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TEACHING AND LEARNING IN THE OR:

A Functional and Theoretical Matrix to Facilitate Surgical Education

HUGH M. FOY, MD, FACS
Professor Emeritus
Department of Surgery
University of Washington, Seattle, Washington 98115
Email: hughfoy@gmail.com

INTRODUCTION:

Prior to the introduction of minimally invasive surgical techniques, little attention had been given to the deliberate training of technical skills outside of the clinical settings in U.S. operating rooms, ERs, and clinics. After the initial instruction in basic suturing skills typically given to medical students, the remaining training was left to the classic Halsteadian model of "see one, do one, teach one." During residency training, direct supervision and instruction was usually given by a senior resident in the OR, often with little direct supervision by attendings. "To call is a sign of weakness" was the unwritten code promulgated by attending surgeons, particularly in the public teaching facilities in our inner cities where the majority of training was accomplished. After the sentinel tragedy of the death of Libby Zion, the daughter of a well-connected New York City publicist in 1984, the New York State legislature passed a law imposing limitation of hours on residents in 1989, which became a national standard when imposed in 2003 by the Accreditation Council on Graduate Medical Education (ACGME) in lieu of it becoming a U.S. Federal law. Further scrutiny by payor's, most notably Medicare and other commercial insurers, resulted in required presence of the responsible attending surgeon in order to submit a bill for professional fees for the operation. As a result, a greater level of attending supervision became routine by requirement.

With the advent of minimally invasive surgery, notably laparoscopic cholecystectomy in the late 1980s and prior gynecologic procedures, the demands and unforgiving nature of this physically detached 2-dimensional environment spawned an increased interest in formal technical skills training outside of the operating room to avoid potentially morbid, lethal, and costly complications common in the first years of deployment. Previously, very little formal instruction of technical skills was practiced, researched, or published. Recognizing this need, formal educational efforts were launched by various professional organizations to "teach the teachers" the rudiments of all aspects of surgical education including technical skills training. Many advances in surgical education were made in 1980: The Association for Surgical Education (ASE) and The Society of Gastrointestinal and Endoscopic Surgeons (SAGES) were formed and the first Advanced Trauma Life Support Course presented after being syndicated by the American College of Surgeons (ACS) expanding on a course developed in response to a local tragedy affecting one of their colleagues by surgeons in Lincoln, Nebraska. To further advance the professionalization of surgical education, in 1993 the ACS held its first *Surgeons as Educators*

course – a week-long, in-residence course for surgeons interested in focusing their careers on the training of students and residents. This intensive course incorporated the fundamentals of surgical technical skills instruction as a component of its comprehensive curriculum that covered all aspects of adult educational principles as they related to the training of students and residents.

In the early years, instructional materials and courses were typically locally authored and produced. In the ensuing 30 years, a plethora of well-organized technical curricula, books and scientific publications have ensued. The research methodology and methods have been developed and refined, and the formal curriculum and accreditation process has been established by SAGES. In order to help train physicians and surgeons in the initial evaluation and stabilization of injured patients, The ACS deployed the first *Advanced Trauma Life Support* (ATLS) course in 1980. Several advanced surgical skills courses for Trauma Surgeons have also been developed and deployed. Notably, the ACS *Advanced Surgical Skills for Exposure in Trauma* (ASSET) and the *Advanced Trauma Operative Management* (ATOM) courses have been developed; however, they are unfortunately very resource intensive and costly to participants which has limited their widespread deployment.

In cooperation with the Association of Program Directors in Surgery (APDS) and the ASE, the ACS has embarked upon the development of a national technical skills curriculum for open technical skills for both medical students and residents. Both the *Medical Student Simulation-Based Surgical Skills Curriculum* and the *Surgery Resident Skills Curriculum* are accessible on the internet and are currently in development.

Coincident with these organized educational efforts have been the development of a whole host of technical skills platforms and methods that cover the spectrum from low-cost, home-built simulation models to sophisticated and often expensive virtual reality platforms. [1] Regardless of the available resources and methods, a well-developed technical skills-based training (SBT) program should utilize the well-established methodology of modern adult educational and technical skills curriculum principles. [2] Kern and associates developed a 6-step approach to course development that includes:[3]

1. Problem Identification
2. Targeted Needs Assessment
3. Goals and Objectives
4. Educational Strategies
5. Implementation
6. Evaluation and Feedback

An effective program development is more than a linear checklist. More importantly, it is a cycle of continuous quality improvement proven essential in most organizational endeavors.

TEACHING AND LEARNING IN THE OPERATING ROOM:

In order to develop and conduct an effective surgical skills training program, it is imperative that one understands and utilizes the Principles of Adult Education as espoused by Malcolm Knowles. He stated that the essential difference of adult education or "andragogy" compared to the teaching of children or "pedagogy" is that the former is 1. learner-centered; 2. conducted in a supportive environment; 3. problem-oriented; 4. an active, rather than a passive activity; and lastly, 5. feedback is vital to attaining the desired change in the learners. [4]

However, surgical expertise is comprised of more than merely the mastery of technical or "psychomotor" skills. As in many professional endeavors, a skilled surgeon draws from all 3 of the domains of learning as defined by Bloom: the cognitive, psychomotor, and affective realms. In common terms, it comes down to what you do with your head, your hands, and your heart. Additionally, a successful operation is not only the result of the thousands of technical steps, but also depends on skillful interactions with the patient in the pre-operative, intra-operative, and post-operative periods. Without a thorough history and physical exam, and a thoughtful discussion of the indications, risks and benefits to be expected and documented in an informed consent, the inevitable physical act of an operation is merely an assault, not a therapeutic act. The pact made with the patient to care for them after an operation in a scientific, diligent, and caring manner distinguishes the consummate surgeon from an itinerant technician. A helpful matrix to consider these principles is to match the 3 domains of learning with the 3 phases of an operation to help illustrate these important concepts.

The Pre-Operative Educational Plan:

Like any complex endeavor, a successful surgical outcome is more likely to be achieved as a result of careful pre-op planning. The preparation for an operation involves many aspects and all three of the domains of learning. In the cognitive domain, it is imperative that the surgeon reviews the medical record including the history and physical, and diagnostic tests, both laboratory values and imaging. Increasingly, much of the pre-operative assessment has been done in the clinic, including obtaining the informed consent from the patient. Often, considerable time may elapse between the clinic visit and the actual operation; therefore, it is essential to revisit the case in detail in the days immediately before the operation. Other pertinent information is then best discussed with the

resident the day before the case, and the patient should be contacted to assure that no other changes in health status have occurred that would preclude the coming operation.

Too often the pressures of daily responsibilities and the dynamic nature of the resident rotation scheduling process make this traditionally effective pre-op discussion less likely. In generations past, it was expected and assumed that the resident would call the attending the night before the operation. More often than not, in a busy teaching practice, the chief resident may assign the resident to a case the morning of the operation. In many large, complex, hybrid facilities like a busy trauma center, residents from several different training programs serve on a single service. This can result in the unfortunate case of the attending never having met – let alone operated with – the resident assigned to the procedure. At the very least, a brief review of the operation can be accomplished in a "just in time" manner at the scrub sink. There, the attending can assess the resident's knowledge of the patient's history, relevant findings, indications, and the operative plan. A "needs assessment" of the resident's prior experience with an operation should also be done. It only takes seconds to ask the resident what their previous experience has been. Take the time to ask. "Have you done a laparoscopic cholecystectomy before?" As the teaching attending, it is important to assume nothing. Without a clear assessment of the resident's prior experience, the expectations and operative plan including the assignment of the exact different roles of each member of the team for each phase of the case must be clearly stated to avoid surprises and to avoid unnecessary disappointment, which may undermine the team's morale.

Technical preparation can be done in a skills lab, if possible. This takes time, and to be most effective, it requires direct supervision of an expert with prior experience**.** Innumerable studies have shown improved operative performance associated with prior skills lab practice. In a perfect world, the resident's prior experience, either in the lab or with other cases can be listed in an operative log and accessible to all involved online. It is the current standard for cases to be logged in real-time to avoid inaccuracies and a bow-wake of clerical chores at the end of the month, year, or training program. The ACS has a well-established operative experience log for both residents and attendings available online. In resource constrained environments, written logbooks or index cards should be maintained and kept up to date by both the trainee and the attending.

The affective or behavioral domain of learning has an equally important role. Hopefully the resident and attending have seen the patient together, either in the clinic, the pre-operative staging area, or both. Here the attending can serve as a role model for the trainees, exhibiting their thoughtful review of the case, the explanation of the expected results, and patiently answering the patient's questions while reassuring the patient and enlisting their trust. With more experience and exposure, the attending should observe the resident assuming the same role and note their bedside manner: skill in communication with the patients and the enlistment of trust. This is best done by direct observation, but sometimes gained by indirect observation and discussion with experienced nurses and others on the team.

The Operation: Technical Teaching Principles and Plan

Depending on the trainee's experience and the practice setting, some cases are still started by a resident. More often in today's environment, the attending is present in the OR and often scrubbed from the onset. Having assigned the respective roles as operating surgeon and teaching assistant, the operation can proceed with clear expectations. Cognitive skills employed by the attending consist of the case review, carefully directed questions of the trainee regarding the salient points of the case, and engaging in a discussion. A timely but efficient set of questions helps establish priorities, evaluates the knowledge of pertinent anatomy and pathophysiology and the logical and tactical abilities of the resident. The attending should be aware of Bloom's taxonomy of questioning levels and the ascending complexity from regurgitation of facts (anatomy) to the most complex.[5] It is important to vary the question level by using a level appropriate to the level of the trainee. Questions of strategy, analysis, and judgment particularly when encountering unexpected findings or changes in patient's physiology are typically reserved for the more advanced trainee.

BLOOMS TAXONOMY OF QUESTIONING SKILLS:

Level I	Knowledge
Level II	Comprehension
Level III	Application
Level IV	Analysis
Level V	Synthesis
Level VI	Evaluation

Technical skills instruction has been characterized as being uniquely different from verbal skills by Prater and can be grouped into 3 characteristics, 3 conditions, and 3 phases.[6] Three distinguishing *characteristics* of technical or motor skills are that they 1. involve a chain of mechanical responses; 2. involve eye-hand coordination; and 3. require organization of subtasks or subroutines. For example,

tension and counter tension on the skin before and during the draw of the scalpel makes the incision more efficient and less traumatic. The clearing of the ends of the bowel before suturing or stapling the anastomosis allows better visualization and more precise and effective closure.

Conditions that make skill learning more efficient and likely are 1. contiguity; 2. practice; and 3. feedback by the instructor. Contiguity refers to repeated trials at a skill in close temporal framework, and performing a similar routine enough to be able to remember and learn from prior attempts. One cannot learn to ride a bike by trying once and waiting a week to try again. The learner must listen to the feedback and encouragement of the instructor and continue to practice to make the necessary corrections on repeated trials as the teacher watches, gives feedback, and encourages them to persist. Experience and research have shown that in complex motor skills, 10 to 12 repeated attempts are typically necessary to reach any initial success. Feedback from an experienced instructor is essential for success and is most effective when it is done in real time, is objective, based on direct observation of the learner, and is non-judgmental. It should highlight specific behaviors and not personality defects or failings. However, feedback in order to be credible must also be both *positive* and *negative*. It should be encouraging when needed, but also point out areas that need improvement before they are forgotten. The delivery of effective feedback itself is a skill that takes knowledge and experience for the teacher to become a master educator. Continued practice, both observed and independently in a safe, non-threatening environment is also critical for learners to progress, build confidence, and become more proficient.

Phases

There are 3 phases of skill acquisition: a *cognitive* phase, *fixative* phase, and an *autonomous* phase. Reaching the third and last phase depends on the prior conditions which the learner brings to the activity. During the cognitive phase the teacher introduces the activity, explains the steps and stresses the importance and rationale. The learner must listen carefully and assimilate this knowledge in order to progress most efficiently. If any instruments are involved, this is the time for the learner to not just see them, but to handle them and become familiar with their function. The instructor must be aware of the learners' level of knowledge and capabilities to be most effective by performing a timely needs assessment. It is well known that trying to force a toddler to snow ski before they are physically capable will only result in frustration for the child and the instructor, and will often result in the child's aversion to any future attempts.

The *fixative* phase involves a 2-way street of trainee-instructor involvement where multiple attempts are made while the instructor provides real-time feedback. After assuring an initial level of competency, the instructor should back away and allow independent practice, but they must circle back to reassess and note any improvement. Lastly, the *autonomous* phase relies on multiple rehearsals and repetitive attempts in order to achieve a level of increased facility and confidence by the learner. Again, reassessment to monitor practice will assure that acquired skills are acknowledged, and equally as important, that any bad habits are recognized and pointed out by the instructor. It has been said that "without feedback mistakes persist uncorrected, good performance is not reinforced and clinical competence is achieved empirically, if at all."

Technical Teaching Concepts and Tips

Whether in the skills lab or the operating room, many principles can help your learner progress more efficiently. Many of these are common sense, but are unfortunately too often overlooked or underappreciated. These concepts include: *parallax*, *bracing*, *simplification of movement*, *visualization*, and *repetition*.

Parallax

Parallax is defined as the apparent displacement of an object when viewed from two vantage points not on a straight line. Simply stated, what you see is not necessarily what your student sees and often it is not even close. In a typical operation, the teaching assistant stands on the opposite side of the table than the learner. Structures in the midline will be seen differently by each observer, and an object, such as the gallbladder under the right edge of the wound, may even be completely hidden to the learner in an upper midline case. In the neck, the course of the recurrent laryngeal nerve can be quite different when viewed from two vantage points, which at the operating table can be 90 degrees different. Appreciation of this difference, anatomic knowledge, and experience of the instructor helps them be aware of the difference in perspective, appreciate the 3-dimensional aspects of the structure, and direct the procedure appropriately. While providing exposure, remember that your goal is to show the structure to the operator and not yourself. One of the advantages of minimally invasive surgery is that the structure in question is seen identically by the operating trainee and the more senior instructor that helps mitigate the lack of depth perception in the 2-dimensional environment. Parallax is inherent in our binocular vision and provides us with depth perception. Like converging lines in a drawing, two instruments introduced via different ports can help provide a sense of depth perception in this 2-dimensional environment.

Bracing

Bracing utilizes the principles of a lever, which requires a fulcrum to dampen the movement of an instrument. Bracing can be considered in both a "micro" and a "macro" context. Precise motor activity in a micro context requires bracing to dampen tremor and improve precision. A lever consists of a lever arm, a fulcrum (brace point), and a moment arm (the distance between the fulcrum and the point of action. Moving the fulcrum closer to the point of action or decreasing the "moment arm" of the lever helps stabilize the instrument and counter any inherent tremor of the operator. Many factors facilitate bracing: the surgeons body position (standing, sitting), resting of the forearms on the patient or the instrument on the wound edge. It also helps check the movement of the instrument after the needle is suddenly released of the friction that holds it in its course through the tissue. It is essential in micro-surgery and other precision movements. Macro-bracing is essential in checking the movement of the instrument as it passes through thicker tissues that impart a greater degree of friction. Once that resistance is suddenly gone, it is critical that the instrument, notably a trocar or chest tube, travel no further to avoid injury to vital organs downrange. Again, body posture is critical – a wide based stance, an engaged core, arms firmly held against the chest wall and elbows firmly resting on ones' hips will help prevent unnecessary injury.

Visualization

Seeing the tissue in the mind's eye and mentally rehearsing the movement in a conscious manner helps the learner become more precise. Being "mindful" in the "consciously competent" phase of development of mastery is essential before a complex motor skill can become truly autonomous and fluid or "unconsciously competent". The latter stage is characteristic of true mastery. One mentor implored me to consider in a Zen-like fashion that the surgeon's whole consciousness should ride the tip of the needle as it scribes its arc through the tissue. "Be the needle," they chanted. Like the slalom skier, snowboarder or gymnast with their eyes closed and head bobbing as they mentally rehearse the course ahead, surgical trainees must learn to "see with their mind, not with their eyes." Indeed, how many seasoned surgeons can well remember a structure that is out of sight and impossible to expose such as a diverticular phlegmon deep in the splenic fossa that defied classic dissection but demanded mindful, careful dissection and removal by feel alone. Extraction of the lost fecalith in the pelvis is one of the earliest challenges in the mindful repertoire of the developing resident.

Repetition

The famous Greenbay Packers football coach Vince Lombardi once quipped that "practice doesn't make perfect, perfect practice makes perfect." Achievement of mastery takes time and multiple repetitions, and sometimes many years of experience. Each trainee brings to the table their own inherent skill and ability. It is important to recognize and appreciate that not all will learn quickly. Given our experience, patience and repeated exposure to a trainee is necessary to help discern the slope of their individual learning curve. Broadwell described a 4 Stage model of achieving competence in skills training.[5] One can consider this relationship of competence and consciousness in a 2 by 2 matrix. Initially, the trainee has no idea of the components of a skill and when they observe a master's performance, it looks easy. They are "unconsciously incompetent." When the student takes the needle holder and makes their first pass with the needle, it goes flying across the wound when the needle is passed through the resistance of the dermis. With their sudden revelation, they become "consciously incompetent." With repeated attempts and concentration, they eventually achieve "conscious competence" and finally after what many have estimated to be thousands of repetitions, they become "unconsciously competent" like the master surgeon who sews the long suture line almost unthinkingly. After years of driving a car, we get in, turn the key and in the process of driving to work, make thousands of movements based on assessments with minimal direct awareness. We have become a masterful driver, almost but fortunately not completely unconscious in a clinical sense, but surely in the paradigm of motor skills acquisition.

The Affective Domain in the Operating Room

Increasingly more attention has been directed towards this vitally important concept. The behavior and emotional tone of the entire surgical team is critical to success for the patient. Traditionally, surgeons were seen as stern taskmasters barking orders, throwing instruments and ruling the room like the tyrannical "captain of the ship." Surely there is need for definitive leadership, but recent experience and the subsequent evolution of "Team Steps" training based on a recognition that how disruptive behavior results in untoward outcomes for patients and may be a sentinel event suggesting the need for evaluation and treatment for personnel. Application of "Team Steps" training in critical clinical settings has resulted in a better awareness of the emotional tone of the OR. Better attention to the hazards of sleep deprivation and excess stress has stimulated wellness programs in most medical centers. Maintaining a sense of calm, focus and attention to the needs of the OR crew is essential. The attending is

the ultimate role model for the trainees and residents should be actively trained in these important methodologies. Consistent, constant attention to basic courtesy and the liberal use of "please" and "thank you" as the case progresses can help foster a happier, healthier environment for the entire staff. Addressing others by name and engaging them in pleasant conversation during mundane, less stressful phases of the case helps build comradery. A simple "thank you" during, and surely the end of the case, can make a huge difference and build trust among the entire team.

The Post-Operative Period

Cognitive Tasks

A "time-out" or "debriefing" review of the case with the entire crew should occur before the patient leaves the room if the clinical condition allows. Discussion of what went well, what could have gone better, and room for further discussion and improvement helps wrap up the case, bring closure, and keep the lines of communication open. Whether in the OR or in the Recovery Room, the post-operative orders must be written. As soon as possible, the Operative Report should be completed. If time does not allow, a "Brief Operative Note" should be completed before handing off the patient to the recovery room or ICU staff. The usual components of this note and the Operative Report help the post op care team understand the case in better detail, the needs of the patients intra-operatively and the plan for further care. Failure to do so, particularly in ICU patients, puts the accepting providers in the dark and the patient at grave risk.

Technical Tasks

Much activity must happen to safely transfer the patient from the table to the stretcher. Helping to clean up, remove trash and help lifting the patient helps engender respect from the rest of the crew. Dressings should be secure and neat. Splints and casts applied if necessary.

Affective Tasks

Remember to thank the team. One person, typically the senior most member of the operative team, should find the family member and speak to them as soon as possible. Until they look you in the eye and hear the words "they are doing fine," the anxious family member assumes the very worst. The hours spent in the OR waiting room are some of the longest hours of one's life. If you cannot locate the family, leave word at the desk with your contact information. Remember to call the referring provider to update them on the patient's surgical care, the findings, the procedure performed and the expected post-op course and patient location. Even in emergent cases, the ER team and the prehospital personnel should be considered just as important as they too are referring providers and will appreciate your treating them as such.

CONCLUSION

Surgical care of the patient is one of life's greatest honors. Surgical education to train the next generation of surgeons, despite its many challenges, is one of life's greatest responsibilities. The Operating Room is the perfect setting for teaching and learning our craft, utilizing the Principles of Adult Learning. Organization of the goals and objectives of the operation around the 3 phases of surgical care; pre op, intra-op and post-op wrapped in the organizational scheme of the 3 domains of learning: the cognitive, the psychomotor, and the affective helps facilitate the learner's development into a competent surgeon to assure today's patients a safe, smooth recovery and the optimal care of patients for generations to come.

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