Factors in Optimizing the Learning Environment for Surgical Training

Wade Gofton, MD*†; and Glenn Regehr, PhD*‡

Today’s surgeon is required to demonstrate a variety of professional competencies in an increasingly complex environment. Recently, the time available to train this surgeon has started to erode due to external pressures on administrators and faculty. This growing crisis has led to questions about how to optimize learning in the surgical environment. Clearly, to adequately train a competent surgeon in all the required aspects, multiple environments will be required. We must, therefore, look carefully at each environment to maximize its educational potential for each of the competencies. At the same time, however, we must ensure these educational environments and opportunities integrate into a coherent and systematic program of training that is flexible and adaptable to the individual needs of the trainees. This paper describes two broad areas that must be at the forefront of the community’s thinking as we strive toward this goal: the irreplaceable value of a mentor and maximizing the potential of optimal challenge points in learning.

The surgical learning environment as we know it may be on the verge of a radical change. Many are beginning to question whether the traditional Halstadian apprenticeship model of surgical education is able to adequately prepare our trainees for today’s environment.” A recent American Surgical Association Blue Ribbon Committee has recommended “... no less than a new surgical education system ...” as being “... essential not only for producing the next generation of highly trained surgeons, but also for enhancing the quality of the most advanced patient care ...” This report endorsed the 80-hour work week and suggested this regulation provides a unique opportunity to restructure programs with the focus on a resident as a learner rather than a provider of service. The report also suggested restructuring should improve the quality of life of the trainee by minimizing the duration of residency. Mechanisms proposed to address the length of the training program have included the possibility of a competency-based progression (rather than time on service) and an increased modularity of the training program to allow greater flexibility in training.13,38 These Blue Ribbon Committee suggestions would also affect orthopaedic training programs, perhaps even resulting in similar dramatic structural program changes. Such a wholesale change in training structure will undoubtedly present a tremendous challenge. The value and implications of these changes need to be carefully considered before their implementation. An important part of this consideration should be a discussion of key factors that affect the learning environment. This paper is an attempt to highlight, through a review of relevant literature, two key factors in optimizing the learning environment: revaluing the role of the mentor in orthopaedic education, and maximizing training efficiency by maintaining the optimal challenge point for each individual learner.

Placing the Discussion in Context

Before attempting to define the optimal learning environment it would first be valuable to define the goals and context of orthopaedic training. The primary goal, of course, is to produce an excellent orthopaedic surgeon. But what might this individual look like? This basic question is complicated by a variety of factors, perhaps the most important of which is the definition constantly changes with the continued evolution of professional and societal expectations. Canadian and American professional bodies have worked to better define the educational standards required of training programs in the hopes this will translate to a better physician. The CanMEDS project, a competency-based framework for teaching and evaluating spe-

From the *Wilson Centre for Research in Education, University Health Network, Toronto, Ontario, Canada; the †Department of Surgery, University of Ottawa, Ottawa, Ontario, Canada; and the ‡Department of Surgery, University of Toronto, Toronto, Ontario, Canada.

One of the authors (GR) has received funding as the Richard and Elizabeth Currie Chair in Health Professions Education Research; one of the authors (WG) has received funding from the Royal College of Physicians and Surgeons of Canada Fellowship for Studies in Medical Education.

Correspondence to: Glenn Regehr, PhD, Wilson Centre for Research in Education, 1E565-200 Elizabeth Street, Toronto, Ontario M5G 2C4, Canada.
Phone: 416-340-3615; Fax: 416-340-3792; E-mail: g.regehr@utoronto.ca.
DOI: 10.1097/01.blo.0000224028.93355.8c

CLINICAL ORTHOPAEDICS AND RELATED RESEARCH
Number 0, pp. 000–000
© 2006 Lippincott Williams & Wilkins

Copyright © Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.
cialists, was developed a decade ago and has been recently reviewed and updated. A similar competency-based educational mandate has recently been developed by the Accreditation Council for Graduate Medical Education (ACGME), requiring programs to redefine their educational goals and evaluation formats. Broad concepts of today’s ideal physician can be identified in these required competencies. In addition to being technically skilled, today’s ideal surgeons must be compassionate and effective communicators, patient advocates in the greater health care system, committed to the continued advancement of the field’s skill and knowledge base, and able to conduct themselves in the ethical fashion expected of a professional. The goal of these stated competencies is not so much the de-emphasis of core knowledge and procedural skills of the surgeon, but a re-emphasis on the full range of abilities demonstrated by excellent surgeons in and out of the operating room. At the risk of reducing the point to a cliché, this is an effort to reinforce the idea the graduating and practicing surgeon should embody the knowledge, skills, and attitudes of an effective and caring professional. It is insufficient to generate a proficient technician who lacks judgment or a knowledgeable individual who cannot effectively work in a multiprofessional team.

While these competencies have been supported in the abstract by surgical graduates and program directors alike, to have relevance for surgeons in training, they must also be applicable to the daily work of the practicing surgeon. Recognizing the difference in practice profiles between specialties, the CanMEDS initiative provided for this flexibility, allowing each national specialty committee to place its own emphasis on these core competencies. Thus, the responsibility of the specialty is to determine how to meet these expectations in the current health care climate (work hour limitations, fiscal constraint, consumerism, and litigation) and to how to nurture, advance, and ensure these ideals are in place at the end of training.

Considering the diversity of the defined professional competencies, it is unlikely a single context (operating room versus skills laboratory versus clinic versus lecture room) will be sufficient for developing all these skills. Rather, each learning context has advantages and disadvantages. Combined effectively, these contexts can supplement and support each other. Proliferated haphazardly, they can create an incoherent learning environment and overwhelm rather than help the trainee. Thus, an additional challenge is integrating these multiple learning contexts into a coherent training program and coordinating them to maximize the extent to which they provide mutual support for each other.

The task before us, therefore, is to train a multifaceted, well-rounded professional using multiple contexts in a complicated (and not always education friendly) health-care climate. Such a task requires surgical educators to rethink approaches to surgical training on a macro scale to maximize not only the number of learning opportunities, but also the potential of those learning opportunities. Thus, questions such as, “What are we going to cut out of our program?” or “How much time do residents need in a simulator?” might profitably be preceded (or at least supplemented) by questions such as “How are we going to ensure a coherent and coordinated educational experience for our trainees?” and “How can we build sufficient flexibility into the program to maximize our responsiveness to the individual strengths and weaknesses of each trainee?” This paper will address two broad topics likely to be valuable for optimizing this form of flexible, integrated learning environment: the role of mentorship and the role of optimally progressive training.

**Redefining and Reasserting the Role of the Mentor**

Traditionally, the art and science of surgery was transferred exclusively through a student-teacher apprenticeship relationship. An experienced surgeon transferred knowledge to a hand-picked apprentice in an informal but intensive relationship. This mentorship was formalized in North America in the late 1800s by William Halsted, who introduced the basis of our current model for surgical training. This model introduced many of the current tenets of academic surgical practice, a close association of the resident with the professor, depth and breadth of clinical experience, teaching of house staff, and participation in research. While well intentioned, this resident-professor relationship was also extremely paternalistic and created the darker side of surgical training: a pyramidal structure with extended work hours, harsh competition for the top spot, and indefinite tenure. However, the potential value of a positive mentor-trainee relationship should not be overshadowed by this history. In one study, nearly 80% of responding pediatric residents reported having a mentor was very useful or crucial to surviving residency. Recent evidence indicates junior academic faculty who have been properly mentored are more likely to have a productive research career, greater confidence, and greater career satisfaction. Jackson et al reported 98% of Harvard medical faculty identified a lack of mentoring as the first (42%) or second (56%) most important factor hindering career progress in academic medicine. And as the education experience becomes increasingly fractured by additional learning contexts and increasingly pressured with more skills and knowledge to learn, the role of a mentor who can help integrate and contextualize training will likely become more, rather than less, important.

Soubra has defined the modern and humanistic surgical mentor-trainee relationship as one that represents a greater two-way relationship based on trust and commitment.
He promotes an evolution of the concept of a mentor from the paternalistic and protective authoritarian model toward one that treats the trainee with the respect of a responsible equal. He further outlines seven qualities of the ideal mentor. An effective mentor needs to be able to motivate the trainee to learn and reach their full potential but the means to do this are variable. A mentor must empower the trainee by working with them to identify and refine their innate ability. A mentor must nurture self-confidence by setting high goals and ensuring they are achieved by providing early support and supervision with progressive independence in a safe setting. A mentor leads by example. As Leach states, “. . . residents seek to mimic good clinicians.” Thus, good mentors treat their patients and colleagues with respect and compassion, conducting themselves and their practices in the manner they would expect of their trainee. An effective mentor takes the time to listen to a trainee’s concerns, making an effort to articulate their ideas and responses with clarity. Respect for a trainee’s question or opinion is essential to ensuring they will take future intellectual risks without the fear of ridicule or rejection. Successful mentors have high expectations of themselves and their trainee but ensure these expectations are attainable. Finally, a good mentor realizes credit lies in the success of the trainee. Therefore, this effort is not made in the hope of credit or reward, but in the hope that one’s trainee will be more successful than oneself. The best mentors in academic surgery are strongly committed to the professional and personal growth of their trainees.

Consistent with these descriptions, research suggests trainees tend to look for several general qualities in a potential mentor. For example, the ability to inspire and support the trainee and to provide career, networking, and psychosocial support are highly valued by residents. Wright suggested residents consider clinical skills, compassion, and excellent teaching as greater attributes than academic title or research accomplishments. Ramanan et al also suggested the characteristics of keeping in close touch regarding progress and not abusing a position of power are essential to the development of a satisfying relationship.

Program support for the development of mentoring relationships between faculty and trainees is not simple. Support of the mentor-trainee concept goes beyond simply assigning a faculty advisor. The assigned advisor may be able to provide invaluable academic or professional advice, but the selection of a mentor by a trainee is quite individual, and based on the right chemistry. Souba also notes a worthy mentoring relationship takes time to develop. Availability of the mentor to early trainees is essential in being identified as a potential mentor. Thus, programs must not only provide an academic advisor, but also make an effort to support the development of true mentor-trainee relationships. An important step in ensuring such relationships develop is providing early opportunities for faculty and junior trainees to interact intensively in relatively stress-free circumstances. Unfortunately, the current training environment is often entirely opposite. Often the senior surgical resident or fellow will have the most exposure to the staff in the operating room, while the novice has little interaction and is often left to manage patients or learn routine skills independently. This problem may be exacerbated by larger program size, hierarchical structure, and greater numbers of associated clinical fellows. Programs need to find means to avoid this situation and ensure program size does not contribute to the so-called darker side of residency. Therein is a potential hidden opportunity for skills laboratories. Anecdotal experience at the University of Toronto has led us to believe an unanticipated but important value of the surgical skills laboratory is the opportunity for early staff-trainee interactions. Trainees appreciate this distraction-free opportunity to learn from and interact with the experts and it provides an opportunity for them to identify potential mentors.

Like any relationship, once created, a mentoring relationship must have an opportunity to evolve and flourish. Ideally, the novice trainee would have a high degree of contact with the mentor. Again, this is not always easy in the current healthcare environment. To a large extent, the cost of this time spent in medical education has been subsidized by clinical income and unreimbursed contributions of an individual physician’s time and effort. However, as the financial environment of the teaching hospital becomes increasingly competitive, faculty have less time available for teaching. As clinicians are forced to direct their focus towards clinical endeavors, the fragile social teaching contract with the academic centers is increasingly at risk. The resultant declining availability of expert teachers for medical education over the last 20 years has been met with increasing calls for a solution to the problem. To reverse this concerning trend, the cost of medical education needs to be shouldered by the academic institution, hospital, and surgical department in addition to the physician. While physician-based alternate funding constructs may alleviate the drive for clinical productivity to some degree, it is unlikely this issue will be truly resolved unless academic hospitals accept they are also in the business of education.

Exacerbating the issue, research universities operate in a competitive environment where their legitimacy and potential for resources is based on research productivity. This has resulted in academic success becoming virtually synonymous with research productivity. As Kenny has stated, “The typical department in a research university asserts it places a high value on effective teaching . . . ,” but
While universities have been given the mandate of medical training, consideration for academic advancement is based primarily on research output or clinical reputation, and remuneration for teaching is far less than for clinical activities. This publish or perish mentality, in conjunction with the increasing difficulty in acquiring research grants has required these physicians to focus on their research at the expense of teaching.

The lack of support and recognition for teaching, and the perception neither the hospital nor the medical school value teaching has also contributed to an exodus of high quality educators from academic institutions. In response to the declining availability of quality educators, many institutions established new positions for the clinical educator. However, good intentions have been compromised by persistent inappropriate promotion criteria or the failure of these tracks to lead to tenured positions. The criteria for university promotion needs to be revised and the potential for tenure needs to be equivalent to the clinician or clinical scientist, to allow these clinical educators to focus on training and mentoring. Levinson and Rubenstein suggest for the clinician-educator the need for a regional or national reputation (publications or presentations) should be replaced with the pursuit of clinical and teaching excellence. This will necessitate the development of new and appropriate means to assess an educator’s value to the institution (perhaps based on time devoted to education or colleague opinion). To resolve the issue of inequality in remuneration, it has been suggested budgetary and reward systems be aligned with the value system of the institution (mission-based budgeting). However, for this budget realignment to provide opportunities for clinician-educators, the mission and values of the institution need to be clarified. If the reward structures in modern research universities truly reflect the synergy of teaching and research, the opportunity to re-establish the pivotal role of the mentor in surgical education will be availed.

In short, mentoring needs to be recognized as a professional activity, one that should be formalized and recognized like any other activity in academic medicine. This process starts with recruitment. Just as a program would seek to improve by identifying and hiring individuals with specific clinical or research expertise, it should also look to add clinicians with the attributes of a strong mentor. These individuals should not only understand and want to teach the expected competencies, but more importantly believe in and embody them in their practice and the way in which they carry themselves professionally and personally. They should also be skilled in teaching and bring energy to inspire and educate trainees. Formalization and recognition of mentoring also involves providing support for the continuing development of these skills in all faculty. Like any attribute, individuals are not equally endowed with the skills of an effective mentor. Fortunately, these skills can be improved with appropriate guidance, practice, and feedback. These skills can and should be improved by the development of a mentoring relationship with senior faculty members who have excelled in developing these attributes. Faculty should be encouraged to attend workshops or pursue advanced degrees in education where appropriate. As with clinical and research developments, education and mentoring knowledge should be shared with colleagues at rounds. Finally, junior faculty need to be provided with the opportunity to practice their mentorship and leadership abilities, but as with other areas of professional development, they should receive appropriate feedback and evaluation from their own mentor.

Of course, the exact details of these efforts are likely to vary depending on the culture of each program. Our purpose here is simply to emphasize the importance of the individual mentor in the development of an optimal learning environment for the individual trainee. In a time when virtual reality (VR) simulations and web-based educational tools are being touted as potential independent learning replacements for lost teacher time, and at a time when skills laboratories and VR laboratories are contributing to the potential fractioning of a trainee’s educational experience, the importance of the mentor in the development of the competent graduate can not be overstated. It is the individual mentor who can aid in the coordinated and integrated development of a sound knowledge base and clinical reasoning skills. It is the mentor who is required to provide the early and continuous supervision, timely feedback, and graded increase in responsibility essential for the safe development of trainee self-confidence and independence. A single individual who cares intimately about a trainee’s educational experience can go a long way to make up for a system that does not always seem to. And no amount of systemic educational innovation can make up for the absence of such a mentor.

Providing an Environment for Progressive Learning

The context of surgical practice is not generally an easy environment in which to function. It is marked by stress, responsibility, and pressure. It requires the management of multiple inputs and demands during critically emergent situations. It is often performed under the suboptimal psychomotor conditions of sleep deprivation or after previous tiring surgeries. Yet societal and professional expectations require the surgeon be able to perform the task well regardless of these difficulties. Thus, it is for these conditions and expectations that programs must prepare their trainees.
The need to prepare trainees for the rigors of practice has often been used as an excuse to impose those rigors early and often in training. And, in fact, a naïve interpretation of the literature on encoding specificity would seem to support such a position. The concept of encoding specificity was first developed to account for the finding that one’s ability to remember learned material is affected by the extent to which the learning conditions match the conditions of later performance. Such effects have been shown for a range of skills from simple memory tasks to more complicated perceptual-motor tasks. One specific manifestation of encoding specificity is the concept of context specificity, which describes the idea that later performance is enhanced if the context of the performance closely matches the context of the learning. In the classic example of context specificity using Royal Navy divers, Goddin and Baddeley suggested word lists learned on land were later recalled better on land while those learned underwater were recalled better underwater. The similarity of the context, however, is not just limited to the external environment. For example, in one experiment on state-dependent learning, participants learned and recalled material while in states induced by smoking tobacco cigarettes or marijuana cigarettes at the time of learning and at the time of recall. A pattern of data similar to the one reported by Godden and Baddeley was observed.

Again, a naïve interpretation of this literature on transfer-appropriate processing would seem to support the concept of teaching residents under conditions of stress similar to those likely to encounter upon graduation. Such an interpretation, however, is the rough equivalent of arranging a swimming lesson by sinking a boat: those who survive do not learn how to swim, they learn how to keep their heads above water, and they graduate with all the attendant bad habits acquired for the sole purpose of surviving. There is no question it is the responsibility of a surgical training program to prepare its trainees for the reality of practice. However, educational theory would tell us this does not, in fact, require an immediate and unfiltered exposure to that reality from the moment they enter the program. Rather than the age old throw them into the fire mentality, we need to gradually prepare the trainee to function in their future professional environment. This will require a graded approach to training, enacting progressively closer approximations of that ultimate reality. Of course, the concept of graded responsibility is well-entrenched in the language of medical training programs. Residency programs have an ethical obligation to develop mechanisms and systems ensuring the training of residents does not risk, harm, or have any detrimental effect on patient outcomes. However, the program also has an obligation to develop a competent physician who can function safely in an independent fashion. The concept of graded responsibility in a supervised environment is essential in rectifying these two opposing requirements. It ensures patient safety while maintaining resident confidence by avoiding situations in which they are overwhelmed or unable to fulfill expectations.

It is important to realize, however, this concept of graded challenges is relevant not only to the concept of responsibility, but to all aspects of the learning environment. A model of graded challenge for motor skill learning, for example, has been formulated by Guadagnoli and Lee. They draw an important distinction between the nominal difficulty of a task (which includes only characteristics of the task irrespective of the person performing the task or the conditions under which the task is being performed) and the functional difficulty of the task (which addresses how difficult the task is given the skill level of the person performing the task and the conditions under which the task is being performed). Further, they assert learning is a matter of information-processing and the information available to be learned arises from the challenge presented by a skill as it is performed. Their optimal challenge point model is built on the following premises: (1) learning cannot occur in the absence of information, so if a skill is insufficiently challenging, no information is present and learning does not occur and (2) too much information can impede learning, so if a skill is overly challenging, the ability to learn is undermined. Thus, optimal learning achievement is dependent on finding the optimal challenge point for the individual, a point determined by the task’s functional difficulty, not its nominal difficulty. A similar line of argument was developed by Easterbrook, who identified and quantified the phenomenon of attentional narrowing associated with rising levels of stress. Easterbrook’s work suggests a certain degree of attentional narrowing is beneficial to learning (in that it aids in filtering out irrelevant details), but excess stress is detrimental to learning (as relevant details are also filtered). Again, the optimal stress point will differ between trainees and requires constant evaluation by supervisors to ensure it is maintained at an optimal level.

At the level of individual skills, these models of optimizing learning would support the use of alternate learning environments (eg, surgical skills laboratories, simulators, and standardized patients) for the learning of the cognitive and technical aspects of procedural tasks. Once mastered in the safe, controlled practice environment, where the stress level and task challenge can be optimized to maximize trainee learning rather than clinical productivity, it will be possible to extend these skills to a supervised, real world setting to ensure maximal transfer-appropriate processing.

At a more program level, this concept of the optimal learning point would manifest as the competency-based
progression recommended by American Surgical Association Blue Ribbon Committees, whereby increases in challenge are based on level of performance rather than (as is often the case) time-on-task. However, a simple translation to a program level version is complicated by each individual’s skills in the various domains of professional practice progressing at different rates. Thus, one trainee may be technically ready to cut before she is cognitively ready to decide when to cut. Another may be cognitively ready to manage a case before he is emotionally ready to manage a team. Thus, on a program level, such a move to competency-based progression will require more effective and frequent evaluation of each dimension of professional practice. On an individual level, this once again speaks to the unparalleled value of an effective mentor who can help a trainee determine the optimal challenge point that will allow him to progress maximally in each of these domains.

Challenge, however, describes only one half of an important duality in optimizing learning. That is, challenge must be balanced with effective support. As Robertson has argued, learning is often disconcerting and anxiety provoking. Thus, a trainee’s willingness to extend himself, to push his learning, to remain regularly at the optimal challenge point, is dependent at least in part on a sense of security in the learning environment. The key, therefore, is to find the right balance. As Keegan has eloquently articulated:

“If I were asked to stand on one leg, like Hillel, and summarize my reading of centuries of wise reflection on what is required of an environment for it to facilitate the growth of its members, I would say this: people grow best where they continuously experience an ingenious blend of support and challenge; the rest is commentary. Environments that are weighted too heavily in the direction of challenge without adequate support are toxic; they promote defensiveness and constriction. Those weighted too heavily toward support without adequate challenge are ultimately boring; they promote devitalization. Both kinds of imbalance lead to withdrawal or dissociation from the context. In contrast, the balance of support and challenge leads to vital engagement.”

Thus, the optimal learning environment, from the perspective of progressive learning theories, involves an individual’s evolution toward the ultimate goal of a practitioner who is prepared for the realities of practice through a gradual layering on of these realities rather than an unfiltered immersion experience. However, it is not a stable, authoritative series of regimented steps that can be applied to all trainees in the same way. Rather it is an individualized, constantly reconstructed balance of a complicated and delicate set of dualities. It is challenging enough, but not too challenging. It is stressful enough, but not too stressful. It is supportive enough, but not too supportive. And it is a different mix of these balances for each individual and for each skill an individual is trying to master.

Managing a truly competency-based training program presents interesting challenges. It is likely to require, for example, a move to more frequent and effective competency-based evaluations in a training program, which requires, in turn, continuing efforts to develop effective measures of surgical competence. More dramatically, it would likely require a substantial change in the structure of current programs, a change that would allow trainees to move through a program at an individual pace as determined by these competency-based evaluations. This will require a corresponding increase in program flexibility, which, regardless, will likely be essential to the success of orthopaedic programs in the future. Not only will increased flexibility allow for individualized and streamlined trainee learning, it should improve the ability of the program to respond to rapid changes in the training environment, and meet the changing needs of all trainees.

However, to truly enact such a change, the clinical programs would need to develop the ability to function independent of the trainee. For example, while it is important for the novice to learn basic skills such as ward management, expecting the trainee to engage in inefficient and repetitive service in the guise of learning would have to be eliminated. It is in the interests of the trainee (and the patient) that they be appropriately guided in learning, supervised in practice, and subsequently relieved of these duties to pursue other training once competency has been displayed. An excellent example of how such a system can be enacted in practice is described by Nishimura et al.

**DISCUSSION**

Today’s surgeon is required to demonstrate a variety of professional competencies in an increasingly complex environment. Recently, the time available to train this surgeon has started to erode through pressures on our administrators to decrease program length and the number of hours of training per week and on our faculty to attend increasingly to competing clinical and academic demands. The result of these pressures has been a sense that we must squeeze more and more information into a smaller and smaller timeframe. This growing crisis has led to questions about how to make learning more efficient. The resulting crisis, however, is also an opportunity to reassess our assumptions of what good education looks like in this environment. Clearly, to adequately train all the required aspects of a competent surgeon, multiple environments will be required. We must, therefore, look carefully at each environment to maximize its educational potential for each of the competencies. At the same time, however, we must ensure these educational environments and opportunities
integrate into a coherent and systematic program of training that is flexible and adaptable to the individual needs of the trainees. We have suggested two broad areas that must be at the forefront of the community’s thinking as we strive toward this goal: the irreplaceable value of a mentor and the maximizing potential of optimal challenge points in learning. Through such mechanisms, we can make education more effective. And if we can accomplish this, efficiency will be a natural consequence.

References

42. Royal College of Physicians and Surgeons of Canada. “The Can-