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Introductory Surgical Skills Course: Technical Training and Preparation for the Surgical Environment

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Abstract

Introduction: Early exposure to surgery in a positive learning environment can contribute to increased student interest. The primary objectives of this study included developing increased comfort in the operating room (OR) environment, confidence in surgical skills, and mentorship for students interested in surgery. **Methods:** The course comprised seven 2-hour sessions covering both nontechnical and technical skills facilitated by attending and resident surgeons. Sessions included nontechnical skills training, basic knot tying and suturing, laparoscopic surgical skills, and high-fidelity operative simulations on animal and cadaver models. The curriculum also matched students with faculty mentors in order to scrub into operative cases. Surveys assessing self-reported comfort in the OR, confidence levels in surgical skills, and whether students had mentors in surgery were distributed before and after the course. **Results:** Thirty preclinical medical students were enrolled in the course in 2016 and an additional 41 students in 2017. Results showed increased confidence in all skills and in comfort in the OR, as well as increased surgeon mentorship. Thirty-two students who completed the course entered clinical rotations in 2018 and, when surveyed, reported increased confidence in the aforementioned domains and in their preparedness for their surgery clerkship, compared to 49 peers who had not completed the course. **Discussion:** The course successfully increased comfort in the OR, increased confidence in performing surgical skills, and provided students with mentors in surgery, all of which will hopefully foster positive experiences during their surgery clerkship and ultimately increase their consideration of surgery as a career.

Keywords

Surgical Environment, Surgeon Mentors, Early Exposure to Surgery, Student Confidence

Educational Objectives

By the end of this course, student learners will have:

1. Increased their self-reported confidence in performing technical skills in the operating room environment.
2. Increased their self-reported comfort in the operating room environment.
3. Developed mentors in the field of surgery.
4. Increased their self-reported interest in a career in surgery.

Introduction

The surgical learning environment can be stressful and one to which preclinical medical students often have limited exposure. Successfully navigating the operating room is a challenge to developing an interest in surgery prior to the clerkship experience. Additionally, the clerkship experience itself can be drastically different for medical students based on student anxiety or comfort in the operating room. Therefore, it is important to create mentored experiences in surgery that facilitate student exposure to and comfort in these environments. Data also suggest that most medical students commit to a career discipline prior to entering their clerkship years, suggesting that early exposure contributes to increasing the number of matched students in general surgery.^{1,2}

Appendices

- A. Week 1.pdf
- B. Week 1 Introductory Presentation.pptx
- C. Two-Handed Knot Tutorial .mp4
- D. One-Handed Knot Tutorial .mp4
- E. Week 2.pdf
- F. Week 3.pdf
- G. Week 4.pdf
- H. Week 5.pdf
 - I. Cognitive Skills of the Hand-Sewn Bowel Anastomosis.mp4
 - J. Technical Skills of the Hand-Sewn Bowel Anastomosis.mp4
- K. Week 6.pdf
- L. Week 7.pdf
- M. Precourse Survey.docx
- N. Postcourse Survey.docx

All appendices are peer reviewed as integral parts of the Original Publication.

The type of exposure that students receive is important. Early operative experience in a positive learning environment has been shown to better prepare students to appreciate and benefit from the real-time teaching that takes place in the operating room.^{3,4} Furthermore, the positive learning environment fostered by surgeon attendings is the strongest predictor of students entering general surgery.⁵ To capture student interest prior to the surgery clerkship, our institution developed a curriculum that provided an intensive and stepwise surgical immersion experience for preclinical medical students. Initially developed as a skills-based course, the curriculum was revised in 2014 to better represent surgery in its breadth and depth. Multiple iterative curricular changes were made over the years based on student feedback, and major curricular changes were made based on a rigorous curriculum evaluation performed in 2016.

During the formal curriculum evaluation and needs assessment, surveys were distributed to students and instructors who had completed the 2015 course. The most common reason students enrolled in our course was to better prepare themselves for the surgery clerkship. As a result, the technical skills training remained an important part of the curriculum but was refocused to emphasize skills students were likely to use on the surgery clerkship, such as basic suturing, knot tying, and laparoscopic camera navigation skills. Our needs assessment also identified a number of nontechnical skills that students desired to learn. In response, a nontechnical skills training component was added, including a review of situational awareness, decision making, communication, and teamwork strategies adapted for medical students from *The Non-Technical Skills for Surgeons (NOTSS) System Handbook*.⁶ Finally, a mandatory shadowing experience with an assigned faculty mentor was incorporated into the curriculum to help increase students' comfort in the operating room environment prior to their clerkship experience.

The course is unique both to the literature at large and, more specifically, to *MedEdPORTAL* in that its primary objectives are to increase student confidence via an intensive, stepwise introduction to surgery and the operating room environment. We accomplished this with discrete modules designed to improve confidence in both technical and nontechnical skills along with providing immersive operating room experiences. Multiple curricula have been published concerning basic suturing skills including knot tying and suturing, in addition to simulations for introducing students to the surgery clerkship.⁷⁻¹⁰ However, our course's sessions were designed to build upon one another, beginning with basic technical and nontechnical surgical skills and culminating in an operation performed on a cadaver in order to allow students to apply the skills learned in a simulated operative experience. Overall, this course provides a broad spectrum of resources that institutions can implement to facilitate preclinical medical students' interest in the surgical profession along with helping them prepare for the surgery core clerkship.

Methods

The course comprised seven 2-hour sessions held once per week during the preclinical years of medical school. Students were selected for the course on a first-come, first-served basis, giving second-year medical students preference over first-year medical students. Second-year students were given preference as they were closer in proximity to their clinical years when the skills learned from this course would be immensely relevant. Requirements outside of the scheduled class time included a compulsory shadowing experience in the operating room with an assigned faculty mentor and the video or written materials distributed in advance of each session to help students come prepared for practice.

Prior to being permitted to shadow in the operating room, students should be taught proper sterile technique. Scrub training should be institution specific as these certification requirements vary by institution. Sample learning objectives for teaching sterile technique are included in Appendix A, though it is expected that students complete the training required by their institution. A study is currently under

review outlining the content of a learner assessment tool for scrub training knowledge in use at our institution (B. Hasty, MD, MHPE, J. N. Lau, MD, MHPE, A. Tekian, PhD, MHPE, S. Miller, E. Shipper, MD, S. Bereknyei Merrell, DrPH, MS, E. W. Lee, MD, Y. S. Park, PhD, unpublished data, 2018). This tool consists of a pre-session knowledge assessment, a video showing sterile technique, an in-person assessment during which students demonstrate their technique, and a post-session knowledge assessment.

Each week, students were provided with prereading and/or videos prior to each session. This helped students come to class prepared to practice and learn the techniques for each session. Session schedules and required readings are included in the guidelines.

Detailed instructions for preparing and leading each session are included in Appendices A-L. Sessions were held in a large room with tables arranged with the same number of small groups as there were instructors for a given day. The laparoscopic skills session required Fundamentals of Laparoscopic Surgery task trainers (or the institution's laparoscopic skills training equivalent), and the cadaver session was arranged with the medical school's cadaver lab facilities (or equivalent).

Materials required for each week are listed under the equipment list section in the guidelines associated with each session. Materials for all sessions were purchased prior to the first week of the course in order to reduce shipping costs and last-minute supply needs. Some sessions required more complex equipment (e.g., laparoscopic towers, surgical instruments, etc.) that was secured prior to the start of the course in order to identify any necessary modifications to the curriculum or course session.

During the first week of the course, students were matched with a surgeon-mentor from a group of volunteer faculty who offered to host a preclinical student in their operating room at least once during the course period. The students were then asked to contact their faculty mentors by email to schedule a date and time to shadow them (example student email in Appendix B).

Course sessions included the course introduction, scrub training, and two-handed knot tying (Appendices A-B), one- and two-handed knot tying (Appendices C-E), basic suturing (Appendix F), laparoscopic skills (Appendix G), two-layer hand-sewn bowel anastomoses (Appendices H-J), laparoscopic cholecystectomy (Appendix K), and a cadaver simulation lab (Appendix L). The overall progression of the course is shown in the Figure.

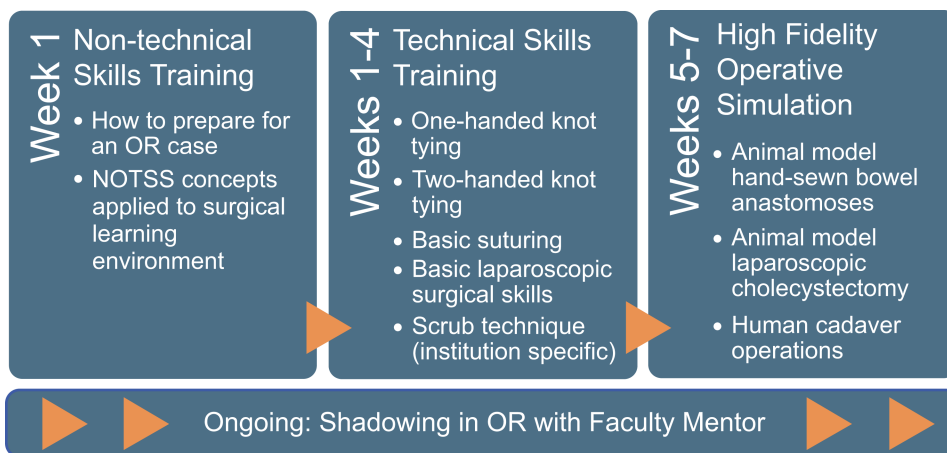


Figure. Overall progression of the introductory surgical skills course. Abbreviations: NOTSS, nontechnical skills for surgeons; OR, operating room.

The course sessions were taught by attending surgeons and supported by surgical education fellows and surgical residents. For each skills session, a faculty member was present to provide expert instruction. It is recommended that surgical residents and fellows be recruited to offer individualized training and feedback. In our experience, a student-to-instructor ratio of 8:1 is sufficient for the technical skills taught throughout the course except for the laparoscopic cholecystectomy simulation (4:1) and the cadaver lab (5:1). Faculty surgeons were recruited to teach skills that fell within their area of expertise (e.g., general surgeons for laparoscopic cholecystectomy). Finally, six attending surgeons, surgical residents, and/or surgical education fellows were necessary to teach procedures during the final cadaver session in which small groups of students performed various operations on a cadaver. These instructors were from a variety of surgical subspecialties so as to expose the students to the breadth of surgery and allow them the opportunity to sign up for the procedure of their choosing.

The course was evaluated using pre- and postcourse surveys that queried students about their comfort level in the operating room, their confidence in performing various technical and nontechnical skills, whether or not they had mentors in surgery, the overall effectiveness of the course, and their level of interest in a career in surgery. The surveys that were distributed to students are included as Appendices M (precourse survey) and N (postcourse survey).

Results

In the 2016-2017 academic year following our curriculum revision, 30 students elected to enroll in the course, which was run between October and December. Pre- and postcourse surveys were distributed to students, and pre- and postcourse mean confidence levels were calculated for a variety of measures. There was a 100% (30 out of 30) response rate on the precourse survey and a 93% (28 out of 30) response rate on the postcourse survey. Detailed results from that year's students can be found in the article by Shipper and colleagues¹¹ and are summarized in [Table 1](#).

Table 1. 2016-2017 Academic Year Student Pre- and Postcurriculum Self-Reported Confidence Levels

Skill	Self-Assessment ^a		p
	Precurriculum M ± SD (n = 30)	Postcurriculum M ± SD (n = 28)	
Knot tying confidence	1.5 ± 0.5	3.5 ± 0.8	<.001
Basic suturing confidence	2.0 ± 0.8	3.2 ± 0.6	<.001
Laparoscopy confidence	1.2 ± 0.4	2.7 ± 0.6	<.001
Bowel anastomosis confidence	1.4 ± 0.7	2.4 ± 0.9	<.001
Scrub technique confidence	1.9 ± 1.0	3.6 ± 0.6	<.001
Overall comfort in the operating room	2.3 ± 1.1	3.3 ± 0.7	<.001

^aFive-point rating scale (1 = *Not at all*, 2 = *Slightly*, 3 = *Moderately*, 4 = *Very*, 5 = *Extremely*).

Of those queried about the addition of the faculty mentor component to the course, 30% of students (nine out of 30) reported that they had a faculty mentor in surgery prior to the start of the course; at the course's conclusion, 62% (16 out of 26) reported that they had a mentor. When asked if the curriculum had been successful in creating learning opportunities related to a career in surgery outside of the formalized course structure, all students (25 of 25) responded yes. Overall, students rated the mean effectiveness of the course as 4.0 (*SD* = 0.4) out of 5, with 4 representing "Very effective." Students' aggregate interest in a

career in surgery did not significantly increase following the course's completion, with mean ratings of 3.8 ($SD = 1.0$) from presurvey data and 4.2 ($SD = 0.9$) in the postsurvey data ($p = .14$).

The positive results from the new curriculum's inaugural year prompted us to increase the class size and to gather additional data the following year, data that have not previously been reported. In the 2017-2018 academic year, 41 students were enrolled in the course, which was run between October and December. Similar to the 2016-2017 year, pre- and postcourse surveys querying self-reported confidence levels in various skills were distributed to students. Forty-one out of 41 (100%) students completed the precourse survey, and 26 out of 41 (64%) students completed the postcourse survey. The decrease in response rate was likely due to the survey being distributed during the USMLE Step 1 study period. The results from these surveys are summarized in [Table 2](#).

Table 2. 2017-2018 Academic Year Student Pre- and Postcurriculum Self-Reported Confidence Levels

Skill	Self-Assessment ^a		p
	Precurriculum <i>M</i> ± <i>SD</i> (n = 41)	Postcurriculum <i>M</i> ± <i>SD</i> (n = 26)	
Knot tying confidence	2.3 ± 1.0	3.9 ± 0.7	<.001
Basic suturing confidence	2.3 ± 0.9	3.5 ± 0.7	<.001
Laparoscopy confidence	1.2 ± 0.5	2.9 ± 0.9	<.001
Scrub technique confidence	2.4 ± 1.1	4.3 ± 0.7	<.001
Overall comfort in the operating room	2.4 ± 1.1	3.5 ± 0.7	<.001

^aFive-point rating scale (1 = *Not at all*, 2 = *Slightly*, 3 = *Moderately*, 4 = *Very*, 5 = *Extremely*).

Twenty-seven percent of student respondents (11 out of 41) reported that they had a faculty mentor in surgery prior to the start of the course; at the course's conclusion, 54% (14 out of 26) reported that they had a mentor. Similar to the previous year, students' aggregate interest in a surgical career did not show a statistically significant increase following the course's completion, with mean ratings of 3.2 ($SD = 1.3$) from presurvey data and 3.6 ($SD = 1.3$) in the postsurvey data ($p = .271$). Overall, students rated the mean effectiveness of the course as 4.0 ($SD = 0.8$) out of 5, with 4 representing "Very effective."

In a separate evaluation of the curriculum for the 2018-2019 academic year, we queried all rising third-year students ($n = 81$) in order to demonstrate that our course was effective in preparing students for their surgery clerkship. Thirty-two students had completed our course, while 49 had not. All students were asked to report their confidence in technical and nontechnical skills required for the surgery clerkship, in addition to overall confidence in the operating room and their self-reported preparedness for the clerkship overall. We subsequently compared responses from students who had taken the course (100% response rate, 32 out of 32 students) to those who had not (100% response rate, 49 out of 49 students) to assess the course's effectiveness. The results from this survey are summarized in [Table 3](#) (demographic information of the respondents) and [Table 4](#) (respondents' self-reported confidence levels).

Table 3. Demographics of Students Who Had and Had Not Completed the Course

Demographic	Students Who Completed the Course (n = 32)			Students Who Did Not Complete the Course (n = 49)			p
	Number	%	<i>M</i> ± <i>SD</i>	Number	%	<i>M</i> ± <i>SD</i>	
Male	13	41%		27	55%		.205
Years since enrollment			2.5 ± 1.1			2.5 ± 1.3	.971

Table 4. Comparison of Self-Reported Confidence Levels Between Students Who Had and Had Not Completed the Course During the 2016-2017 and 2017-2018 Academic Years

Skill by Demographic	Confidence Level ^a				p
	Students Who Completed the Course (n = 32)		Students Who Did Not Complete the Course (n = 49)		
	M ± SD	p ^b	M ± SD	p ^c	
Knot tying					
All students	3.4 ± 0.8		2.1 ± 1.1		<.001
Male	3.3 ± 0.6		2.1 ± 1.0		
Female	3.5 ± 0.9	.46	2.1 ± 1.2	.93	
Basic suturing					
All students	3.1 ± 0.6		2.0 ± 1.0		<.001
Male	3.0 ± 0.6		2.0 ± 0.9		
Female	3.2 ± 0.7	.50	2.1 ± 1.2	.55	
Laparoscopic skills					
All students	2.3 ± 0.8		1.2 ± 0.6		<.001
Male	2.0 ± 0.7		1.2 ± 0.5		
Female	2.6 ± 0.8	.04	1.2 ± 0.7	.83	
Scrub techniques					
All students	3.2 ± 0.6		1.9 ± 0.9		<.001
Male	3.2 ± 0.8		1.8 ± 0.9		
Female	3.2 ± 0.4	.79	2.1 ± 1.0	.39	
Operating room etiquette					
All students	3.1 ± 0.8		2.1 ± 1.0		<.001
Male	3.0 ± 1.0		2.0 ± 1.0		
Female	3.1 ± 0.6	.71	2.2 ± 1.0	.52	
Overall comfort in the operating room					
All students	3.1 ± 0.7		1.9 ± 0.9		<.001
Male	3.1 ± 0.6		1.9 ± 1.0		
Female	3.1 ± 0.8	.92	2.0 ± 0.9	.70	
Preparedness for clerkship					
All students	2.8 ± 0.8		1.8 ± 0.9		<.001
Male	2.6 ± 1.0		1.8 ± 0.8		
Female	2.8 ± 0.7	.46	1.7 ± 1.0	.60	

^aFive-point rating scale (1 = *Not at all*, 2 = *Slightly*, 3 = *Moderately*, 4 = *Very*, 5 = *Extremely*).

^bThis p value compares mean confidence levels between male and female students who completed the course.

^cThis p value compares mean confidence levels between male and female students who did not complete the course.

There were no statistically significant differences in demographics between the two groups. Compared to their peers who did not take the course, students who took our course self-reported significantly higher confidence levels in technical skills, nontechnical skills, and preparedness for the surgery clerkship, in addition to comfort levels in the operating room. Female students who completed the course reported a significantly higher level of confidence in laparoscopic skills (2.6 ± 0.8) compared to their male counterparts (2.0 ± 0.7; $p = .04$).

Discussion

Generating interest in surgery among preclinical medical students can be challenging as few representative surgical experiences are offered to students early in medical school. This course was designed to fill that gap with an intensive surgical immersion experience with a mentorship component for preclinical medical students. Not only are these early experiences important for students interested in surgery but also the skills taught in this course serve to prepare students for their required surgery clerkship. Student interest in our curriculum came from those who were surgically inclined but also from those seeking preparation for the surgery clerkship. The overwhelmingly positive evaluations, in addition to the course's lengthy waiting list each year, are suggestive of the course's continued success.

By providing a curriculum for students to increase their confidence in both technical and nontechnical skills, we have facilitated their ability to fully explore the field of surgery early in their medical school tenure. As has been reported, positive experiences with surgeons foster interest in a surgical career, and thus, we have enabled students to pursue their interest in surgery.¹¹ The course's success is evident in a comparison of students who had and had not taken the course upon entering clerkships in the 2018-2019 academic year. Students who had taken our course felt significantly more prepared for the surgery

clerkship as compared to students who had not taken the course, thereby setting the course-takers up for success through a more positive clerkship experience.

While self-reported student interest did not statistically increase during the short 3 months of the course itself, we anticipate that the positive surgical experiences created by the course will lead to preservation of student interest and eventual pursuit of a career in surgery. A recently published systematic review by Marshall and colleagues identified a number of factors associated with positive surgical experiences, including creating a positive and welcoming learning environment, direct instructional contact with surgeons in the operating room, and preparation and active participation, among others.¹² As the first cohort of students who completed our course are entering the 2019 National Resident Matching Program match this year, additional studies are currently in progress investigating whether or not the course contributed to an increase in applications into surgical specialties from our institution. Mentorship opportunities have similarly been shown to be of the utmost importance to medical students deciding to pursue a career in surgery.^{5,13-15} By providing the opportunity for students to connect with surgeon mentors, this course serves to facilitate a well-studied component of student decision making to pursue a career in surgery.

The course's main challenge is gathering the resources needed to execute it. The course is constructed in a stepwise fashion, so while most sessions could be taught independently of one another, they have been designed to build upon the previously taught skills, creating a resource-intensive curriculum that can accommodate only a limited number of students. Enrollment is limited due to the cost of supplies and the desire for a high instructor-to-student ratio in order to provide individualized feedback. Based on our institution's resources and instructor availability, 30-40 students have historically been the appropriate amount, but the class size is entirely adaptable based on institution. The operative case simulation sessions (i.e., laparoscopic cholecystectomy, cadaver simulation) were by far the most time intensive, requiring advance planning and preparation to gather operating room supplies, schedule rooms, coordinate with attending and resident surgeons, and acquire animal or cadaver models. In troubleshooting challenges that arose, we found it was important to have a course coordinator or teaching assistant who was responsible for recruiting mentors, buying and gathering supplies, scheduling resident and faculty presence, and other advance preparation that was required.

Limitations of the course and its implementation include the course's cost of execution, the advance planning required to coordinate the course, the specificity of materials required to execute the course, and the time requirements from surgical residents and faculty. The advance planning can be managed by a designated course coordinator and is significantly reduced by closely following the outlines included in the attached appendices. The materials required can be adapted to match the resources at a given institution, but additional planning may be required to make these adjustments. The time asked of busy attending and resident surgeons is also an important consideration when determining the timing of the course and the number of students able to be accommodated. In addition, students who enrolled in the course were a self-selecting cohort signed up on a first-come, first-served basis. This is important to consider when interpreting the analysis comparing students who had and had not taken the course regarding their comfort levels with technical skills and their preparedness for the surgery clerkship, as it is possible that this increase in preparedness was attributable not only to the course but also to other surgical experiences. Future studies are warranted to further identify the course's effects within these subgroups of students. However, as the skills taught are applicable to all medical students in preparation for their surgery clerkship, we believe the significant increase in comfort and preparedness would likely apply to students interested and not interested in surgery alike.

For many students, this course served as a first exposure to the field of surgery and provided a cohesive progression from basic skills to simulated full operative procedures. In addition to the technical skills, it

improved student confidence in the operating room and empowered many students to further pursue opportunities in surgery outside the classroom setting. We believe that this early exposure will allow students to continue exploring surgery through faculty mentorship, increased confidence in the operating room, and facilitation of positive experiences during their future clinical clerkship.

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Ethical Approval

The Stanford University School of Medicine's Institutional Review Board approved this study.

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