Active Learning in Medical Education: Application to the Training of Surgeons

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ABSTRACT: Our article defines active learning in the context of surgical education and reviews the growing body of research on new approaches to teaching. We then discuss future perspectives and the challenges faced by the trainee and surgeon in applying active learning to surgical training. As modern surgical education faces numerous challenges, we hope our article will help surgical educators in the evaluation of curriculum development, methods of instruction, and assessment.

KEYWORDS: active learning, surgical education, residency, student-centered

Introduction

“The inability of students to appreciate the scope, meaning, and limitations of science reflects our conventional lecture-oriented curriculum with its emphasis on passive learning ... What is urgently needed is an educational program in which students become interested in actively knowing, rather than passively believing.”

—Volpe.¹

As surgeons, we make decisions for our patients based on the best available evidence in a patient-centered approach. Does it not naturally follow that we would teach our prodigies by evidence-based student-centered approaches as well? Active learning is well supported by evidence to be an effective approach that leads to longer lasting, meaningful learning,² though unique challenges exist in its application to surgical education. Challenges include a heightened emphasis on operating room efficiency, patient safety concerns, and duty hour restrictions, which have led to a decrease in patient-based learning experiences for surgical trainees.³ Thus, there is a growing call to the development and adoption of a standardized training curriculum that actively engages the surgical trainee to maximize confidence and competence.

The purpose of this review is to define active learning in the context of surgical education and review the growing body of research on new approaches to teaching that can be adopted by surgical teaching communities. We then discuss future perspectives and the challenges faced by the trainee and surgeon in applying active learning to surgical training.

What is Active Learning?

According to the Greenwood Dictionary of Education,⁴ active learning is defined as the process of having students engage in regular reflection, self-assessment, problem solving, and attaining knowledge through participation or contribution. Whereas student-centered learning is defined as the approach in which students influence the content, activities, material, and pace of learning,⁵ Barr and Tagg⁶ have discussed a change in the educational paradigm from one that focuses on teaching (teacher-centered) to one that focuses on learning (student-centered). Thus, the teacher designs and implements the learning environment in a student-centered active learning approach, and the student’s behavior is the significant determinant of what is learned. This approach can be implemented in simulation and role-play environments using self-paced or cooperative team-based learning. Student-centered learning places the responsibility for learning on the student and has been shown to increase the motivation to learn with greater retention of knowledge and a deeper understanding of the subject being taught.⁶

History of Reform in the Teaching of Surgery

Surgery is a very large discipline, and the surgical education community has begun to make significant contributions to research on teaching and learning. The American College of Surgeons began a certification program in 2005 dedicated to establishing excellence and ingenuity in surgical training.⁷ This consortium continues to function as a resource for centralizing research on the topic of surgical education, both new techniques and updates of old approaches. The common theme from the
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The need for change. Present day surgical education is facing numerous challenges. In 2003, the American Council for Graduate Medical Education imposed a limit on resident work hours to no more than 80 hours in the hospital per week. The intention behind duty hour restrictions was to improve patient safety and resident quality of life, though limited operative hours place the training of surgeons using the traditional, apprenticeship-style “see one, do one, teach one” mode at a significant disadvantage. These changes occurred in the setting of increased external pressures on faculty to enhance operating room efficiency as well as clinical and research productivity that led to diminished prioritizations of teaching. Expanding medical and technological innovation as well as regulatory requirements has increased the amount of knowledge residents are expected to master during their training. Owing to these and other converging factors, pass rates on the American Board of Thoracic Surgery examination remain suboptimal, and the importance of improved teaching and learning efficiency is at its height.

Michael and Modell have described some student-centered active learning approaches, each will be discussed along with their application specifically to surgical education.

Application of student-centered active learning to surgical education.

Learning involves the active construction of meaning by the learner. In Bloom’s Taxonomy of Educational Objectives, the stages of learning range from memorization to the meaningful application of knowledge and finally to the mastery of metacognitive skills to monitor one’s own thinking process. An important aspect of meaningful learning is the extent to which what has been learned can be applied in, or transferred to a context different from the one in which it was originally learned.

As Driver et al states, “knowledge cannot be transmitted but must be constructed by the mental activity of learners.” Students construct meaning by linking new information with what they already know. In the training of surgeons, students should be given opportunities to engage new material in a context that creates multiple representations of the new knowledge and facilitates establishing relationships between old and new knowledge.

To facilitate the active construction of meaning, one can provide new information using multiple modalities including vision, auditory, and touch. Recent innovations in this direction include the utilization of three-dimensional printing to generate a visual and tactile model, which has led to improved surgical education and practicing of operative technique by senior surgeons for challenging cases. Other instructional techniques to encourage active learning include discovery-based learning, discussion of patient cases along with simulation using high- or low-fidelity models. These techniques have been shown to lead to transferrable skills to the operating room and result in improved performance on questions related to the topic. The benefits of discovery-based learning include its (1) focus on ideas and concepts rather than conceptually unrelated pieces of information and (2) encouragement for strong active participation driven by the requirements to solve the problem at hand. While some decisions in surgery afford the luxury of time to consult other sources of information, many decisions do not. Thus, both time-limited and unlimited discovery-based learning should be incorporated to ensure students experience the pressure and realistic problems that they will have to manage.

Learning to do something (how—procedural knowledge) and learning facts (what—declarative knowledge) are two different processes. Knowing how to do something and knowing what something is, procedural and declarative knowledge, respectively, are distinct knowledge sets that come with different challenges to learning.

Surgery is a specialty that requires mastery of both procedural and declarative knowledge. Patient care is always of paramount importance. Students should first observe skills being modeled by the teacher, understand what the task is, master the individual steps through practice with timely and appropriate feedback, and then apply these skills to patient care. In 2004, the American Surgical Association Blue Ribbon Committee Report on Surgical Education recommended defining a curriculum for surgical skills to be acquired by students outside the operating room prior to practicing on actual patients. Although this has resulted in a guideline for surgical skill education, the repetition of tasks does not necessarily result in proficiency. The essential element to acquiring proficiency is feedback, each step must be critiqued and challenged to analyze student performance and make adjustments to improve.

In the acquisition of procedural knowledge, there has been a rise in interest in teaching laboratories with formal curricula designed to teach surgical skills on models and simulators. Live animals, cadavers, bench models, virtual reality surgical simulators, and human performance simulators have all been employed for single as well as team training and crisis management with demonstrated efficacy for various procedural skills. These have the benefit of reusability, objective evaluation, and data capture of learner skill proficiency as well as interactivity to promote active learning, problem solving, and patient management. However, widespread applicability of these models and simulators is limited by cost, availability of models for specific procedural skills, situations or environments, and the level of fidelity. Though fidelity is improving with technological developments, these tools will never completely replace learning in the clinical setting, and thus, may be limited to junior trainees or teaching new skills to practicing surgeons.
In the realm of improving active learning in declarative knowledge, innovative educational techniques, including Internet-based courses, have been shown to be effective in supplementing clinical teaching efforts in surgical education with incorporation of active learning through embedded assessments. Other novel methods to active learning of declarative knowledge include online journal clubs as well as the extension of surgical education from operating and lecture theaters to the worldwide web, which improves ease of access, time efficiency, and student online engagement with the material. Students can also access multimodal surgical education portals including the Surgical Council on Resident Education and assess their understanding through incorporated question banks. These initiatives have been shown to improve the learning and retention of medical knowledge, patient care, professionalism, and interpersonal communication skills.

Active learning is enhanced by learning in group environments and by articulating explanations. Learning is often treated as though it should be a silent and independent process with students reading or solving a problem. However, the acquisition of new knowledge can be improved by articulating one's understanding of the material through hearing, reading, speaking, and writing to themselves, peers, or instructors. Learning in a group environment allows students to take responsibility and maximize their own and each other's learning. These environments in the surgical setting can be a discussion or debate surrounding a realistic case or challenging concept with other students or a conversation about why we do the things we do in the operating room. The aforementioned methods can also be used to acquire declarative knowledge. As adults learn better when given information in the context of real-life situations, this is something we can leverage to our advantage in the training of surgeons. Articulating or explaining one's reasoning to others can allow students to engage in active learning, promote interlearner relations, collaboration, focus on the thought process and not just the generation of a correct answer, readily obtain feedback, and learn the skills to apply their growing knowledge. In contrast, copying solutions to a problem from a blackboard or learning the right answer from the back of a textbook does not offer these benefits. Group learning also improves teacher and student interactions and addresses student perceptions, misconceptions, and learning difficulties as a team. Whether improved communication skills of students with each other and their teachers in group learning environments can translate to superior patient education skills has yet to be reported.

Despite the benefits of group learning, its success heavily relies on communication and the willingness of students to share their ideas, what they believe in, understand, and do not understand. Communication can take form in arguments, debates, explanations, and negotiations and overall has been shown to lead to a better understanding of the subject matter.

Measures of outcome. The goal of any surgical education program is to train students into competent surgeons. A method to objectively assess the success of surgical training programs and student knowledge and management of clinical problems related to surgery is the American Board of Surgery In-Training Examination (ABSITE). Institutions that provide students with study programs that involve active learning demonstrate improved scores on standardized tests where ABSITE scores that rose 34% in four years were linearly correlated with active learning interventions. Though interestingly, subjective surgeon evaluation of surgical student, patient care, technical skills, problem-based learning, interpersonal and communication skills, professionalism, systems-based practice, and medical knowledge do not correlate with ABSITE scores, nor do they predict passing. Furthermore, there may be unintended bias of the ABSITE against students who prefer to learn by listening and speaking, while favoring learners with a predominant read/write preference. Thus, it is unclear whether subjective student evaluation and ABSITE scores fully assess the competency in surgical students.

Other avenues of evaluation include the Fundamentals of Laparoscopic Surgery tasks for surgical skills acquisition, online surgical courses with embedded assessments, standardized patient encounters for interpersonal and communication skills, and mock oral examinations for patient care-related decision-making. Innovations in models and simulation technology for surgical training and objective evaluation by the Association for Surgical Education are eagerly anticipated.

Regular evaluation of surgical residency models should be done to ensure that programs are meeting their training goals in the areas of rotations, student quality of life, operative experience, ABSITE, faculty, and hospital patient care metrics. Utilization of a uniform and comprehensive evaluation of resident competency that is consistent within and across programs is warranted.

Challenges and future perspectives of active learning in the teaching of surgeons. In the following section, the challenges in training surgeons through active learning approaches are reviewed. In addition, other points of interest towards improving surgical education include curriculum planning by regular needs assessment. These will include a survey of the current and projected needs of the profession, role of the surgeon in the setting of increasing medical specialist roles, emerging technologies, and their projected impact on the surgical workforce. It will also include the revolving indications for procedures and patient population, as well as the anticipated changes in health-care practices in response to economic, political, or societal influences.

The trainee perspective. In the education of surgical trainees, it is imperative that we ask: how do surgical trainees prefer to learn? The traditional paradigm of surgical training by apprenticeship assumes that all residents learn and progress in a similar fashion and pace. Leveraging trainee learning
style preferences has been proposed to maximize learning efficiency,\(^4\) with the majority of surgical learners preferring to learn in a multimodal fashion.\(^8\) Although developing individualized curricula for every learner would be highly time and resource intensive and likely not feasible, a coordinated effort to promote a student-centered multimodal learning environment may lead to benefit.\(^2\) Furthermore, tailoring of student-centered approaches can be done in longitudinal apprenticeship-based training.\(^49\) This can be accomplished by blending learning environments with as many sensory modalities as possible that would maximize the number of students who would receive their preferred learning style as well as getting to know the strengths and weaknesses of the students. Examples include making didactic lectures available for review in transcript (read/write), audio podcast (aural), and PowerPoint presentation formats (visual) with anatomic models or hands-on sessions (kinesthetic).\(^50\) In addition, it has been proposed that increased awareness of learning style preferences\(^51\) as well as the matching of learner to teacher with compatible learning and teaching preferences shows benefit in surgical training.\(^52\)

Exposure to surgical procedures depends on the availability, case diversity, program caseload, duration of training, as well as the risk and learning curve of the procedure—where high-stakes procedures are more likely to be performed primarily by faculty.\(^53,54\) Intersurgeon procedural variation may add a layer of complexity to learning surgical technique, skills, and assessment of competence.\(^55\) Though it is an accepted philosophy that learning different approaches of surgeons for the same procedures creates a catalog for students to use in future practice for situations of variable patient anatomy, logistics, and learner characteristics.\(^55,56\) Nonoperative patient management may also vary by programs with differing amounts of participation by medical specialists.

Beyond procedural and declarative knowledge, surgical students must also master nontechnical skills including situation awareness, decision-making, teamwork, and leadership. Nontechnical skills matter in surgical care and are not universally trained, practiced, or assessed in surgical education.\(^57\) Active learning of nontechnical skills through simulation, coaching, regular reflection, self-instructor, and peer assessment have demonstrated improved students’ operative performance and leadership.\(^34,58\) Yule et al.\(^56\) demonstrated that coaching improved resident Non-Technical Skills for Surgeons score by 3 compared with −0.1 in the control group \((P = 0.04)\). Mapping of the learning curve and robustness of nontechnical skill acquisition and competency deserve further exploration.\(^58\)

The surgeon perspective. In the training of surgeons, surgeons must create an environment to help students engage in an active learning process. Though challenges for surgeons to implement active learning include the lack of role models and the experience to do this, as the model of education they have been exposed to is one in which the teacher gives knowledge and the students receive. Another challenge is that surgeons operate at opposite ends of the spectrum of mastery as the student and will need to break up an automated skill into components so that each part can be demonstrated and taught.\(^49\) The key to successful teaching is to focus on the student and what they need to reach their intended output state. To anticipate the needs of the student requires reflection and a targeted needs assessment as well as the trust, given the opportunity and appropriate direction, the learner will learn.

In the education of students to become competent surgeons, external pressures of public accountability for surgeon decision-making, health-care outcomes, and the need to increase both clinical and research productivity place constraints on the available time.\(^49\) This has been shown to lead to decreased faculty–resident interactions and faculty teaching.\(^31\) Although patient care will always take precedence to teaching, teaching should be regarded as a scholarly work, like research, which can be carried out in conjunction with clinical responsibilities. As the goal of scholarship is used to advance the knowledge in a field, critique what others do, and expect critique for what you do, does teaching not align with these goals also? There is an obligation to practice teaching as we practice any other scholarly activity and those that do, will find that they will become part of a community of educators whose goal is to improve the educational process, in addition to disseminating information about a particular content area.\(^6\)

Cooper\(^59\) defined the roles of the teacher in a student-centered active learning environment. The teacher\(^1\) develops the educational program;\(^2\) models the kinds of behaviors they expect their students to engage in;\(^3\) functions as a mentor or facilitator of the students’ learning efforts;\(^4\) and evaluates student performance and learning. There is a lot to learn in surgery, including procedural, declarative, nontechnical knowledge, and professionalism that we, as surgeons have spent years to master, hope to impart to our trainees in as evidence-based a manner as we can. Furthermore, students challenge their teachers to set appropriate goals, solve student difficulties, and be reflective in our surgical practice and teaching. Educating students is as much as educating the educator, and can be embraced to make us better surgeons for both our patients and our students.

**Conclusion**

The pressures of learning the art of surgery with duty hour restrictions require new approaches to learning. Just as we practice patient-centered care with evidence-based medicine, so too, should we teach by active learning, student-centered approaches with evidence-based teaching. There is evidence that active learning leads to superior understanding and retention of procedural, declarative, and nontechnical knowledge. This kind of learning is a reminder to both students and surgeons that teaching and learning is a lifelong requirement of our profession and if
embraced, will help us reach our ultimate goal—to train competent, knowledgeable, and compassionate surgeons of the future.

**Author Contributions**

Wrote the manuscript, jointly developed the structure and arguments for the paper, made critical revisions, and approved the final version of the manuscript: IGYL and MBA.

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