

# Performance of High School Students in a Laparoscopic Training Program

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## ABSTRACT

**Background and Objectives:** We hypothesized that high school students can be subjected to the same laparoscopic surgical training curriculum used by surgeons and successfully complete it. The goal of this study was to evaluate the appropriateness of early training in minimally invasive surgical techniques.

**Methods:** Thirteen high school students, ages 15–18, participated in the validated Top Gun Surgeon Laparoscopic Skills and Suturing program. The students performed 3 preparatory drills 10 times each. The students' scores were then compared to a database of 393 surgeons. Performance graphs were prepared to allow comparison of skills acquisition between the 2 training groups.

**Results:** All 13 students successfully completed the tasks. The Students' performance (expressed as time/percentile range/average percentile) for each task were as follows: rope pass 101.8 seconds/3.8–47.1/11.8; bean drop 149.5 seconds/18.7–96.0/59.4; triangle transfer 303.2 seconds/1.3–16.0/5.8. The students started each drill with slower times, but their average improvement (decreased time to complete tasks) was more rapid than that of the surgeons between the first and second trials for each drill (–83 seconds vs –25 seconds, –120 seconds vs –53 seconds, –100 seconds vs –60 seconds). Average student times compared to average surgeon times during the last trials measured were not significantly different in the triangle transfer and rope pass drills ( $P = .40$  and  $.18$ , respectively). Students' times were significantly faster than surgeons' in the last measured trial of the bean drop ( $P = .039$ ).

**Conclusions:** Despite the small sample size, this investigation suggests that high school students can successfully complete skill-building programs in minimally invasive surgery. Further study is needed to evaluate the appropriateness of starting surgical training of future residents at an earlier stage of their careers.

**Key Words:** High School surgery training, Laparoscopic curriculum, Laparoscopic training program, MIP training.

## INTRODUCTION

One of the greatest concerns of modern medicine, especially in the United States, is the current and impending shortage of physicians and surgeons. According to the 2005 report by the Council on Graduate Medical Education, there is an expected deficiency of >85,000 physicians nationally by 2020.<sup>1</sup> Furthermore, there is a rural/urban imbalance that accentuates this deficiency in certain regions. This deficit has led to an unacceptable lack of availability of quality care in many communities.<sup>2</sup> With a significantly growing and aging population and the struggle to retain and harvest physicians, this problem is only going to get worse in the future. According to the U.S. Census Bureau, the >65-year age group, which is the group that typically requires the most healthcare, is expected to grow by 55% by 2030. In the United States, new health care reforms will add >32 million newly insured citizens, and the shortage will be exacerbated.<sup>3</sup> This ominous outlook for physicians in general is even more alarming for surgeons. In 2008, the Association of American Medical Colleges (AAMC) predicted that by 2020, there would be a shortage of roughly 46,000 general surgeons and surgical specialists.<sup>3</sup> In 1981, there was an average of 7.68 surgeons per 100,000 people; in 2005, that number dropped to 5.69/100,000 and is continuing to fall. This is a reduction of general surgeons per 100,000 population of 25.91%.<sup>4</sup> In addition, it has been predicted that the amount of surgical work will increase between 14 and 47% from 2010 to 2020, representing an increased demand for service.<sup>5</sup> This increased need for practicing surgeons leads to a grand dilemma: an urgent need to recruit more providers to the work force and train them thoroughly.

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To address this problem, there have been multiple new MD, DO, and international programs, as well as expansion of established programs. In fact, the enrollment of first-year medical students has risen by 3029 (18%) for MD programs and 2896 (96%) for DO programs. By 2017, there will be a 30% increase in students since 2002.<sup>6</sup> Even though medical school positions are increasing, residency spots are growing at a much slower pace, especially for general surgery, which according to the 2014 National Residency Match Program has 1205 positions, compared to 1057 in 2006, an increase of 148 spots.<sup>7</sup> Even though medical student positions are increasing, it will not cover the impending physician shortage. Furthermore, available residencies are growing at an even slower pace. It is too little, and will soon be too late.

Another training challenge is increasing the adoption rate of advanced minimally invasive procedures (MIPs). A plethora of robotic and laparoscopic MIP surgeries have been shown to yield equal or better results than their traditional predecessors, all while decreasing cost, hospital length of stay, and associated morbidities.<sup>8,9</sup> These procedures represent a value-based performance profile that is aligned with value-based modern healthcare.<sup>10</sup> Hospitals now have incentives to use these techniques because of recent healthcare reform and the shift from a volume- to a value-based system. Hospitals and physicians will be paid in full only if patient care is cost effective, efficient, yields minimal complications, and produces optimal outcomes while maintaining a high patient satisfaction level. It is now in the best interest of hospitals, providers, and patients that surgical services be provided with a minimally invasive approach.

Unfortunately, despite all efforts, there has been an abysmally low rate of adoption of advanced MIPs. The advantages of MIPs compared to the traditional predecessors have been shown repeatedly, yet the use of these modalities remains significantly underused.<sup>11</sup> A recent large study showed the average MIP utilization for common procedures in the United States: 13.0% for hysterectomy, 71.0% (high) for appendectomy, and 28.4% (high) for colectomy. This study also noted that use of MIP procedures varied widely with some hospitals not using MIP at all.<sup>12</sup>

A significant barrier to a more widespread use of MIP is the lack of clinical experience and availability of structured training opportunities. Because of the poor adoption rates, surgeons in training have highly varied exposure to advanced procedure. Even today, graduating trainees often lack the technical skills, confidence, and

experience needed to perform MIP. Fortunately, there are ample data that support the use of simulators to more efficiently and cost effectively train surgeons without being in the operating room, thus providing the opportunity to train without risking harm to the patient.<sup>12-14</sup>

The restriction of resident hours is another reason that many residents do not have adequate hands-on exposure to the wide range of general MIP options.<sup>15</sup> To address this challenge, there has been discussion of adding an extra year to general surgery training. However, without increasing residency programs, extending the training period would further exacerbate the already growing surgeon shortage. The position of this research effort is to maximize the efficiency and effectiveness of training, there must be an exploration of the possibility of earlier technical skill development. If the establishment of basic MIP skills could begin before residency, there would be more time to build a cognitive knowledge base, clinical experience, and hone clinical judgment.

Recruitment of future medical students and residents is suspect when looking at the appallingly low interest and competency of American youth in the fields of science, technology, engineering, and math (STEM). Despite a growing need for job applicants in STEM fields, including surgeons and other health care professionals, a recent study by the Business Higher-Education Forum showed that only 17% of high school seniors around the country were both interested and competent in STEM fields.<sup>16</sup> Without an applied learning reference point and mentoring in STEM careers, many high school students feel that what they learn in the classroom lacks real-world relevance. A recent study indicated the importance of communities of practice in career identity development and concluded that students had more positive outlooks in areas where professionals in the field mentor them. Programs with active learning through relevant real-life experiences help students develop core skill sets and may serve as a means of early recruitment. It has been postulated that giving high school students the opportunity to gain insight on what science careers actually entail and having intimate exposure may lead to increased interest and success in these fields.<sup>17</sup>

In this investigation, we sought to evaluate whether high schools students could participate in a standardized laparoscopic skills training program originally designed for surgical residents and trained surgeons. Also, we wanted to determine whether they would demonstrate similar performance profiles when compared to their more experienced and senior counterparts.<sup>18</sup>

## METHODS

The program used in this study is the Rosser Top Gun Surgeon Laparoscopic Skills and Suturing training program. It is a highly validated curriculum that establishes basic/advanced MIP skill sets and intracorporeal suturing.<sup>13,14,19</sup> The program has a performance database of surgeons who have taken the course and can give the participant percentile ranking of his or her skill level in comparison with other surgeons and trainee surgeons.

This study focused on 13 high school students from the Piney Woods School in Piney Woods, Mississippi. The Piney Woods School is a private Christian based historic African-American boarding school in which all students receive financial assistance via scholarship. The grade levels of the students who participated ranged from 9 to 11 and the ages were 15–18 years. The student participant population included 7 females and 8 males. Of the participants, 8 identified themselves as international students from Africa, 4 as African American, and 1 as multiracial. All students participated in the skill-building segment of the program, which has been described in other publications.<sup>14,19</sup> The course was held over 2 days: 8 h the first day and 4 h the second day for 12 h total.

The high school students were compared to a database of the scores of 393 surgeons who had completed the program with the new error -system described and validated above. All of the surgeons in the database were board eligible, board certified, or currently undergoing residency training. The time required to perform each drill was recorded in seconds. Each error added an additional 5 seconds to the final score. The total time required to perform the first 10 drills in each exercise was calculated for every participant and used for comparison with all the calculations.

Each student performed 3 standardized, drills (“cobra rope,” [rope pass] “slam dunk,” [bean drop], and “terrible triangle” [triangle transfer]) 10 times each. Names in quotation were given to the students while brackets represent the official name of the task. Trained Top Gun instructors collected the data and confirmed the scoring and competency of each exercise. Each participant executed the drills within a standardized laparoscopic trainer (Rosser Inanimate Proctor, Stealth Learning Company, Orlando, Florida USA). An electronic proctor, which has been previously described was used in both the bean drop and triangle transfer drills to count errors made by the participant.<sup>14</sup> The instructors also monitored for mistakes during all 3 tasks. Each error made added 5 seconds to the participant’s final score for that exercise. Each student com-

pleted a short survey detailing his or her current and past video game experience. Immediately preceding performing the drills, each student warmed up with Super Monkey Ball Deluxe (SEGA, San Francisco, California, USA) for 6 minutes. Playing video games before participating in these procedures has been shown to improve performance.<sup>18,20</sup>

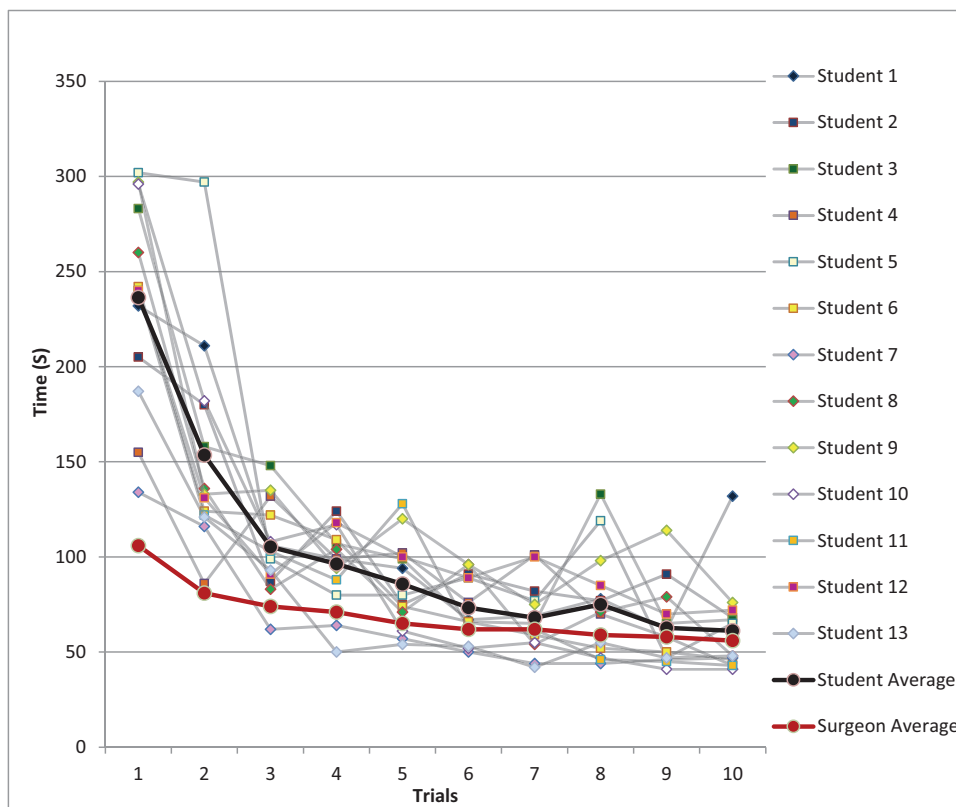
Between-group comparisons of student characteristics on time-to-completion scores for all 3 tasks were made using independent-samples *t*-tests and analysis of variance (ANOVA), as appropriate, for normally distributed continuous data, or using nonparametric Mann-Whitney *U* tests and Kruskal-Wallis tests, as appropriate, for non-normal continuous data. Multiple linear regression models were constructed to identify combinations of student characteristics that significantly predict time-to-completion scores on each task. Comparison of time to completion scores at the last trial for each task between students and surgeons was conducted with independent-samples *t*-tests or nonparametric Mann-Whitney *U* tests, as appropriate. A mixed repeated-measures ANOVA model, using time as a within-subjects factor and group (ie, students vs surgeons) as a between-subjects factor, was used to examine main effects of time and group and time × group interaction effects for each task. All follow-up pairwise comparisons upon a statistically significant omnibus test were made using the Bonferroni correction to control for inflation of family-wise error rate. All tests were 2-sided, and *P* < .05 indicated statistical significance. Statistical analyses were performed using SPSS (Statistical Package for the Social Sciences) 20.0 (IBM, Chicago, Illinois, USA).

## RESULTS

All 13 students successfully completed the tasks. Students’ average time (percentile range) [average percentile] were as follows: cobra rope, 101.8 seconds (3.8–47.1)[11.8]; slam dunk, 149.5 seconds (18.7–96.0)[59.4]; and terrible triangle, 303.2 seconds (1.3–16.0)[5.8]. Data analysis using Mann-Whitney *U* test showed that gender, grade average, and video game habits were not significantly relevant to students’ performance levels on the tasks (*P* > .05). Kruskal-Wallis test analysis showed that grade level and years of video game experience did not correlate with task performances (*P* > .05).

**Figures 1–3** show the individual performances of all 13 students in each drill, the student average score per trial, and the surgeon average score per trial.

**Figure 1** shows a significant main effect of trial (*P* < .001), given that the trial number influenced the participants’



**Figure 1.** Rope pass performance.

score on the rope pass. As participants became more familiar with the exercise and conditions, they probably adapted and improved with each subsequent trial. There is a main effect of trainee type ( $P < .001$ ) with the outcomes dependent on whether each participant was a student or surgeon. Mean times of students differed across most trials ( $P < .001$ ), but were not significantly different in trials 3–4, 3–5, 4–(6–10) and 5–(6–10). Mean times of surgeons differed significantly across all trials ( $P < .001$ ) except trials 2–4, 3–4, 4–(5–7), 5–6, 6–7, 8–9, 8–10, and 9–10. Students and surgeons performances were significantly different in trials 1, 2, and 3 ( $P < .001$ ) and trials 5 and 8 ( $P = .004$ ) with surgeons having faster times. Students' and surgeons' performances were not significantly different in trials 4 ( $P = .110$ ), 6 ( $P = .052$ ), 7 ( $P = .319$ ), 9 ( $P = .402$ ), and 10 ( $P = .400$ ). Whereas surgeons performed 130 seconds faster in trial 1, students' scores improved more rapidly over time, leading to final scores in trial 10 that were comparable to those of the surgeons. The most dramatic decrease in performance time occurred between the first 2 trials where the surgeons averaged 25 seconds faster, and the students improved, on average, by 83 seconds. It should also be noted that all students began

with a slower time than the average surgeon in trial 1, but 7 of 13 students ended trial 10 with a faster score than the average surgeon.

**Figure 2** shows a significant main effect of trial ( $P < .001$ ), given that the trial number influenced the participants' scores on the bean drop. There is a main effect of trainee type ( $P = .004$ ), with the outcomes dependent on whether each participant was a student or surgeon. Mean times of students differed in trials 1–(2–5) ( $P < .05$ ) but were not significantly different in trials 2–(3–5), 3–(4–5), and 4–5. Mean times of surgeons differed significantly across all trials ( $P < .05$ ) except trials 4–5. Students and surgeons did have significantly different performance in trials 1–3 ( $P > .176$ ) but differed significantly in trials 4 and 5 ( $P = .022$  and  $0.039$ , respectively) with the students having the faster times. Data in the figure represent only up to trial 5, because of the loss of individual scores for trials 6–10. In this drill, the average surgeon score was faster than the student average by 27 seconds in trial 1. The average improvement between the first 2 trials for surgeons was 53 seconds, whereas the student average improvement was 120 seconds. Students ended trials 4 and 5

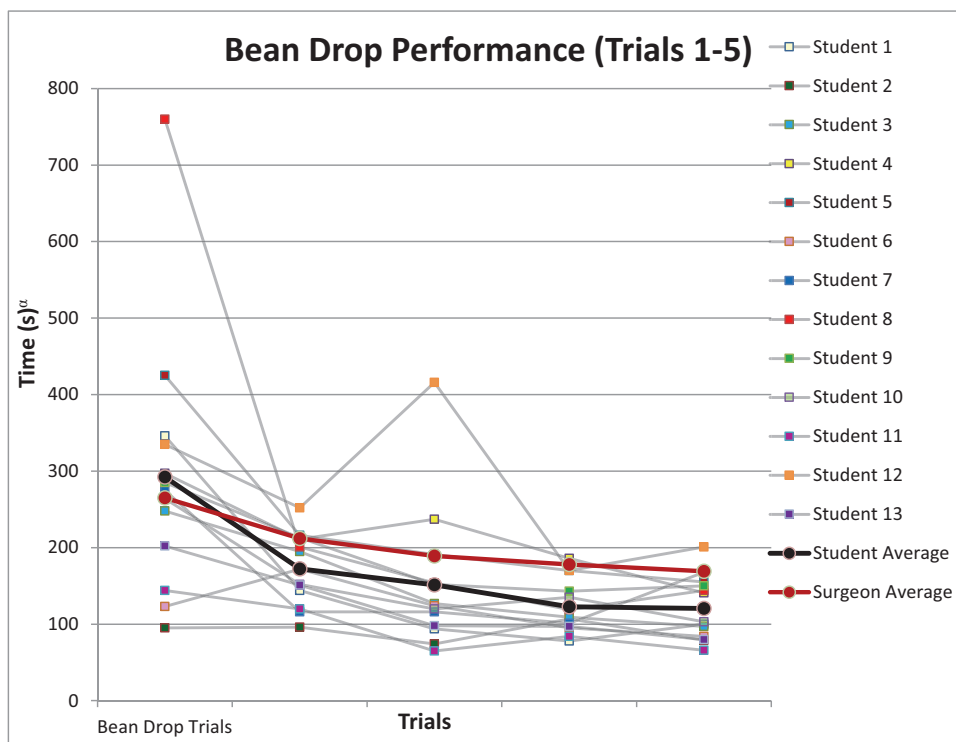


Figure 2. Bean drop performance.

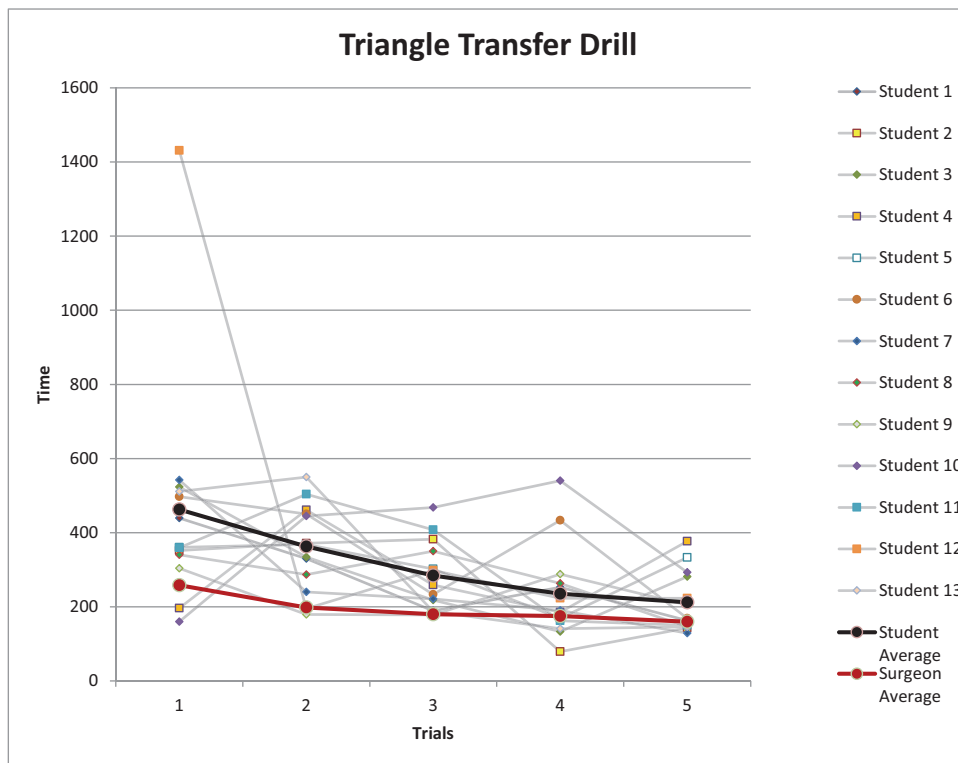
with significantly faster times than the average surgeon’s time.

Figure 3 shows a significant main effect of trial ( $P < .001$ ), given that the trial number influenced the participants’ scores on the triangle transfer, and main effect of trainee type ( $P = .034$ ), with the outcomes dependent on whether each participant was a student or surgeon. Mean times of students differed in trials 1–(3–5) and 2–(4–5) ( $P < .05$ ), but were not significantly different in trials 1–2, 2–3, 3–(4–5) and 4–5. Mean times of surgeons differed significantly across all trials ( $P < .05$ ) except trials 4–5. Student and surgeon times were significantly different in trials 1–3 ( $P < .002$ ) with surgeons having superior times but are not significantly different in trials 4 and 5 ( $P = .156$  and  $.178$ , respectively). Student average time was 205 seconds slower than surgeon average in trial 1. The student average performance improved and ended trial 5 only 52 seconds slower than the surgeon average. Data in the figure represent only the times up to trial 5 because of the loss of individual scores from trials 6–10. The average surgeon’s time was faster in each trial; however, skill acquisition was more rapid among the students.

## DISCUSSION

Healthcare career exposure and recruitment programs for high school students have been on the scene for quite some time at the local, state, and national levels. Moorpark High School in California has partnered with a local college to give high school students the chance to experience preprofessional classes related to health. The state of New York houses the Science and Technology Entry Program, which tries to stimulate a greater interest in STEM fields, and more specifically, medicine, for New York students by providing opportunities and workshops for academic skills. On a national scale, the Health Professions Recruitment and Exposure Program allows high school students across America the chance to sit in on lectures and workshops designed around science career possibilities.<sup>21</sup> Programs like these are providing an excellent opportunity to our youth and are attempting to address the declining interest in STEM careers. However, most of these programs positioned participants as observers.

Rosser<sup>22</sup> introduced participation skill development in high school students with SAGES Mini Med School (MMS) concept, a program that provides high school students



**Figure 3.** Triangle transfer performance.

exposure to the field of surgery through hands-on interactive simulations, mentorship, and knowledge exchange in a fun environment. Students who participated in this program were briefly exposed to laparoscopic skill training with the bean drop as well as the Fundamentals of Laparoscopic Surgery peg pass. These students were able to successfully acquire these skills in a short but structured time period. Surveys following the event showed that 93% of participants were more likely to consider a career in medicine, 89% a career in surgery, and 100% would recommend the program. The data suggest that it is possible for this training experience to provide mentorship and applied learning to motivate students to consider a medical or surgical career.

This is not the first time that researchers have evaluated the performance of preresidency laparoscopic skills training. Rosser et al<sup>23,24</sup> extensively studied skill acquisition in medical students who participated in the Top Gun Surgeon Skill and Suturing Program. Medical students without prior MIP exposure learned to successfully perform intracorporeal suturing when provided a structured learning curriculum. However, the participation of high school students in this program had yet to be attempted.

All 13 of the high school students in this study were able to successfully complete the same Top Gun laparoscopic tasks designed to train board-certified surgeons. When looking at the data in all 3 trials, as would be expected, the starting times for students were much slower than those of the surgeons; however, a significant finding is that the students' learning curve showed faster skill acquisition, resulting in times during the later trials that rivaled and even surpassed those of the surgeons. The students faced the challenge of acquainting themselves with unfamiliar instrumentation and a 2-dimensional environment. They were able to adapt quickly, as witnessed by the significant decrease in time from the beginning trials. This improvement was strikingly displayed by the performance of the rope pass and bean drop. In both of these tasks, the students started off with times that were inferior to those of the surgeons. The students improved at a much faster rate than the surgeons with the most significant decreases in time within the first 2 trials of each drill. In the rope pass drill, the students were, on average, 130 seconds slower than surgeons in the first trial, but were only 5 seconds slower on the last trial. Despite no previous training, the high school students were able to rapidly adapt and per-

form on a high level. The bean drop had a higher degree of difficulty, but the students had an even higher performance profile. They were, on average, 40 seconds slower than surgeons on the first trial but were 21 seconds faster than the surgeons by the fifth trial. This result again reinforces the ability of students to successfully acquire these skill sets.

The results of this study showcase the ability of young untrained students to successfully achieve minimally invasive skill acquisition in the same structured curriculum designed for surgical residents and trained surgeons. Although the findings by no means imply that students are capable of performing surgical procedures, they show that it may be appropriate to start minimally invasive surgical skill development earlier in one's career. The off-loading of skill acquisition at the high school level could one day allow part of the training of a surgeon to be completed by the time the surgeon enters residency. This could reserve more time for the other facets of surgical training. Also, it could serve as a great recruiting asset.

In conclusion, these findings suggest that the performance of high school students in a standardized training program in laparoscopic surgery is similar to that of trained surgeons. Despite the limited sample size, the findings in this study suggest that the students have a more rapid and enhanced capacity for skill acquisition than the trained surgeons who participated in the Top Gun Surgeon Laparoscopic Skills and Suturing Program. The results are very encouraging, but further study is needed to determine the appropriateness of starting surgical training of future residents at an earlier stage of their education career.

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