and available tools. The simulators are designed to mimic the fidelity needed to stem bleeding in a real patient and give real-time visual feedback that bleeding cessation has been achieved.

The self-assessment presents a variety of clinical cases for learners to evaluate and identify the appropriate steps to treating the patient and when to apply their new skills.

Reconstructive and plastic surgery

Patients who have scars from burns, trauma, or congenital anomalies can face a number of difficulties when the scar contracts. The AmoSmile team initially designed a module to teach Z-plasty, a local flap procedure considered to be an essential tool within the reconstructive surgery repertoire for releasing problematic contractures. They have since developed modules for V-Y advancement flap and orthoplastic reconstruction.

Orthoplastic reconstruction aims to reduce the need for amputation and provides a treatment plan that combines orthopedics and plastic surgery. The module teaches users how to remove contaminated debris and all devitalized tissue, stabilizing the skeleton and covering the soft tissue defect. The goal is to reduce deep surgical site infections.

The modules are accompanied by a free and easy-to-use smartphone application that provides virtual simulation.

The components of the modules include:

- Pre-module assessment to gauge the learner's baseline level
- Educational content, including skin tension lines and flap classifications
- Virtual simulation of incision planning using the smartphone app
- Post-module assessment
- Physical simulation and self-assessment

The educational portion of the module is broken into different chapters with specific objectives, with each building upon the learner's knowledge. Segments can include reviews of indications and contraindications for the procedure, as well as highly detailed, interactive 3D graphics.

After completing a review of the education content, learners complete the post-didactic assessment. Users must pass the assessment with a minimum rate of 80 percent before moving on to the physical practice. The app compares the learner's pre- and post-assessment scores.

Once they complete the post-test they move on to building their own physical simulator from a wood block, nails, screws, rubber bands, cotton, markers and other easily-accessible materials. A video demonstrates how to build the simulator.

Throughout the building and use of the physical simulator, they return to the app to respond to questions to assess how well they have done. This way, they are self-assessing as they follow along with the instructions. As the suturing component is fairly straightforward, and the clinical success is more dependent on the surgical planning of where to make the incisions, the assessment emphasis is on the surgical planning components.

How you can get involved

We encourage all surgeons, surgical students, innovators, makers, and educators to join this global movement.

- Visit the Appropedia Web site to learn surgical skills from existing modules
  appropedia.org/Global_Surgical_Training_Challenge
- Work with us to create or adapt your own modules to include self-assessment
  intuitive-foundation.org/global-surgical-training-challenge/open-source-clinical-skills-training-grant
- Clinically evaluate existing modules as an independent examination site. Email us at:
  info@intuitive-foundation.org

Learn more
www.intuitive-foundation.org/self

The Intuitive Foundation is dedicated to reducing the global burden of disease and suffering through philanthropy, research and education aimed at better outcomes for patients everywhere. The Intuitive Foundation funded the Global Surgical Training Challenge and is sponsoring the SELF programme.

Created in 2018, the Intuitive Foundation promotes health and advance education by making grants to section 501(c)(3) organizations and foreign charities medical and technology research; science, technology, engineering, and math-related educational programs, training, and fellowships; healthcare training programs and facilities; direct disaster relief; and for other similar purposes.

Learn more at **www.intuitive-foundation.org**

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