

Medical Student-Driven Multimodal Surgical Training to Enhance Preclinical Surgical Skill Acquisition, Surgical Clerkship Readiness, and Career Exploration

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Purpose: Following the recent change to pass-fail scoring in the United States Medical Licensing Examination Step 1 exam, medical students pursuing careers in surgery must focus on alternative areas to distinguish themselves. In particular, preparation and success in surgical clerkships have both become critical. However, the optimal pre-clinical preparation to enhance medical students' surgical skills prior to active clinical involvement currently remains unclear. We tested the hypothesis that a student-driven, mixed-modality surgical skills program would increase surgical skills, promoting readiness for clerkships and interest in surgery.

Patients and Methods: This study assessed the efficacy of a student-led interest group which organized weekly in-person morning longitudinal skills sessions and in-person quarterly long-form evening skills workshops for pre-clinical students in their first and second years of schooling. Fifty-five participants were prospectively recruited and engaged in these skills events over an 18-month period. Students were surveyed anonymously using Likert scale qualitative instruments to assess the effectiveness of skills training, interest in surgery, and clerkship readiness.

Results: Confidence in hand skills increased significantly (suturing: $p = 0.0046$; knot-tying: $p < 0.001$) after engaging in the interest group, with responders reporting that skills acquisition motivated attendance. All students reported improved clerkship readiness and either "slightly" or "greatly" increased interest in Surgery. Furthermore, 90.4% of participants considered the sessions "very important".

Conclusion: This student-led, mixed-modality curriculum improved skill confidence, anticipated clerkship readiness, and career interest in surgery. The model may guide other student groups preparing trainees for surgical careers.

Keywords: clerkship preparation, clinical skills, pass-fail grading, peer teaching, surgical education

Introduction

The recent transition to pass-fail scoring for the United States Medical Licensing Examination (USMLE) Step 1 exam has increased the pressure on medical students pursuing surgical careers.¹⁻⁵ Consequently, stellar performance in clerkships and the USMLE Step 2 exam has emerged as a critical factor in competitive residency applications.⁶⁻¹¹ However, institutional barriers, including faculty time and financial costs, can hinder career exploration and clerkship anticipated clerkship readiness in the preclinical environment.¹²⁻¹⁴ These barriers are heterogeneous across institutions, particularly at primary care-focused medical schools, which may dedicate less funding to early surgical education than surgery-focused institutions.¹⁵ To address these gaps in early surgical education, and in other subspecialty education, medical students frequently form their own interest groups to generate extracurricular sessions.¹⁶ Surgical interest groups

can enhance preclinical skills training, career discernment, and preparation in their clinical years; however, institutional support for these initiatives also varies widely.^{17–19}

In our institution, first-year students participate in specialty interest groups during an annual interest group exploration event. In 2009, students at our institution collaborated with the Surgery Faculty to form a general surgery interest group (GSIG). The group's mission is to provide weekly, case-based seminars highlighting high-yield surgical topics, provide opportunities for early career exploration, and connect students to mentors in surgery. In the past several years, GSIG leadership expanded these seminars to include knot-tying and suturing training augmented by quarterly intensive evening skill acquisition events. Consequently, an intentional two-part surgical curriculum has been established: weekly morning skills sessions reinforced with evening workshops that focus on periodic immersive skill acquisition.

The effectiveness of intensive workshops in medical student skill acquisition has been preliminarily assessed.^{20–23} However, these studies predominantly focused on short, high-volume education series. As such, the existing literature is insufficient to fully understand the value of true spaced-repetition design on skills acquisition in pre-clinical medical students. With a vast body of previous literature demonstrating clear benefit of spaced-repetition learning in the acquisition and durable retention of knowledge and skills, the authors were interested in assessing this model in the context of surgical skills education.^{24,25} Indeed, a recent student commentary voiced the desire for implementation of such longitudinal designs for the very same reason.²⁶ In the present study, we aimed to present the outcomes of our program as an implementable model for other medical student surgical interest groups. In developing this program, we hypothesized that combining longitudinal, spaced-repetition skill acquisition events and periodic intensive surgical skills workshops would improve the student basic surgical skills and increase their interest in surgery as a career.

Methods

This survey-based, prospective, rolling enrollment study was conducted at a liaison committee on medical education (LCME)-accredited, primary care-focused medical school.²⁷ This institution predominantly trains students in an urban area, although an important subgroup is educated in a more rural context. Each class comprises approximately 240 students, of which 40–50% have historically matched into primary care specialties.²⁸ Participants were attendees of a program hosted by a student-led surgery interest group, and the study population comprised students in their preclinical years recruited through an activity fair and social media outreach program conducted on Instagram. All ~480 first- and second-year students were invited to participate in skills events. Participants entering the study had varying prior experiences with surgical knot-tying and suturing (eg, prior research work with mice involving dissection), and none of the students were excluded from the analysis based on prior skill. This study was reviewed by the University of Minnesota institutional review board (IRB# STUDY00023328), and designated as exempt from requiring consent. Nevertheless, consent was obtained from each participant prior to engagement with the study.

Our surgery interest group has been conducting the surgical skills session program for more than 18 months, with no more than a 2-week pause in longitudinal sessions. In these situations, longitudinal morning sessions were paused to accommodate didactic course examinations and scheduled recess (eg winter break). Intensive evening sessions were planned to avoid any overlap with course examinations and scheduled recess to maximize attendance. This program was designed to follow the spaced-repetition learning model originally proposed by Hermann Ebbinghaus in the late 1800s and subsequently supported in numerous current pedagogical studies.^{29–32}

Weekly Morning Longitudinal Sessions

Participants attended weekly morning teaching conferences following a grand rounds-style, case-based format with topics selected and presented by preclinical student leadership to align with the didactic curriculum. Sessions were offered weekly to encourage regular attendance and to establish a routine for students. After lectures, participants were given instruction and hands-on practice. Surgical knot-tying practice boards were comprised of thin rope and varying hooks to approximate real operating scenarios. Suturing pads were made from latex to simulate human tissue, and surgical instruments analogous to those found in the operating room were supplied (iris scissors, Adson forceps, standard needle driver). Session durations varied in length but were approximately 30 minutes to one hour. The teaching methods utilized were developed through collaboration between senior surgery faculty, graduate trainees (fellows and residents),

Session type	Questions asked
Longitudinal skills session	How confident are you in your suturing skills?
	How confident are you in your knot-tying skills?
	How did offering knot tying practice impact your decision to attend the GSIG Friday lecture today?
	How did offering suturing practice impact your decision to attend the GSIG Friday lecture today?
	Do you believe that knot-tying is an important skill for a physician to have, regardless of specialty?
	Do you believe that suturing is an important skill for a physician to have, regardless of specialty?
	How many knot-tying practice events held by GSIG have you attended?
	How many suturing practice events held by GSIG have you attended?
	How has coming to GSIG Friday lectures affected your interest in pursuing a career in surgery?
	What is your current level of progression in medical school?
Intensive session	How would you rate your current interest in surgery?
	How many prior GSIG skills nights/workshops have you attended?
	How many prior GSIG Friday knot-tying/suturing sessions have you attended?
	Do you think this event contributed to your medical education and preparedness for clerkships?
	Did this workshop increase your interest in surgery as a career?

Figure 1 Survey Questions for Weekly Longitudinal Skills Sessions and Quarterly Evening Intense Sessions.

Notes: This figure reports the survey instruments utilized for longitudinal and intensive skills sessions. Respondents were given a 5-point Likert scale for qualitative questions and numerical options for quantitative questions (eg, 0–≥10 sessions attended).

and medical student leaders. Each task was taught in a stepwise manner by senior surgery faculty and graduate surgical trainees, with particular attention to ergonomics and consistency. We emphasized 1:1 teacher-to-student instruction with frequent check-ins to correct “training scars”, described as “residual performance habits and psychological damage when facilitators or peers fail to help learners improve during training”, that may have arisen in between weekly morning longitudinal sessions.³³ Instructors, no fewer than three in number at any given time, included attending physicians, resident and fellow physicians, and advanced medical student peers.

Voluntary anonymous surveys were administered to the participants (Figure 1) after sessions at approximately three-month intervals to allow time for meaningful skills acquisition without overburdening participants. Confidence in knot-tying and suturing was recorded using five-point Likert scales, as was the skills sessions’ influence on career discernment and anticipated clerkship readiness.

The survey questions were developed in consultation with senior surgical faculty and graduate medical trainees. The questions were piloted with student group leadership (first- and second-year medical students) but were not formally validated. Partially completed surveys were still included in analysis.

Quarterly Intensive Evening Sessions

Participants attended quarterly intensive evening sessions consisting of several hours of hands-on surgical simulation sessions. Sessions were quarterly in interval to optimize access to students while balancing the logistical/financial limitations of the student group. Longitudinal session attendance was not a prerequisite for quarterly intensive sessions, but seats were prioritized for those who participated in weekly morning sessions. The topics covered in these sessions included knot-tying, suturing, wound closure, hemostasis, laparoscopic technique, rib plating, and vessel anastomosis. Learning objectives were generated for all sessions (Table 1). Session attendance was limited to maintain a 4:1 student-to-instructor ratio and promote wide exposure to preclinical education. Participants who had not previously attended were preferentially selected to maximize exposure to pre-clinical surgical education. Anonymous surveys were administered after each intensive session to assess the success of learning objectives, career discernment, and perceived value of these sessions as an adjunct to medical education. Partially completed surveys were still included in analysis. Figure 2 visual

Table 1 Effectiveness of Learning Objectives for Intensive Skills Sessions Using a Likert Scale Measurement

Intensive Session Type	Learning Objective	Mean (SD) Rating (0–5)
Hemostasis and General Skills	1. Understand and apply principles of hemostasis	4.18 (0.529) n = 13
Vessel anastomosis and General Skills	2. Understand and apply the principles of vessel anastomosis	4.52 (0.512) n = 21
Rib Fixation and General Skills	3. Understand and apply the principles of rib fixation	4.18 (0.529) n = 17
Laparoscopic Technique and General Skills	4. Understand and apply the principles of laparoscopic technique	4.38 (0.129) n = 21
Shared across sessions	5. Develop suturing and knot-tying skills	4.33 (0.592) n = 30

Notes: Each sample size reflects the number of individuals at the relevant session.

Abbreviation: SD, standard deviation.

depicts the sequence of weekly morning longitudinal sessions, quarterly intensive evening sessions, and survey administrations.

Statistical Analysis

Descriptive statistics were generated for all outcome variables. Fisher’s exact test was used to compare participant demographic data. To understand the relationships between cumulative longitudinal skills session attendance and skills acquisition, all data points were examined for normal distribution using a Shapiro–Wilk normality test. Linear regression analysis was performed for confidence in knot-tying and suturing as functions of cumulative longitudinal session attendance. Post-hoc power analysis was utilized to determine the power value (β). Statistical significance was set at $p = 0.05$, and sufficient power for analysis was set at $B = 0.8$. All statistical analysis was performed using G*Power (RRID:SRC_013725), GraphPad Prism (RRID:SCR_002798), and Microsoft Excel (RRID:SRC_016137).

Results

An estimated total of 55 medical students participated in the weekly morning longitudinal sessions with varying degrees of repetition (ie, some students attended 10 sessions while others attended 3). Attendance varied due to the voluntary nature of sessions and individual participant availability. The survey response rate was approximately 50%. The relationship between knot-tying confidence and cumulative sessions attended is illustrated in Figure 3A, while the same relationship for suturing confidence is illustrated in Figure 3B. Linear regression analysis for knot-tying revealed a significant improvement with increasing session attendance (slope = 0.264, $p < 0.001$, $R^2 = 0.377$). Suturing session data demonstrated an even greater improvement (slope = 0.304, $p = 0.0046$, $R^2 = 0.425$). For both skills, normality of

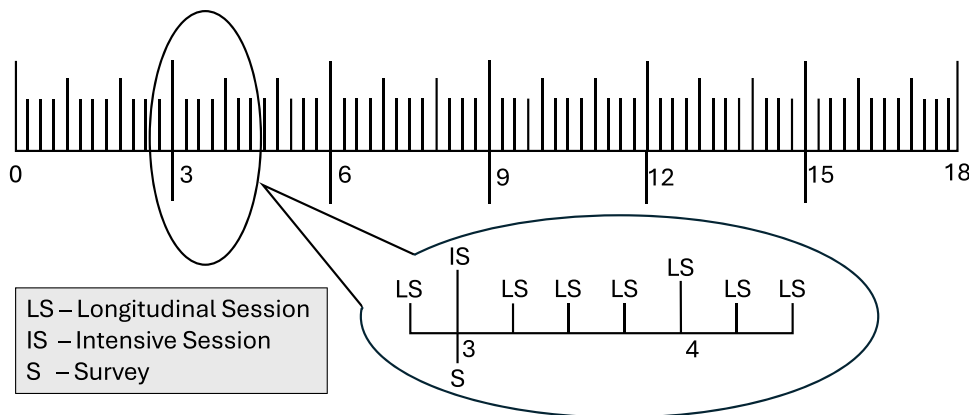


Figure 2 Timeline of Longitudinal and Intensive Skills Sessions.

Notes: A timeline depicting the sequence of longitudinal weekly and quarterly intensive skills sessions, denoted LS and IS in the figure, respectively. Surveys were conducted every three months, depicted with the vertical lines below the x-axis and the S marking in the enlarged portion. Quarterly month timepoints are indicated numerically along the main x-axis and monthly on the enlarged x-axis.

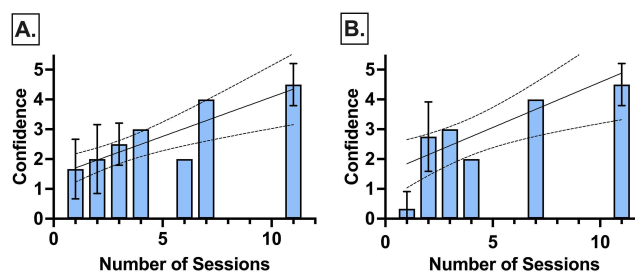


Figure 3 Progression in Confidence with Longitudinal Repetition.

Notes: Self-assessed confidence in (A) knot-tying and (B) suturing skills versus sessions attended. Error bars indicate ± 1 SD (where available). Dashed lines show linear regression trends.

Abbreviation: SD, standard deviation.

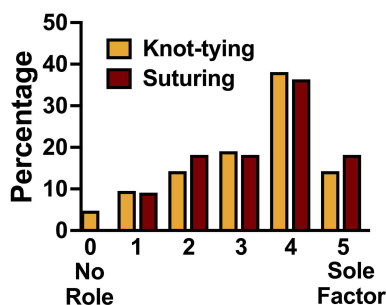


Figure 4 Influence of Surgical Skills on Didactic Seminar Attendance.

Notes: Histogram of a five-point Likert scale assessing the impact of longitudinal skills sessions on attendance of weekly morning didactics lectures.

data was confirmed (knot-tying: $W = 0.940$, $p = 0.121$; suturing: $W = 0.924$, $p = 0.171$). Post-hoc power analysis confirmed an appropriate power value (knot-tying: $B = 0.977$; suturing: $B = 0.911$). Participants consistently indicated that the skills component was highly influential in their decision to attend sessions (Figure 4). Importantly, 92% of knot-tying and 94% of suturing survey respondents reported they would be more likely to pursue a surgical residency if they had more confidence in their knot-tying and suturing skills before entering surgical clerkships.

For intensive evening skill acquisition sessions, 69 unique individuals attended the 4 workshops (survey response rate = 75.4%), with 26 students attending multiple evening workshops. The participants were equally distributed between first- and second-year cohorts (46.2% and 53.9%, respectively, $p = 0.733$). The participants reported a minimum 4/5 Likert score for every learning objective in the evening sessions (Table 1) and affirmed that the sessions were either “slightly helpful” (16.3%) or “greatly helpful” (83.7%) in their preparation for clerkships. Additionally, they reported that the sessions either “slightly” (52.9%) or “greatly” (47.1%) improved their interest in surgery as a career. No participant rated the sessions as “neutral” or “less than helpful”, and they reported that sessions were either “important” (95%) or “very important” (90.4%) to their medical education.

Discussion

In this prospective study of student-driven preclinical surgical medical education, confidence in surgical skills correlated with session attendance, and skill-based education was identified as a primary motivator for attendance. Quarterly intensive evening sessions achieved key learning objectives and were reported as beneficial for current medical education, future clerkships, and career exploration. These findings supported the hypothesis that the combination of longitudinal skills sessions and intensive workshops increased student confidence in surgical skills, interest in surgery as a career, and anticipated readiness for surgical clerkships.

We demonstrate a positive association between student confidence in knot-tying and suturing and repetitive session attendance. Confidence for both skills appeared to dip after approximately five to six sessions, but later increased with additional sessions; this may align with the Dunning–Kruger effect. This phenomenon, which refers to an instance when

an increasing understanding of the complexity of a task aligns with increased experience, affects medical student self-evaluation (Figure 3B).^{32,34-36} The positive association between confidence and attendance is well-supported by existing simulation research, highlighting the benefits of repeated training in spaced-repetition models.^{37,38} If students can better demonstrate their basic surgical skills, they may be permitted to participate more directly in the procedural aspects of surgical clerkships. Superior clinical clerkship performance is likely to be associated with positive letters of recommendation, clerkship feedback on dean's letters, and other important residency application assessments.³⁹

In addition to the weekly morning longitudinal sessions, the quarterly intensive evening sessions were highly effective in engendering interest in surgery and anticipated surgical clerkship readiness. All students reported that the sessions were helpful for clerkship preparation, with over 80% of respondents reporting the sessions as "very helpful". These opportunities to explore surgical topics provided a similar experience to our institution's surgery clerkship orientation session, although they were available to first- and second-year students and expanded on surgical subspecialty and advanced surgical skills such as vessel anastomosis and laparoscopy. The goal was to give students an idea of what they may experience if they pursued surgery as a career. Like the responses to the weekly morning longitudinal sessions, all students reported an increased interest in surgery following intensive skills sessions.

Skill retention is subject to decay, with the rate of decay inversely proportional to the number of distinct learning trials.^{40,41} This is particularly salient for students whose next surgical experience is distant. In contrast to prior studies, our study provided a framework for the consistent and longitudinal acquisition of surgical skills that supports longer and higher fidelity retention.^{20,21,23} As evidenced by the students' responses, this method contributed to the attendance of weekly morning longitudinal sessions and assumed attendance at focused intensive skills sessions (Figure 4). The increasing expectation for medical students to differentiate themselves in an ever-changing and competitive environment leads to a demand for excellent clinical performance. Students going to institutions driven by non-surgical stakeholders may benefit from this model of multimodal preclinical surgical skills programming. We believe our approach is readily expandable to other institutions, particularly with the use of the American College of Surgeons Medical Student Simulation-Based Surgical Skills Curriculum, which efficacy has been previously reported.^{42,43} Furthermore, this program is available at no additional cost to the students, presenting a logistically simple means to replicate our model. The major barrier to implementation at other institutions is the allocation of funding for intensive simulation sessions, which often involve specialized spaces and materials (suture, synthetic tissue models, etc).

This study has some limitations. Direct comparisons between longitudinal and quarterly intensive evening sessions (longitudinal versus intensive effect) were limited, as anonymity was considered a priority for unbiased data collection. Cumulative attendance varied by individual, and thus may not have corresponded directly with the total number of skills sessions offered if the student did not attend all sessions. Individuals also entered the study with differing prior experience: some variation was introduced by the cohort comprising first- versus second-year students, while some participants had experience prior to acceptance into medical school. While this made analyzing the absolute confidence levels before and after the intervention, our primary goal was to examine student growth over time, which was observed regardless of prior experience. Additionally, quarterly intensive evening sessions primarily aimed to expose many students as possible to surgical techniques, rather than creating multiple replicates of intensive versus longitudinal interaction. This study was conducted at a single institution with a limited sample size and may not reflect national educational outcomes. Finally, confidence in surgical skills was self-perceived by the students, and not formally measured by unbiased faculty observers or compared against a control group. This adds a layer of complexity to the value analysis of this program from an educator's perspective while simultaneously highlighting the student experience in preparation for careers in surgery.

Conclusion

Overall, this study showed that a student-led surgical interest group utilizing a two-part skills instruction modality increased students' confidence in surgical skills acquisition, preparation for surgical clerkships, and interest in surgery as a career. Students demonstrated growth in surgical skills over time and successfully engaged with career exploration activities. As residency programs increasingly rely on alternative metrics, such as clerkship evaluations and letters of recommendation, this model could be used to improve students' success in the residency matching process by better

preparing them to excel in clinical rotations.³⁹ We look forward to future cross-institutional studies utilizing this education strategy.

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Disclosure

The authors report no conflicts of interest in this work.

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