

Review of Influential Articles in Surgical Education: 2002–2012

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Abstract

Background Exploring the trends in surgical education research offers insight into concerns, developments, and questions researchers are exploring that are relevant to teaching and learning in surgical specialties.

Objective We conducted a review of the surgical education literature published between 2002 and 2012. The purpose was 2-fold: to provide an overview of the most frequently cited articles in the field of surgical education during the last decade and to describe the study designs and themes featured in these articles.

Methods Articles were identified through Web of Science by using “surgical education” and “English language” as search terms. Using a feature in Web of Science, we tracked the number of citations of any publication. Of the 800 articles produced by the initial search, we initially selected 23 articles with 45 or more

citations, and ultimately chose the 20 articles that were most frequently cited for our analysis.

Results Analysis of the most frequently cited articles published in US journals between the years 2002–2012 identified 7 research themes and presented them in order of frequency with which they appear: use of simulation, issues in student/resident assessment, specialty choice, patient safety, team training, clinical competence assessment, and teaching the clinical sciences, with surgical simulation being the central theme. Researchers primarily used descriptive methods.

Conclusions Popular themes in surgical education research illuminate the information needs of surgical educators as well as topics of high interest to the surgical community.

Introduction

The aim of educational research in any field is to provide descriptive, predictive, or explanative information relevant to learners and learning. Learning the trends in surgical education research offers insight into concerns, developments, and questions that researchers were exploring during a given period. Important reasons to study central research themes include contributing to an enhanced

understanding of popular research foci during a given period; helping to determine if research themes meet critical information needs; identifying underresearched topics and potential future priorities; and documenting current themes to enable analysis in future decades to reveal consistency in interests or major changes in research themes.

The purpose of our article is to provide an overview of the most frequently cited articles in surgical education in the last decade, and describe the themes explored and the study designs used in these publications.

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Methods

The most frequently cited articles published in US journals between the years 2002–2012 were identified by using Web of Science (Thomson Reuters, New York City, NY), with “surgical education” and “English language” as search terms. Web of Science is an online academic search engine that references 12 000 of the highest impact journals, providing access to multiple databases, cross disciplinary research, and in-depth exploration of multiple fields and subfields within an academic scientific discipline.¹ Because Web of Science selects journals on the basis of impact evaluations, we considered it the most comprehensive

TABLE 1 FREQUENCIES OF CATEGORIES CODED AS PRIMARY TOPIC OF ARTICLE		
Primary Topic	Frequency	% of Total
Use of simulation	11	45.8
Issues in student/resident assessment	4	16.7
Specialty choice	3	12.5
Patient safety	2	8.3
Team training	2	8.3
Clinical competence assessment	1	4.2
Teaching the clinical sciences	1	4.2

approach to identifying quality articles with cited reference searching. A key feature of Web of Science is that it allows researchers to track the number of citations of any particular work and can also eliminate self-citations. Of the 800 articles found in our initial search, 23 had 45 or more citations and were considered for further review. These articles were further scrutinized to eliminate self-references, and the 20 most frequently cited articles were included in our analysis. Additionally, each of the authors chose an article he or she felt was the most influential. This exercise was performed to allow inclusion of recent articles, which may be influential but have fewer citations than older articles. The first and senior authors abstained from choosing an article to maintain objectivity. Therefore, a total of 24 articles are included in this review.

Two investigators independently classified each article according to the 29 topic categories proposed by Rotgans.² The 2 investigators then compared their classifications in a discussion that followed. Two additional categories were added when both agreed that several articles fell outside Rotgans' classification list of research topics. For example, the topic "Team Training" is important in teaching technical and cognitive surgical skills and was left out of the Rotgans' categories. Two investigators also independently classified each article according to its research design, from categories described by Gall et al,³ which included descriptive, experimental, relationship, and test assessment. Classification tables were compared and discussed. The Cohen κ was used to analyze the interrater reliability,⁴ and the number of discordant categories was tabulated and used to calculate percentage agreement.

Results

TABLE 1 reflects the frequency of themes for the 24 articles. The independent classification of primary topic for all articles resulted in 7 initially discordant categorizations

TABLE 2 FREQUENCIES OF CATEGORIES CODED AS PRIMARY METHODOLOGY USED BY THE ARTICLE		
Primary Method	Frequency	% of Total
Descriptive	12	50.0
Experimental	6	25.0
Relationship	3	12.5
Test assessment	3	12.5

(agreement, 71%; κ = 0.603). Follow-up discussions resulted in achieving 100% agreement. Simulation was the predominant topic for research.

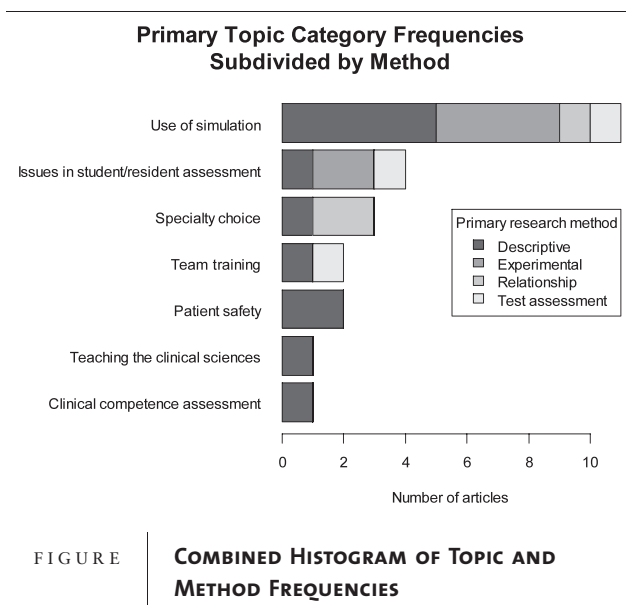
Analysis of primary methodology resulted in 1 conflict (agreement, 96%; κ = 0.937). Descriptive surveys were the most commonly used research method, with 12 of the studies (50%) using descriptive methods (TABLE 2). The FIGURE synthesizes these results. The 24 influential articles reviewed in this article are organized by year of publication, listed by first author, and described individually below.

Ali MR, et al. Training the novice in laparoscopy. *Surg Endosc.* 2002;16(12):1732–1736.

This study⁵ evaluated the impact of training novices to perform a laparoscopic cholecystectomy by using either simple or more complex skills training. After a pretest of basic laparoscopy skills, high-school students were randomly assigned to either low-level or medium-level skills training on a Minimally Invasive Surgical Training–Virtual Reality System. Both groups improved in all skill areas after 8 training sessions, but the students exposed to higher levels of skills training scored significantly higher in the final examination. This study has significant implications for virtual reality skills training of entry-level surgeons by demonstrating that virtual reality training practiced over a significant number of sessions improves the skill level in a relatively short period.

Hamilton EC, et al. Comparison of video trainer and virtual reality training systems on acquisition of laparoscopic skills. *Surg Endosc.* 2002;16(3):406–411.

This intervention study⁶ has 49 junior residents completing baseline skill testing on virtual-reality (VR) and video trainers. Participants were then randomly assigned into structured VR or video training. Study results suggest that VR training has better skills transfer to the operative environment than video training. Both the VR- and video-trained participants improved; however, the VR-trained group improved more on the video trainer posttest than the



video-trained group on the video trainer posttest. When comparing effects on operative performance, only the VR-trained group showed improvement.

Holcomb JB, et al. Evaluation of trauma team performance using an advanced human patient simulator for resuscitation training. *J Trauma*. 2002;52(6):1078–1085.

This study⁷ analyzed the use of a human patient simulator in trauma resuscitation training. Results showed that the trauma teams showed improvement in 4 of 5 scored and 6 of 8 timed tasks. The authors showed that the participants' performance improved; however, the ultimate validation would be to document improvement in real-life trauma resuscitations. The study supports the use of simulation to acquire certain medical and surgical skills before applying those skills in real-life scenarios.

Gallagher AG, et al. Fundamental principles of validation, and reliability: rigorous science for the assessment of surgical education and training. *Surg Endosc*. 2003;17(10):1525–1529.

The authors⁸ explored how psychometric principles such as validity and reliability are applied in surgical education. A significant portion of the article addresses concerns that researchers are reporting a simulator's "reliability" by using correlation coefficients, which explains the amount of agreement between 2 measures (eg, 2 raters observing a resident perform a skill on a simulator), instead of reporting the reliability coefficient measures of agreement. The differences between agreement, association, and concordance were demonstrated. This article guides efforts for establishing and interpreting assessment strategies for surgical performance.

Anastakis DJ, et al. Evaluating the effectiveness of a 2-year curriculum in a surgical skills center. *Am J Surg*. 2003;185(4):378–385.

The authors⁹ tested the hypothesis that implementation of a 2-year surgical skills course would improve the technical skills of participating junior residents. They found that the technical performance of the residents who went through this curriculum was no better than the performance of a historical control cohort. Their results showed that a relatively brief exposure to a new procedure is not sufficient practice to consolidate learning; rather, a greater proportion of practice versus didactic learning is necessary to ensure proficiency.

O'Herrin JK, et al. Why do students choose careers in surgery? *J Surg Res*. 2004;119(2):124–129.

A survey study of medical students¹⁰ explored the attributes of third-year surgical clerkship experiences that were most strongly associated with medical students' decision to choose a career in a surgical specialty. After completing the clerkship, 40% of respondents indicated their interest in a career in surgery or a surgical subspecialty had increased, while 15% indicated their interest had declined. Factors significantly associated with an increased interest included the number of cases in which students participated (95%), their interactions with residents (85%), interaction with faculty (80%), and the number of cases they observed (65%). The only statistically significant negative factor was the number of hours worked. This article stresses the importance of residents and faculty in mentoring medical students, as these interactions may have the strongest influence on future career choice.

Hsu JH, et al. Use of computer simulation for determining endovascular skill levels in a carotid stenting model. *J Vasc Surg*. 2004;40(6):1118–1125.

This study¹¹ evaluated baseline endovascular skills for novice and experienced participants using the Vascular Intervention Simulation Trainer (VIST). At baseline, 92% of the experienced group successfully completed the pretest as compared to 63% of novice participants. In addition, there was a significant difference in time to completion for the groups. Baseline performance on the carotid stenting task in the VIST simulator correlated well with previous endovascular experience. Although it is unclear whether improvement in performance times is due to procedural skill acquisition or increased familiarity with the simulator, these findings may support use of the simulator to track and assess learning curves.

Debas HT, et al. American Surgical Association Blue Ribbon Committee Report on Surgical Education: 2004. *Ann Surg*. 2005;241(1):1–8.

This report¹² addresses surgical workforce issues, recommending an increase in medical students and in residency

positions for general surgery and surgical specialties to offset an anticipated shortage of surgeons. Regarding medical student education, the Committee recommended that surgery programs focus on learning theory, research data, and hire professional educators to enhance faculty teaching skills. The report also called for a nationwide study to determine the impact of the 80-hour workweek on patient safety and resident operative experience as well as quality of life. Other key points addressed in the report include expanded efforts to recruit women and minorities, debt payback programs for residents, and the development of a fundamental curriculum in surgery that prepares all surgery residents for further training.

Gallagher AG, et al. Virtual reality simulation for the operating room: proficiency-based training as a paradigm shift in surgical skills training. *Ann Surg.* 2005;241(2):364–372.

The authors¹³ evaluated the integration of virtual-reality simulators into the surgical residency curriculum. The authors discuss that, given the need to teach complex laparoscopic and robotic skills, surgical training programs should be teaching residents how to automate basic psychomotor skills before operating on patients. Surgical educators often believe that high-fidelity simulators are better than simple, inexpensive trainers. Although high-fidelity trainers have utility in certain situations, the authors suggest that program directors should realize that more expensive is not necessarily better. They advised that research support the fact that interval practice (training over time) is more effective than massed practice (all at once). Accordingly, most surgical skills courses may not be structured correctly. The authors recommended that, rather than bundling courses into 1- to 2-day sessions, surgical skills ought to be taught in intervals over a longer period.

Vassiliou MC, et al. A global assessment tool for evaluation of intraoperative laparoscopic skills. *Am J Surg.* 2005;190(1):107–113.

This article¹⁴ discussed use of a global assessment tool in addressing the need for a reliable, valid, and feasible measurement instrument to measure the impact of educational interventions on technical performance in the operating room. The authors describe a global assessment tool to assess the technical performance of residents performing laparoscopic surgery (GOALS). Evaluators found that the GOALS instrument was reliable and demonstrated it could be reliably administered by untrained faculty. Each of the 5 GOALS items also demonstrated statistically significant differences between novice and expert (P value between .0006 and .02).

Woodrum DT, et al. Construct validity of the LapSim laparoscopic surgical simulator. *Am J Surg.* 2006;191(1):28–32.

The authors¹⁵ evaluated the ability of a laparoscopic trainer to measure differences in skill levels among 3 groups of new users: medical students, surgical residents, and faculty members. In each task, there was at least 1 performance variable that could discriminate the degree of prior laparoscopic performance, and most tasks had multiple variables that could discriminate. Some aspect of time (either total task time, time spent using either the left/right instrument, or time-out failure rate) was a discriminating variable in each of the 6 tasks. These findings show that, while there may be shortcomings in virtual-reality trainers (such as lack of haptic feedback), there is evidence that they contribute to skills acquisition.

Korndorffer JR Jr, et al. Laparoscopic skills laboratories: current assessment and a call for resident training standards. *Am J Surg.* 2006;191(1):17–22.

This study¹⁶ evaluated the prevalence, utilization, and costs of skills laboratories. The authors surveyed 253 general surgery program directors with a 64% response rate. Eighty-eight percent of responders consider skills laboratories effective in improving operating room performance. Only 55% have skills laboratories. Of the programs with skills laboratories, 99% reported having video trainer equipment (mean, 3.8 trainers per laboratory; range, 1 to 15) and 46% reported they had virtual-reality trainer equipment (mean, 1.7 trainers per laboratory; range, 1 to 7). On average, residents train 0.8 hours per week (range, 0 to 6 hours); training is mandatory in 55% and supervised in 73%. The mean development cost was \$133,000 (range, \$300 to \$1 million). The survey is useful in capturing the epidemiology of skills laboratories.

Hutter MM, et al. The impact of the 80-hour resident workweek on surgical residents and attending surgeons. *Ann Surg.* 2006;243(6):864–871.

This article¹⁷ aggregated the results of 4 prospective studies from a single institution, conducted before and after the institution of the Accreditation Council for Graduate Medical Education (ACGME) mandated 80-hour workweek. The authors reported that surgical residents perceived that they had a better quality of life inside and outside of the hospital after institution of the 80-hour workweek. This sense of better well-being was associated with more sleep, less work, and improved motivation in their job. Using National Surgical Quality Improvement Program data on patient outcomes, they found no decrease in quality of care when comparing outcomes data for specific surgery procedures performed before and after the implementation

of duty hour limits. ACGME case logs of surgical volume and American Board of Surgery In-Training Examination scores also did not change with the institution of the 80-hour workweek. However, attending surgeons reported that their own quality of life inside and outside the hospital deteriorated after the implementation of the duty hour standards.

Yule S, et al. Non-technical skills for surgeons in the operating room: a review of the literature. *Surgery*. 2006;139(2):140–149.

A review of the literature from Scotland¹⁸ identified the nontechnical skills surgeons need in the operating room and analyzed whether a valid and reliable taxonomy and assessment tools existed for evaluating these skills. The literature showed that deficiencies in nontechnical skills, such as breakdowns in teamwork, communication, lack of situation awareness, and flawed decision making, led to poor patient outcomes. Although the evidence was limited, the results suggested that these nontechnical skills are a critical component of surgical competence. The literature did not show any assessment tools with acceptable validity, and the authors conclude with a call to action to develop a valid taxonomy of nontechnical skills important to surgical practice and outcomes to facilitate the development of curricula and assessment tools to advance this aspect of surgical education.

Sanfey HA, et al. Influences on medical student career choice: gender or generation? *Arch Surg*. 2006;141(11):1086–1094.

The authors¹⁹ explored the role of gender on surgical career choice. The study used a Web-based survey, which was completed by 1300 US medical students. While respondents agreed that the surgical profession offered prestige, fewer than 10% agreed with the statement, “Surgeons live well-balanced lives.” Most respondents felt that surgeons have a higher earning potential and have rewarding careers; however, the minority felt that surgeons are happy with their work. Only 1 in 50 male and 1 in 200 female medical students believed that surgery residents are capable of maintaining a balanced lifestyle. Therefore, understanding gender and lifestyle biases are important steps in turning around the declining interest in surgery among medical students.

Aggarwal R, et al. A competency-based virtual reality training curriculum for the acquisition of laparoscopic psychomotor skill. *Amer J Surg*. 2006;191(1):128–133.

A study from Imperial College, London,²⁰ developed and tested a curriculum for a virtual-reality simulator designed to develop technical competence in laparoscopic procedures. The findings suggested that novices can acquire the same level of skill whether time is spent practicing only 2 of the most complex tasks or all 12 tasks on the simulator. This is an important finding as program directors struggle

with determining time allocation and simulator practice guidelines for residents. Skills laboratory curriculum time is difficult to protect and defend, thus these findings provide evidence-based support for a standardized curriculum for enhancing laparoscopic skills.

Greenberg CC, et al. Patterns of communication breakdowns resulting in injury to surgical patients. *J Am Coll Surg*. 2007;204(4):533–540.

A qualitative, retrospective review of closed surgical malpractice claims from a previous study by Greenberg analyzed communication errors that contributed to surgical patient injury.²¹ Attending surgeons were the most common agents involved in communication errors, with surgery residents and operating room nursing staff almost equal after that. Synchronous, verbal communication (both parties are involved in a conversation at the same time, either face-to-face or by phone) was the most common communication method that broke down. Status asymmetry (eg, attending physician talking to resident) was the most common system or human factor involved in communication breakdown. In second place was ambiguity of roles, responsibilities, or leadership. This study highlights that trainees are involved in most of these cases; that handoffs are risky; and that status asymmetry plays an important role in communication errors.

McDougall EM. Validation of surgical simulators. *J Endourol*. 2007;21(3):244–247.

This review²² discusses validity in simulation and provides a framework for validation of surgical simulators. Content validity is a formal appraisal by experts in the field and determines whether the simulator is a realistic teaching model. Construct validity considers whether the simulator can distinguish the experienced from the inexperienced surgeon. For example, fellowship-trained laparoscopic surgeons outperforming junior residents on a laparoscopic simulator provide construct validity. Practicing repetitive tasks in a controlled environment before real-life application has various benefits. Surgical simulation is not meant to replace traditional methods of education; it is meant to be an adjunct to other education methods.

McCluney AL, et al. FLS simulator performance predicts intraoperative laparoscopic skill. *Surg Endosc*. 2007;21(11):1991–1995.

A study from McGill University²³ explored performance on 5 tasks on the Fundamentals of Laparoscopic Surgery (FLS) simulator for 22 novice, 10 intermediate, and 8 experienced subjects. This showed that FLS scores significantly correlated with the subjects' scores on a 5-dimension global tool to assess technical performance in residents performing laparoscopic surgery (GOALS) also developed at the same

institution.¹⁴ Regression analysis determined that both FLS score and postgraduate year level were independently predictive of GOALS score. From this regression model they determined that an FLS score of 70 (maximum 100) best predicted an “expert” level GOALS score greater than 20 (maximum 25). Performance on these simulator tasks was predictive of performance during a laparoscopic operation.

Park J, et al. Randomized controlled trial of virtual reality simulator training: transfer to live patients. *Am J Surg.* 2007;194(2):205–211.

In the face of increasing emphasis on simulator training for procedural skills, the authors²⁴ evaluated the effect of a short amount (2 to 3 hours) of colonoscopy simulator time on novice trainee performance during their first patient colonoscopy. During the study period, each subject performed a colonoscopy on a patient and was graded by an expert endoscopist blinded to the trainee’s allocation group and prior performance scores. Authors found that trainees who spend a few hours on a simulator before the first patient colonoscopy convey measureable but small performance improvement. They call for further research to measure whether such improvement is clinically significant.

Dunkin B, et al. Surgical simulation: a current review. *Surg Endosc.* 2007;21(3):357–366.

This review of the literature on surgical simulation²⁵ makes an important distinction between low-level skills that may require inexpensive simulation devices and high-fidelity simulators that are designed for more complex laparoscopic and endoscopic procedures. This article provides a detailed analysis of existing surgical simulators and offers an overview on surgical education theory. The findings are important to faculty members looking to start a simulation program.

Scott DJ, et al. The new ACS/APDS skills curriculum: moving the learning curve out of the operating room. *J Gastrointest Surg.* 2008;12(2):213–221.

The article²⁶ summarized recent changes in surgical education that have led to greater emphasis on simulation, including limited trainee work hours, real or perceived decreases in case volumes, and broader and more structured educational objectives. A 3-phase curriculum development plan was created: basic and core skills first, followed by advanced skills, and finally a set of team-based skills. Where simulators were required, emphasis was placed on low-cost, reliable, reproducible methods. The authors noted that assessment methods for simulation remain a challenge. Validated techniques require substantial investment of time by expert surgeons, and automated

scores generated by computerized simulators have not often shown to be as effective as observation by an expert.

Sturm LP, et al. A systematic review of skills transfer after surgical simulation training. *Ann Surg.* 2008;248(2):166–179.

This review of randomized controlled trials and nonrandomized comparative studies²⁷ reports on the use of simulation-based training and the transferability of skills to the operative setting. For laparoscopic cholecystectomy and colonoscopy/sigmoidoscopy, participants who received simulation-based training before undergoing patient-based assessment performed better than members of comparison groups who did not receive previous training. However, improvement was not demonstrated for all measured parameters. From their review, the authors conclude that skills acquired by simulation-based training seem to be transferable to the operative setting.

Borman KR, et al. Changing demographics of residents choosing fellowships: long-term data from the American Board of Surgery. *J Am Coll Surg.* 2008;206(5):782–788.

This study²⁸ used data from a survey completed by residents taking the American Board of Surgery In-Training Examination between 1993–2005 to explore the relationship between resident demographic attributes and plans to pursue fellowship training. During that period, the number of female chief residents almost doubled, and the number of international medical graduates nearly tripled. In 2005, the percentage of chief residents pursuing fellowships rose from 67% to 77%. A principal finding was that changes from “no fellowship” to “fellowship” were heterogeneously distributed over time and with respect to demographic characteristics. The results showed that a larger number of general surgery residents are fellowship bound regardless of sex or demographics. The findings have important implications for surgical workforce planning, the surgical residency clinical curriculum, and career mentoring.

Discussion

The last published review of surgical education research by Derossis et al²⁹ was based on articles published from 1968 to 1998. This study found curriculum and teaching to be the most frequent themes, followed by assessment and program evaluation. Similar to our findings for research methodology, the earlier review also found that descriptive research methods were used most often. Our study demonstrates that surgical education researchers focused on the use of simulation. This is not surprising, given the advances in simulation technology, concerns with the 80-hour limitations on duty hours creating barriers to adequate technical preparation, the ACGME requirement

that simulation be a part of general surgery residency programs, and the need for program directors to better understand how to integrate simulation into busy education programs. Researchers have attempted to enhance their understanding of simulation, especially given its cost in equipment and time. Most of these investigators have concluded that simulation is effective.³⁰ However, others have analyzed medical education research efforts and noted that most simulation research is effectiveness driven rather than discovery driven. In other words, researchers study the relative effectiveness of existing simulators or other instructional strategies rather than discovering new innovations.

Similar to the review by Derossis et al,²⁹ descriptive research methods (largely surveys) remain the dominant method of inquiry. Descriptive research is an appropriate and necessary method to observe or describe a phenomenon or set of behaviors. Although survey research and other descriptive-type methods can be informative, experimental studies are needed to establish causal relationships. Hypothesis-driven experimental studies require the background information often provided by descriptive studies, but it is disappointing that both our study and that of Derossis et al²⁹ show that descriptive research remained the dominant method in the past 2 decades. As noted by Cook and Beckman³¹ in “Reflections on Experimental Research in Medical Education,” education research requires rigorous methods to address the questions facing medical education today. Qualitative and experimental methods continue to be popular, but experimental research remains problematic for medical educators.³¹

There are several limitations to this study. The Web of Science was the sole database used to identify the most frequently cited articles; it would have been optimal to use multiple databases. We used the number of citations as a proxy for “best papers.” Citation frequency is used in many academic institutions as part of a promotion dossier to evaluate the impact that an author has had in his or her field. The limitation of using citation numbers is that older articles have more probability of being cited than newer articles. We attempted to offset this by inviting coauthors to each submit a recent, highly influential article. There is bias in this selection process, but it is the basis for methods others have used to identify “best” articles previously.³²

Conclusion

Popular research themes and trends in surgical research during the past decade highlight the emphasis on simulation, assessment of competence, patient safety, team training, and teaching the clinical sciences as key themes, with simulation as the central theme. A number of studies also explored changing patterns in specialty selection, including declining interest in traditionally highly desirable careers in surgical

specialties. The popular themes of research in surgical education illuminate the information needs of surgical educators as well as topics of high interest to the surgical community.

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