The Use of a Novel Teaching Rubric Improves Technical Skill Acquisition and Retention

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ABSTRACT:

INTRODUCTION: Many clinicians lack formal training as educators, and surgical trainees often report that they do not receive adequate teaching and feedback. Given the importance to make use of every surgical encounter, there is a need for a more deliberate approach to surgical skill teaching. We developed a teaching rubric (N.O.D.O.F.F.), which outlines for the instructor the use of Needs, Objectives, Demonstration, Observation, and Feedback for technical skills. We hypothesized that N.O.D.O.F.F. will improve instruction and learning, and therefore, improve basic surgical skills acquisition and retention.

METHODS: Sixty-five consecutive medical students were recruited before their surgical clerkship to undergo basic surgical skills pre-test (knot-tying and suturing) at the simulation center. They were then immediately, randomly assigned to a blinded 90-minute skills session with an instructor trained to use N.O.D.O.F.F. (intervention) or standard instructor (control). Immediately afterwards, students performed post-test, followed by 1-month retention test. All tests were videotaped and scored by two blinded raters using validated assessment tools. Repeated-measures-ANOVAs were conducted to test for differences in performance scores over time (pre-post-retention). Students and instructors completed questionnaires on the use of N.O.D.O.F.F. Qualitative and quantitative analyses of questionnaires and observer notes were also conducted.

RESULTS: Baseline-skill was equivalent across conditions. Improvements in surgical skills performance was significantly higher for intervention than control group $F(1,60)=35.37$, $p<.001$(suturing), $F(1,60)=18.42$, $p<.001$(knot-tying). The intervention group continued to perform significantly better at 1-month follow up than control for suturing, $F(1,12)=12.91$, $p<.01$. Analyses of questionnaires and observer notes revealed the tool was easy to follow and improved instructors' teaching and feedback.

CONCLUSION: The use of the simple cognitive aid, N.O.D.O.F.F., to help instructors, resulted in a significant improvement in skills learning and retention in a novice cohort. Hence, it can be used as a practical teaching tool for surgical skills training. In future work, we plan to test its use in the operating room.

RESUME:

INTRODUCTION: Beaucoup de cliniciens n'ont pas de formation officielle en tant qu'éducateurs et les stagiaires en chirurgie déclarent souvent ne pas recevoir d'enseignement et de rétroaction adéquats. Étant donné l'importance de faire usage de chaque rencontre chirurgicale, il est nécessaire d'adopter une approche plus délibérée de l'enseignement des habiletés chirurgicales. Nous avons développé une rubrique d'enseignement (N.O.D.O.F.F.), qui décrit pour l'instructeur l'utilisation des besoins, des objectifs, de la démonstration, de l'observation et de la rétroaction pour des qualifications techniques. Nous avons émis l'hypothèse que N.O.D.O.F.F. Permettra d'améliorer l'enseignement et l'apprentissage et, par conséquent, d'améliorer l'acquisition des compétences chirurgicales de base et de la rétention.

MÉTHODES: Soixante-cinq étudiants de médecine consécutifs ont été recrutés avant leur stage chirurgical pour subir un pré-test de base en chirurgie (nouage et suture) au centre de simulation. Ils ont ensuite été immédiatement assignés au hasard à une session aveugle de 90 minutes avec un instructeur formé pour utiliser N.O.D.O.F.F. (Intervention) ou instructeur standard (contrôle). Immédiatement après, les étudiants ont effectué post-test, suivi d'un test de rétention de 1 mois. Tous les tests ont été enregistrés sur vidéo et notés par deux évaluateurs aveugles à l'aide d'outils d'évaluation validés. Mesures à répétition - Les ANOVA ont été effectuées pour tester les différences dans les scores de performance au fil du temps (pré-post-rétention). Les étudiants et les instructeurs ont rempli des questionnaires sur l'utilisation de N.O.D.O.F.F. Des analyses qualitatives et quantitatives des questionnaires et des notes d'observateurs ont également été effectuées.

RÉSULTATS: La compétence de référence était équivalente dans toutes les conditions. L'amélioration de la performance des interventions chirurgicales était significativement plus élevée pour l'intervention que le groupe témoin $F (1,60) = 35,37$, $p < 0,001$ (suture), $F (1,60) = 18,42$, $p < 0,001$ (nouage). Le groupe d'intervention a continué à améliorer significativement le suivi au cours d'un mois que le contrôle pour la suture, $F (1,12) = 12,91$, $p < 0,01$. Des analyses de questionnaires et de notes d'observateurs ont révélé que l'outil était facile à suivre et que l'enseignement et la rétroaction des instructeurs étaient améliorés.

CONCLUSION: L'utilisation de l'aide cognitive simple, N.O.D.O.F.F., pour aider les instructeurs, s'est traduite par une amélioration significative de l'apprentissage des compétences et de la rétention dans une cohorte novice. Par conséquent, il peut être utilisé comme un outil d'enseignement pratique pour la formation des compétences chirurgicales. Dans les travaux futurs, nous prévoyons de tester son utilisation dans la salle d'opération.

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CONFLICTS OF INTEREST:

I have no conflicts of interest or disclosures to declare.

LIST OF FIGURES:

CONTRIBUTION OF AUTHORS:

Marina Ibrahim:

1. Methodology, design and planning of study
2. Conducted the study and collected the data
3. Interpreted the data
4. Performed manuscript preparation and editing

Melissa C. Duffy:

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2. Performed statistical analysis
3. Contributed to data analysis
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Kevin Lachapelle:

- Methodology, design and planning of study
- Supervised the study
- Contributed to data analysis
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SECTION 1:

INTRODUCTION

INTRODUCTION:

1. BACKGROUND

Teaching practical skills is a core component of undergraduate and postgraduate surgical education. Feedback is a fundamental aspect of the teaching and learning process that helps trainees reach their maximum potential (2, 3). It is described by Rowntree as as the ‘‘lifeblood of learning’’ and by Ende as “information describing students’ or residents’ performance in a given activity to guide their future performance in that same or related activity,”(1). Performance-based feedback enables good habits to be reinforced and faulty ones to be corrected (4). Ericsson explains that deliberate practice means: focusing on a particular aspect of performance to improve; receiving detailed, immediate feedback on the performance; and having multiple opportunities to practice the performance (5). Although the “learn by doing” approach allows multiple opportunities for practice, without the focus and the feedback, learning will be haphazard at best (6). If the learner fails to come into contact with the to-be-learned material, no amount of activity or discussion will be able to help the learner make sense of it. In addition, Mayer in 2004 suggested that pure, unguided discovery learning is ineffective and inefficient, does not guarantee that students will even come in contact with the needed learning opportunities, and does not guarantee that students will learn the rules that guide future practice (7). However, in guided discovery learning, an expert provides the novice with preparatory information before the experience and offers verbal and perhaps manual guidance during the experience and feedback afterward. Students using guided discovery learning learn more quickly, more accurately, and were more likely to remember what they learned, than those who used pure (unguided) discovery learning (6-9).

While the importance of teaching is widely recognized there appears to be inconsistency in the amount, type and timing of deliberate instruction received in clinical practice (10-12), predominantly in surgical skill training (3). “We are training a group of physicians who have never been observed,” wrote Ludwig Eichna, MD (13). Not only are clinical skills infrequently observed, but when they are, the information does not get back to where it can be most helpful – back to the trainees themselves (1). In the absence of feedback from teachers, learners have to rely on self-assessment to determine what has gone well and what needs improvement. But this self-assessment does not consistently help in identifying learners’ own strengths or weaknesses. Learners may also interpret an absence of feedback as implicit approval of their performance. Medical students and residents have stated that feedback, when given effectively, is useful in helping them gauge their performance and making action plans for improvement (14-17). Yet, trainees report that feedback is given infrequently and/or ineffectively, whereas teachers themselves believe that they provide frequent and adequate feedback (18).

It is crucial to optimize our current learning and teaching models, particularly in a climate of decreased clinical exposure. Hence, the need for a more deliberate approach to operating room teaching is necessary. Moreover, as much as there is rising evidence for the use of surgical checklists to optimize patient care (19, 20), there is also evidence for the use of standardized scripts in improving learning outcomes (21). Hence, a good model for deliberate teaching in the operating room would focus the teacher on setting objectives for the learner’s performance, providing immediate and specific feedback, and providing guidance for future practice (6). The ideal model would allow surgeons to achieve these educational goals within the context of their already existing routine. We propose a model for teaching in the operating room that fosters good educational practice, while taking advantage of the already present observation and teaching opportunities available to the teaching surgeon, and fits easily into the surgeon's existing practice.

We propose a structured, brief approach to teaching and giving effective feedback on surgical skill in the operating room, a teaching rubric by the name of N.O.D.O.F.F. This outlines for the instructor the use of Needs, Objectives, Demonstration, Observation, and Feedback for technical skills. We hypothesized that N.O.D.O.F.F. will improve instruction and learning, and therefore, improve basic surgical skills acquisition and retention.

2. HISTORY OF TEACHING AND LEARNING IN SURGERY

2.1 Apprenticeship model

Up until the 19th century, the most common and well-established method of training surgeons has always been an apprenticeship system, with trainees working under supervision until judged competent to operate on their own (22, 23). Apprenticeship is a particular way of enabling learners to learn by doing(24). It is often associated with vocational training where a more experienced mentor models behavior and the apprentice attempts to follow the the model, and the expert provides feedback (24, 25). By developing similar performance to other experts, an apprentice will come to understand the implied duties of the position. In essence, the student learns to perform surgery through direct observation and then by mimicking the actions of a skilled mentor, both in the operating room and in the clinical environment (23).

Apprenticeship learning has several formal definitions. According to Barab and Hay 2001, “apprentices work side by side with an expert in order to learn a specific task,” (26, 27). They go on to describe the model in three stages. First stage is the development of learning contexts that model expertise, followed by coaching and scaffolding in the second stage, and in the final third stage, learners go on to independent practice so that they gain an appreciation of the use of domain-related principles across multiple contexts (26, 27). As per Collins and Brown 1989, apprenticeship is a form of “on-the-job training”, that is used by mentors to teach learners how to solve problems, understand tasks, perform specific tasks and deal with difficult situations, through the process of observation and imitation (28).

Unlike other models in education, the apprenticeship model is rarely formally taught. The concepts communicated through apprenticeship are often practical, inferred strategies for achieving goals that do not always conform to standard procedure(22). The Apprenticeship Perspective can be used to teach procedures to students(24, 29). For example, tying a knot, and taking blood can all use the apprenticeship model to teach students these skills. It can also be used to develop experts in fields that involve increased complexity, numerous grids of interaction, or variable situations demanding constant attention(24). For example, learning how to drive, how to sail a boat and sports training all use the apprenticeship model for learners to learn a specific task(24). Length of training and the starting age of the apprentice could vary, but a classic apprenticeship in the mid 1500s would last five to seven years and that's starting around the age of 12 or 13 (30).

Hansman 2001, describes the apprenticeship model in five phases that delineate the roles of the learner and teacher during the process of observing and endorsing concepts(31). Phase I is the 'Modeling' phase, where the act is observed and contemplated. He explains by saying, "Modelling occurs in two parts: behavioral modeling allows learners to observe performance of an activity by experienced members to share "tricks of the trade" with new members" (31). Phase II is the 'Approximating' phase, where the learner begins to imitate the actions of the teacher and then once they try it, they start reflecting on it and examine what they did compared to the expert and why they did it that way (31). For phase III, the 'fading' phase, the learner begins to operate in a more detailed manner, and the learner's abilities are increased as the experts support decreases (31). In phase IV, the 'self-directed learning' phase, the learner performs the actions within real society, and only seeking guidance from the expert when required (31). The final phase, phase V, is the 'generalizing' phase. This is when the learner generalizes what has been learnt, tries to employ those skills to various situations and relates what he/she learnt to other relevant situations (31).

As the field of surgery gradually evolved, the apprenticeship model remained the gold standard of surgical education. However, there were 'no principles or guidelines for what knowledge or skills were to be taught, who should be trained, when training should start, or how long training should last'(22). The end of the 19th century and beginning of the 20th marked the first major turn from the apprenticeship training model to more standardized and structured education, the Halstedian Model (32). The manner in which surgical residents are trained is the lasting legacy of Sir William Halstead(33).

2.2 Halsted Model and Transformation during the 20th Century

In the late 1800's, direct patient contact was thought to be beyond the capabilities of medical students(34). However, Dr. William Osler, strongly believed in learning from patients; thus, in the late 19th century, he introduced the concept of clinical clerkships (34). He had also integrated bedside rounds into all of his classes, which was a rare happening at the time (34). By embracing Dr. Osler's concept of beside rounds and the European curriculum (formal training with close integration of basic sciences into the curriculum), Dr. Halstead, introduced the Halstedian model (35).

In the early 1900s, Sir William Halstead delivered a landmark lecture at Yale University, proposing his model of surgical training grounded on increasing responsibility with each advancing year of postgraduate training, and finally reaching the level and responsibility of the chief resident (33). Surgical trainees were required to perform clinical duties, as well as work in the laboratory (36). The average length of training for a resident was approximately 8 years. An integral part of the Halstedian training model was 'didactic' teaching, usually in the form of lectures given by attending surgeons(37). This had been maintained in most teaching hospital centers through grand rounds, teaching conferences, journal clubs, and basic science reviews(32, 33). These lectures played a big role in reinforcing the concepts that surgical trainees learn on the wards(36). The Halstedian model principles of surgical training were as follows:

- "The resident must have intense and repetitive opportunities to take care of surgical patients under the supervision of a skilled surgical teacher,"
- "The resident must acquire an understanding of the scientific basis of surgical disease,"
- "The resident must acquire skills in patient management and technical operations of increasing complexity with graded enhanced responsibility and independence," (22).

The increased understanding of the educational process during this period laid the foundation for significant developments in the field of surgical education in the 21st century. The Halstedian model created numerous leaders in the field of surgical education who went on to institute various distinguished organizations, including the Council on Medical Education (CME) and the American Medical Association (AMA) and the American College of Surgeons (ACS), in order to set standards for graduate medical education (22). In 1927, the ACS published the *Fundamental Requirements for Graduate Training in Surgery* as its own surgical education standards(38). In 1937, the ACS and the AMA and the American Board of Surgery (ABS) formed a committee on graduate training in surgery to examine, analyze and evaluate the opportunities for the training of surgeons North America. The board's findings then led to the ACS' *Manual of Graduate Training in Surgery*, guidelines set in 1939, which describes the minimum standards or criteria for graduate training in surgery (39).

The Coordinating Council of Medical Education (CCGME) was established in 1972 (40), to guarantee coordination between all organizational groups. This council then created a liaison committee for graduate medical education the same year, which is now known as the Accreditation Council for Graduate Medical Education (ACGME) (40). The ACGME headed several landmark alterations in graduate surgical education. In 1999, the ACGME outlined six core competencies that trainees must attain and master during their residency. These include: medical knowledge, patient care, interpersonal and communication skills, professionalism, practice-based learning and improvement and systems-based practice(40). This model used by the ACGME shifted from a focus on knowledge acquisition and duration of training towards the achievement of learning outcomes and preparation of physicians for meeting individual and population healthcare needs (41). Resident working hour restrictions mandated in 2003 (which was further modified in 2011) is another ACGME regulation that has had a paramount impact on the training of surgical trainees (42). Residency programs had to extensively restructure their education and service activities to conform with this regulation.

2.3 21st Century Training

With the start of the 21st century new challenges were brought to the surface. With the wide range of diseases that are treated surgically and the advancement of new therapies, residents are expected to learn more in a limited period of time. In addition, in light of the work-hour restrictions and increasing demand for documentation and other “service-related duties,” less time is available for learning or education (43).

The Halstedian model of surgical training, which is often described as the “see one, do one, teach one” approach, is inadequate as the sole training method for multiple reasons. It is limited by the availability of surgical mentors and their teaching capabilities (44). It is also very individualized. For example, a poor surgical educator, can propagate inadequate surgical skills and decision-making in the operating room. Moreover, residents, as adult learners, are aware of their own learning methods and preferences, which is often inconsistent and unpredictable as a learning process. Finally, the operating room time is too valuable may not be an ideal environment to permit teaching and learning of basic surgical skills.

Moreover, this system, which is often referred to as “education by random opportunity”, is dependent on opportunistic encounters, particularly of the complex case mix variety, which makes it very time dependent(45). This model resulted in surgical residency being extended in order to gain adequate surgical exposure to attain a sufficient level of operative experience (22). However, the modern era of surgical training mandated reductions in the number of hours trainees can legally work (46), based upon safe guarding both patients and doctors alike in order to decrease potential errors in the health care system. This resulted in a major reduction in the surgical trainees’ opportunity for surgical operating time exposure with actual patients. As a direct consequence of these challenges, interest in laboratories with formal curricula, specifically designed to teach surgical skills, has increased dramatically (47) and many residency training programs are now using animate and inanimate modules as an integral part of their curricula (47).

The use of surgical simulators and inanimate bench models for training, has been the center of attraction among training institutions around the world. The use of simulators for surgical skills training provided opportunities to acquire familiarity with instruments, improve dexterity, and offered trainees the opportunity to become knowledgeable about surgical management techniques, and potential complications, in a more controlled environment without risking the life of any patient (22, 44, 45). Trainees may also practice the skills required of their training program at their own pace. Surgical simulators have been extensively validated by an increasing body of data demonstrating transference of these skills to the operating room (41, 48-52). The integration of simulation into training surgical programs therefore seemed the next most instinctual step for the design and employment of any modern surgical training curriculum.

3. EDUCATIONAL THEORY TO PROMOTE EFFECTIVE LEARNING

In surgical education, our focus has always been on the learner and less on the teacher, in the sense that we always aim at increasing the learner experience in terms of more operative exposure, animal labs, and simulation as noted above. These are all very important elements for learners to achieve their program milestones. However, we also have learned from the literature, that deliberate instruction and feedback are critical for surgical skill training (1, 2). In order to attain their milestones, trainees need a mentor to teach, evaluate and give feedback to guide trainees' future practice. Yet, many of us clinicians, lack formal training as professional educators.

The teaching of surgical skills can be modeled on established educational theory. This helps explain, for example, how motor skills are acquired and expertise is attained. We will review the approach of practical skills teaching in contemporary surgical education in light of educational theory. We will present key concepts from some models of educational theory, critically analyzing the literature, and emphasizing how such theory can promote effective teaching and learning.

3.1 Constructivist Learning

Founded by Jean Piaget, constructivist learning postulates that learning always builds upon knowledge that a student already knows (22, 23). Constructivism assumes that all knowledge is constructed from the learner's previous knowledge, regardless of how one is taught. Constructivists suggest that learning is more effective when a student is actively engaged in the learning process rather than attempting to receive knowledge passively(24). Therefore, the learners learn best when they are allowed to construct a personal understanding based on experiencing things and reflecting on those experiences (25). Learners are the makers of meaning and knowledge. Constructivist teaching promotes critical thinking and creates motivated and independent learners. According to Audrey Gray, in a typical constructivist classroom the learners are actively involved, the environment is democratic, the activities are interactive and student-centered, the teacher facilitates a process of learning in which students are encouraged to be responsible and autonomous (26). The teacher's role is to prompt and facilitate discussion. Thus, the teacher's main focus should be to direct students by asking questions that will lead them to develop their own inferences on the subject.

Hence, in practical skills learning, this theory clarifies that trainees are more likely to acquire a skill based on a similar previous learning experience (27, 28). Thus, trainees would provide analogies when learning skills based on operative experiences from the past (27, 28). For example, trainees would compare the principles of vascular anastomosis in vein graft anastomosis to a common femoral artery in femoral to popliteal bypass to the proximal anastomosis in coronary artery bypass surgery of a vein graft to the ascending aorta.

3.2 Scaffolding and the Zone of Proximal Development

Having the opportunity to practice procedural skills repeatedly is a critical for learning, but it is surely not sufficient. Feedback is an essential component of the process. It is clear that expert assistance is vitally important, but also clear that such assistance must be wisely applied if it is not to become counterproductive (29). Lev Vygotsky, the early 20th century Russian psychologist, put forward the concept of a "zone of proximal development," or ZPD, which is an area of learning that occurs when a trainee is assisted by a teacher or peer with a skill set higher than that of the trainee (30, 31). It was also described as, “temporary learning support by an expert tutor,” by Bruner (32). The person learning the skill set cannot complete it without the help of the teacher or peer. The teacher then helps the student attain the skill the student is trying to master, in hopes that the teacher will no longer be needed for that task (30). Each learner has his/her own ZPD. Some trainees begin at a more advanced ZPD, whereas others do not.

Scaffolding is a key feature of effective teaching and can include modeling a skill, providing hints or cues, and adapting material or activity (33). The term ‘scaffolding’, has been introduced by Wood et al. in 1976 and has been described as 'those elements of the task that are initially beyond the learner’s capacity, thus permitting him to concentrate upon and complete only those elements that are within his range of competence' (34). ZPD has become synonymous in the literature with scaffolding (34). Once the learner, with the benefit of scaffolding, masters the task, the scaffolding can then be removed and the student will then be able to complete the task again on his own. Scaffolding (i.e. guided learning) is most effective when the support is matched to the needs of the learner. This puts them in a position to achieve success in an activity that they would previously not have been able to do alone. Wood et al. (1976) named certain processes that aid effective scaffolding: 1. gaining and maintaining the learner’s interest in the task, 2. making the task simple, 3. emphasizing certain aspects that will help with the solution, 4. control the child’s level of frustration, and 5. demonstrate the task (28). Scaffolding can can be performed with any learning activity. Silver stated these guidelines for scaffolding instruction: 1. evaluate the learner's current knowledge and experience for the task, 2. relate content to what the learner already understands or can do, 3. break the task into small, more adaptable tasks with chances for intermittent feedback, 4. use verbal clues and incites to assist the learner (35).

In effect, this already takes place in many teaching settings, but trainees can profit more if this is acknowledged by trainers. This involves allowing the learner to progress within his/her ZPD with the available help of an expert teacher, who can provide feedback to aid in skill acquisition. In addition, Wood suggested the idea of 'contingent instruction' of available help when required, but that deliberately faded when no longer needed (29, 32, 36). Thus, the progress through the ZPD could be seen as one that's dynamic, where each learner first receives external help, then performs under 'conscious' guidance from the self, and finally internalizes the process to render it automatic (37). At this stage the assistance is not only not needed, but also counterproductive, because it interferes with the process of 'internalization' (38). If the 'automatization' process is only partially completed, there maybe be regression to an earlier stage, where a teacher's support is needed again (38). Hence, each learner's ZPD may differ, requiring varying levels of peer-support and trainer-prompting, until eventually the skill can be mastered. Thus, this allows the trainee to define personal development while still in his/her comfort zone (ZPD), before advancing to the level of an expert.

3.3 Adult Learning Theory and Workplace-based Learning

The conventional model of clinical skills acquisition, where a learner learns by 'sitting at the feet of a master,' is being replaced by a more contemporary view of apprenticeship based on communities of practice and of learning (39, 40). Instead of seeing learning as a process of internalization of individual experience, Lave and Wenger see it as a fundamental and inseparable aspect of social practice:

> *"Learning viewed as situated activity has as its central defining characteristic, a process that we call legitimate peripheral participation. By this we mean to draw attention to the point that learners inevitably participate in communities of practitioners, and that the mastery of knowledge and skill requires newcomers to move toward full participation in the sociocultural practices of a community. A person's intentions to learn are engaged and the meaning of learning is configured through the process of becoming a full participant in a sociocultural practice. This social process includes, indeed it subsumes, the learning of knowledgeable skills."(39)*

Lave and Wenger point out that great deal of the learning that takes place does so through interactions between peers, as part of their engagement in the workplace. Expertise, they say, resides not in the expert but in the 'organization of the community' of practice of which the expert is part. The major defining component of learning, when seen from a 'situated learning' activity perspective, is the process of 'legitimate peripheral participation'(39). This essentially means that trainees, in order to master practical skills, are required to move toward full participation in the sociocultural practices of their community of practitioners (40). Participation is critical in the 'situated learning' theory, and becomes even more evident once trainees become involved with peers within the same community (39). Although the work by Lave and Wenger is not directly related to health care, it can be seen that continued interaction is crucial to acquire skills successfully. If we begin by teaching simple ad basic practical skills, trainees can achieve identifiable goals within their community of practice.

The goal of recent approaches to training is to provide learner-focused education in the setting of a 'situated learning environment'(39). In the Knowles model of adult learning theory, the trainee is an active driven adult learner characterized by self-direction and a readiness to learn (Table 1) (41, 42).

Table 1: Andragogy Assumption of Adult Learning

CHARACTERISTICS	MATURATION PROCESS	END RESULT
SELF-DIRECTION	Concept of self-moves from dependent personality toward one of self direction	Determines own learning needs and finding the means to meet them
EXPERIENCE	Accumulates a growing reservoir of experience	Provides context for the acquisition of new knowledge and skills
READINESS TO LEARN	Values learning that integrates with the demands placed on them in their everyday life	Learning is increasingly oriented to the need to know
ORIENTATION TO LEARNING	Perceptions change from one of postponed application of knowledge to immediacy of application	Learning shifts from one of subject centered to one of problem-centeredness
MOTIVATION TO LEARN	Motivation to learn driven by internal factors rather than external ones	Satisfaction of learning and the presence of personal goals have a greater effect on maintaining motivation than external incentives and rewards

Adapted from Adult Learning Principles (41, 42).

Knowles principles delineate that adults learn best when: (1) they want or need to learn something, and hence take responsibility for their own learning; (2) there is active cognitive pyshomotor participation in the process; (3) sufficient time is provided for assimilation of new information, i.e. they are able to advance at their own pace; (4) there is immediate feedback to assess progress towards their goals; (5) receive contextual learning, i.e. there is an opportunity to practice and apply what they have learnt; (6) there are opportunities for them to have control over the learning process, i.e. they are taught according to their own learning style; (7) do not have to repeat what they already know, and their previous experience is valued and utilized (Table 2) (41, 42).

In this model, trainees take responsibility for their own learning by reading about their cases, understanding different treatment options, and preparing for the appropriate procedure and hence maximizing every opportunity for work-based learning. For example, the trainee would set learning objectives with their mentor at the beginning of every surgical procedure. The teaching process would then be focused on the already preset objectives prior to the surgical procedure (43). Then, a structured debriefing would be initiated at the end of the procedure in order for the learner to know what is it that they do correctly and what needs improvement. Knowles suggests that educators follow the basic steps highlighted in Table 2 to ensure best approach for adult learning(41, 42). The principles of adult learning inform the instructor on how to best approach and teach the adult learner such as a resident trainee or medical student in order to maximize the learning opportunity in every clinical encounter.

Table 2: Principles of Adult Learning

ESSENTIAL COMPONENTS	RATIONALE	EXAMPLES OF PRACTICAL APPLCATION
CREATION OF AN EFFECTIVE LEARNING ENVIRONMENT	Learners should be comfortable both physically and emotionally	Residents require a designated work space and a nonthreatening work environment
LEARNER INVOLVEMENT IN MUTUAL PLANNING METHODS AND CURRICULAR DIRECTIONS	Ensures collaboration in the content and learning process, increases relevance to the learners' needs	Residents should be able to make recommendations on how to improve upon their learning experience(s)
LEARNER INVOLVEMENT IN DIAGNOSING THEIR OWN LEARNING NEEDS	Ensures meaningfulness and stimulates learners' intrinsic motivation, promotes self-assessment and reflection, and effective integration of learning	Residents should know what operative cases they need at completion of training to fulfill these ABS criteria
LEARNER INVOLVEMENT IN FORMULATION OF THEIR OWN OBJECTIVES	Encourages learners to take control of their learning	Residents should seek out cases needed to fulfill these ABS criteria
LEARNER IDENTIFICATION OF RESOURCES AND STRATEGIES FOR USING THEM TO ACCOMPLISH THEIR OBJECTIVES	Connects adult learning needs to practical resources for meeting learning objectives, provides motivation for using such resources for specific and focused purpose	Residents should identify strategies to meet therse ABS operative log criteria should they be deficient in certain areas
LEARNERS SHOULD BE SUPPORTED IN CARRYING OUT HEIR LEARNING PLANS	One of the key elements of motivation is expectancy of success. Learners will become discouraged and lose the motivation if the learning task is too difficult.	Residents should be provided responsibility for patient care commensurate with their experience, e.g., an inexperienced intern should not be responsible for managing patient in the ICU
LEARNER SHOULD BE INVOLVED IN EVALUATING THE LEARNING	Self-directed learning requires critical reflection on experience	Residents should be provided timey feedback, both in their operative and non-operative encounters

ABS, American Board of Surgery; ICU, Intensive Care Unit.
Adapted from Adult Learning Principles (41, 42).

3.4 <u>Affective component of Learning</u>

In traditional teaching, the affective content of learning is most often neglected. This is because the theory of skills acquisition is most often dominated by cognitive issues. The 'ABC' model describes how all the affective, cognitive and behavioral components all structure our 'attitude'(43). Attitude' is defined as a person's overall approach regarding events, ideas, people or other items, especially when this approach endures over time(43). According to Mcleod in his article about 'Attitudes and Behavior', a person's attitude is the result of an evaluation he or she has made about the 'attitude object'. As per the 'ABC' model, attitude is made up of three components: affective (feelings and emotions about the attitude object), behavioral (the behavior one exhibits when faced with the object) and cognitive (the thoughts and beliefs one has about the object) (43, 44). Hence, as much as there is a strong cognitive process, there is powerful affective element to any learning activity, that may exert a potent positive or negative effect (45-47). Most of us, for example, can give examples of professional stories that greatly inspired and profoundly affected our development. On the other hand, we can also give examples of very humbling experiences that humiliated us in front of our patients and peers. Such intense experiences often endure in our memories for a while.

Motivation is also a main issue whose effect upon learning is often under recognized. It seems clear that to achieve adequate skill acquisition, surgical trainees must be responsible for their own development and take ownership of their own training(48). Learning must be underpinned by a determination to improve, and that a sense of self-efficacy is crucial to effective development (48, 49). As per Maslow's hierarchical model, physical, emotional, and psychological needs of the learner need to be met before effective learning can take place (50). Thus to deliver surgical skills teaching, the educator needs to create a sustainable environment that will motivate the trainee, and encourage participation and feedback, positively affecting the learner's experience.

3.5 <u>Experiential Learning and Reflective Practice</u>

Experiential learning is the process of learning through experience, and is more precisely defined as "learning through reflection on doing" (51). Experiential learning requires self-initiative, an "intention to learn" and an "active phase of learning" (52, 53). As per Moon, experiential learning is most effective when it comprises: 1) a "reflective learning phase" 2) a phase of learning resulting from the actions inherent to experiential learning, and 3) "a further phase of learning from feedback" (53). This process of learning results in 'changes in judgment, feeling or skills' for the individual (54) and can provide direction for the 'making of judgments as a guide to choice and action' (55). A conscientious mentor and an independent trainee continually should reflect on practice to ensure ideal progression to an effective practitioner. Kolb(56), Bound(57), and Schon(58) have described experiential learning and reflection as processes by which trainees learn from practice. For example, reflection can be a retrospective activity after performing the procedure (on action), while performing the procedure (inaction), and/or forward reflecting (for action); a combination may prove to maximize the reflective process(27). As per Ende (1) feedback from educators is as essential as trainee feedback (59) to aid reflection and development, to help direct future development.

4. STAGES OF MOTOR SKILL ACQUISITION AND RETENTION

Motor skills learning theory is also important when considering the acquisition of technical skills for surgical trainees. Fitts and Posner, the 3-phase theory of motor skill acquisition, is very well-recognized in the surgical skills literature (60-62). It is composed of 3 phases: the cognitive phase (when the learner has to understand the mechanics of the skill), the associative phase (when knowledge is translated into appropriate behavior as the learner practices with formative feedback), and the autonomous phase (when practice results in smother performance of the skill, wherein the student is no longer concentrating on the component parts and has the capacity to concentrate on other parts of the procedure) (Table 3) (61-63).

Table 3: The Fitts-Posner Three-Stage Theory of Motor Skill Acquisition

STAGE	GOAL	ACTIVITY	PERFORMANCE
COGNITIVE	Understand the task	Explanation and demonstration of task	Erratic, discrete and distinct steps
ASSOCIATIVE/INTEGRATIVE	Understand how discrete parts of the task relate to one another	Repetitive deliberate practice with feedback	More efficient and fluid with fewer errors
AUTONOMOUS	Unconsciously perform the task with speed, efficiency, and precision	Sustained practice with additional practice beyond that required for proficiency (overlearning)	Refined, automatic, effortless, and adaptive

Adapted from Fitts and Posner (62).

For example, with a surgical skill as simple as tying a knot, in the cognitive stage the learner must grasp the mechanics of the skill, which may require task-analysis to breakdown the skill into component parts, and establishing links between the steps, i.e. learning how to hold the ties, how to cross the hands, and how to place the throws to lay down a square knot. With continued practice and feedback, the learner will reach the 'associative' or 'integrative' stage, in which knowledge is translated into appropriate motor behavior. The learner is still thinking about how to move his hands and hold the tie but is able to execute the task more fluidly, with fewer interruptions. Finally, in the autonomous stage, practice gradually results in smooth performance. The learner no longer needs to think about how to execute this particular task and can concentrate on other aspects of the procedure (27, 61). The learner may no longer be able to actually describe and decompose the steps of the process as they become ingrained and autonomous.

As per this model, the trainer should target technical skills teaching appropriately. When teaching more complex procedures, errors noticed by the trainer are corrected and hence are reduced in frequency. After increased opportunities for performing related tasks, the trainee will become more capable of producing improved outcomes more easily, swiftly, and effortlessly(61). With trainer reinforcement and involvement in the early stages, a capable trainee can reach the autonomous stage.

5. PURE DISCOVERY VS. GUIDED DISCOVERY LEARNING

Mayer in 2004, talks about the guided vs. the unguided discovery learning theory. He suggested that pure, unguided discovery learning is ineffective and inefficient, and does not guarantee that students will even come in contact with the needed learning opportunities, and does not guarantee that students will learn the rules that guide future practice(7). In the absence of feedback from expert teachers, learners are will rely on their own self-assessment to determine what went well and what needs improvement. Although effective feedback promotes self-assessment, studies have shown that inexperienced learners do not consistently identify their own strengths and weaknesses (7). Learners may also interpret an absence of feedback as implicit approval of their performance. Thus, without appropriate feedback, clinical skills will not improve. In guided discovery learning, however, an expert provides the novice learner with preparatory information before the experience and offers verbal and manual guidance during the experience and feedback afterward. Students using guided discovery learning learn more quickly, more accurately, and are more likely to remember what they learned, than those who used pure (unguided) discovery learning(8, 9). The learning in surgery more closely approaches pure discovery learning than guided discovery learning. We believe this can be changed.

6. ROLE OF DELIBERATE PRACTICE IN THE ACQUISITION OF EXPERTISE

Guided discovery learning partners well with deliberate practice to improve performance. Deliberate practice calls for the individual to focus on a particular aspect of performance to improve; receiving detailed, immediate feedback on the performance; and having multiple opportunities to practice the performance(5, 64). The attained level of expertise has been shown to be closely related to time devoted to deliberate practice in the performance(65). Expert performance represents the highest level of technical skill acquisition(5, 64). It is the end result of gradual improvement in performance through lengthy experience in the field (61). As per Ericsson, most professionals reach a steady, average level of performance and preserve this standing for the rest of their careers. Surgical experts, accordingly, have been defined as experienced surgeons with constantly better results than non-experts. Many professionals probably do not attain true expertise in practical skill acquisition. Practice is critical for the attainment of expertise and an extensive literature on the relationship of operative volume to clinical outcomes supports the hypothesis that practice is an important determinant of outcome (66-69). However, it is apparent that sheer operative volume alone, with simple repetition, does not guarantee attainment of expertise and explain the skill level among practitioners, because disparities in performance have been shown among surgeons with very high volumes.

Ericsson argues that the number of hours spent in deliberate practice, rather than just hours spent in surgery, is an important determinant of the level of expertise (5, 64, 70). Immediate informative feedback must be provided so that learners understand the results of their performance. Thus, deliberate practice is a critical process for the development of mastery or expertise(65, 70). An example is learning to perform a coronary distal anastomosis. Performing the entire procedure over and over again, does not guarantee that you will be an expert at doing it. Practice should focus on the aspects of the procedure that are most challenging; for example, the corner sutures or the back hand sutures of the contralateral side. Practice should also be reinforced by immediate focused feedback related to the challenging aspects of the procedure(71).

Current residency training, provide experience but not necessarily adequate opportunity for such dedicated deliberate practice. There is a move toward a shorter workweek for residents (72) and an emphasis on operating room efficiency, both of which diminish teaching time, there are fewer opportunities for deliberate practice. Moreover, the increasing complexity of cases and a greater emphasis on lessening medical error limit a faculty's leeway in assisting residents with technical procedures. Thus, when developing curricula, educators should ensure that there is ample opportunity for deliberate practice and feedback early into training programs. By practicing regularly and learning from feedback, trainees can achieve an excellent level of performance (73).

It can be seen that feedback is a critical component of learning surgical skills, whether outlined by the Vygotskian approach (while the trainee is in his/her ZPD), the situated learning theory (in which feedback represents continued interaction within the community of practice), or deliberate practice, helping the learner achieve expertise.

7. FEEDBACK

7.1 Why feedback in Medical Education?

In the new era of medical education, the focus has moved away from knowledge acquisition and duration of training to accomplishment of specific learning outcomes and preparation of physicians for meeting population and health care needs (74, 75). In this competency-based curricula, learners are expected to reach specific pre-set objectives, as they develop the competencies expected of a physician. Detailed and timely feedback on performance, along with continued practice, will help learners achieve these milestones (74, 75).

Feedback can be defined as a process which embodies communication of information followed by reactions to such communication(76). It has been defined as specific information comparing the difference between a trainee's observed performance with a given standard, with the objective of achieving improvement in performance in order to attain that standard (77). Ende (1983) defines feedback as, 'information describing learner's performance in a given activity that is intended to guide their future performance in that same or related activity' (1). Heskesth and Laidlaw (2002) describe feedback as an 'essential element of the educational process that can help trainees reach their maximum potential' (2).

Feedback is central to medical education in promoting learning and ensuring that standards are met. It encourages and enhances the learner's knowledge, skills and professional performance. It helps learners achieve their program milestones by reinforcing good performance and providing basis for remediation when needed(78, 79). In the absence of feedback, learners have to rely on their own self-assessment to determine what has gone and what needs improvement(7). However, learners are not consistently able to identify their own strengths and weaknesses. Learners may also interpret lack of feedback as implicit approval of their performance (80). Hesketh and Laidlaw highlight this point as follows:

> *"Feedback has the purpose of raising the trainee's self awareness about their performance and leaves them to choose their future actions. It can reinforce good practice as well as be corrective. When reinforcing it encourages continued good practice and has a motivating effect on the trainee. When corrective it enables the trainee to recognize the consequences of their actions and encourages them to modify their behavior to achieve a more desirable result"(2).*

7.2 <u>Characteristics of Effective Feedback</u>

Without effective feedback, learners struggle to achieve defined goals. For feedback to be useful it has to be effective (14, 81). When feedback is given effectively, learners will be more receptive to the feedback and this will aid improvement of performance based on that feedback. Below are some strategies from the literature that describe the tips to giving effective feedback.

Feedback should be given within an atmosphere of trust and concern where both the trainee and mentor know that they are working as 'allies with common goals – these being best outcome for the patient and the development of the trainee' (2). A positive learning ambience is essential in order for feedback to be effective (15). The learning climate should promote the notion that the mentor and learner achieve projected outcomes, with an expectation that the mentor will observe performance and give timely feedback regularly in an atmosphere of mutual trust and respect (17). Both the learner and the mentor should be partners in the process of feedback. The feedback process is viewed as a two-way conversation in which the learner in which the learner asses his own performance and the teacher should be receptive to feedback from trainees (74).

The first step is to communicate the goals and objectives of the learning encounter and what the learner is expected to achieve during the experience (15). The teacher should inform the learner ahead of time about the feedback session, schedule the meeting in a private location and set the session goals and expected outcomes (17). This makes the learner more comfortable and more recipient to the feedback and more motivated to learn (82). Feedback should also be clear, specific, and based on direct observation; it should focus on performance rather than personality (2, 82, 83). As the learner advances from a beginner to a competent practitioner, a more experienced mentor should observe the performance and note important areas of success or remediation(1, 84). Direct observation is the basis of the feedback session(84). Focus on behaviors that can be changed, not the person or personality and give clear examples (82, 85, 86). When possible, base the information on first-hand data, i.e. direct observation by yourself or other people. Try to get specific examples from them to back up their comments, otherwise the trainee will not believe your feedback if they feel that you don't have adequate knowledge of their performance(2).

Feedback has to be delivered using neutral, non-judgmental language; it should emphasize positive aspects; be descriptive rather than evaluative (15, 17, 85, 87). Positive communication techniques are important. Body language is important when delivering feedback; sitting down beside the learner, use a respectful, supportive tone and specific, neutral language (15, 17, 86). Make the session a two-way conversation. The learner should be a partner in the feedback process. Understand the learner's response, personality and temper. Limit the feedback to what the learner can grasp (17, 82, 86). When feedback is handled well, it can improve the teacher–learner relationship and lead to constructive changes in the learner's performance (Cantillon & Sargeant 2008 (85).

Begin the feedback session by encouraging self-assessment by the trainee (84, 85). Starting the feedback session by asking the learner to self-assess their performance, promotes the learner's reflection on their own practice (17). This self-assessment can also make delicate, corrective feedback more accepted by the learner, as it can lessen the perception of harshness (88). Feedback should also acknowledge and support their exemplary behavior. This will give them confidence in their skill and highlight areas requiring improvement (88, 89). When you start by acknowledging and reinforcing good behavior, this will encourage good practice and motivate the learner to repeat them and urge him/her to seek more feedback (74, 85). As per Bing-You et al. 1997, positive feedback on what trainees were doing correctly gave them the self-assurance in their skills an created a healthier learning environment (14, 16).

Next the teacher needs to highlight necessary correction, providing specific examples, as mentioned earlier and an action plan for improvement (14, 17, 82). Constructive feedback is beneficial when it is focused on specific performance with reasons why the performance was incorrect and how is it that the learner can modify their behavior to improve their performance (15, 82). As per Pendleton el al. feedback can be carried out in a four step process(90). First start with learner's self-assessment; ask the learner what he or she feels was done well. Then agree as appropriate and add reinforcing comments. Next, ask the learner to identify areas in need of improvement; then agree as appropriate and add more corrective feedback. Finally, end with an an action plan; two or three points based on direct observation of the procedure to guide future learning direction of the learner to improve performance(74, 86). Also, invite the learner to ideas, then support or modify them. Asking the leaner to come up with a future plan for improvement, will help them develop skills of reflection(17).

You should always confirm the learner's understanding and facilitate acceptance. The session can be filled with emotion for both the teacher and the learner. You have to always take into account the learners background, character and willingness to change (91). Learn about the learner's perspectives and possible motives behind specific behaviors. Confirm with the learner that he/she has a firm understanding and invite him/her to ask questions. Sargeant el al. talked about a three-step process, the ECO (emotions, content and outcome) to facilitate acceptance in feedback (92). In the 'emotions' phase of the ECO model, the emotional reaction to the feedback received by the learner is acknowledged and explored. The 'content' phase of the model aims to explain the particular content of the feedback as it relates to the trainee's performance. In the final 'outcome' phase, the trainee's identified learning and development needs are confirmed and outcomes plan that will meet the learner's needs and improve performance is created(92).

Finally for feedback to be effective, it has to be timely and a regular occurrence – i.e. formative (17, 87). It has to be part of the day-to-day work and as close to the event as possible. This enables the learner to make the needed changes before the end of the rotation. The teacher should give feedback as soon as possible after the event so that the learner has enough time to act. The learner will not have sufficient time to change their behavior if the feedback is not given until the very end of the rotation (93). Also, when feedback is given directly after the encounter, both the teacher and the learner recall the events accurately and the learner can make adjustments in performance (93). This formative feedback session can be related to correcting a specific skill, for example how to accurately and precisely place the aortic cannula without losing to much blood. A summative feedback session should also still accompany the final evaluation so that the learner can continue to develop(87).

7.2 Barriers to Effective Feedback

Hesketh and Laidlaw state that the first step to delivering effective feedback is being aware of the barriers (2). One barrier is fear of upsetting the trainee and ruining the trainee-mentor relationship, and hence doing more harm than good (2). Also, the learner may view feedback as negative event in which his/her performance will be critiqued because of the hierarchical culture of medicine that promotes a one-way flow of information from teacher to learner instead of a two-way conversation (17, 74). Hence, the trainee might be resistant or defensive when receiving this criticism, which might make the teacher reluctant to give feedback in the next time around (2). Moreover, many of us as mentors have not received any teaching of giving effective feedback (94). Hence, the teacher may lack confidence in his/her observations and may not know how to explain these observations into 'specific, non-judgmental and constructive' feedback (85, 95, 96). Another important barrier is the fact that the importance and purpose of the feedback session may not be clear to the teacher or the leaner and hence they might not allocate the place or time for the feedback session(17).

There also may be no appropriate time or place for a feedback session, especially in a field like surgery where time is very limited. Brief interaction with learners and busy schedules results in limited opportunity of direct observation of learners (97). Thus, feedback might also be very general and not related to specific facts or observations and thus not guiding the learner on how to rectify performance (2, 95). Another barrier is receiving inconsistent feedback from multiple sources (2). A lack of respect or credibility for the source of feedback might also influence the effectiveness of this feedback(98). If the source of the feedback is respected and there is a good rapport between the source and the recipient, negative feedback will be more readily accepted and well-taken(2, 98). The feedback will less likely be neglected if the feedback is seen as important or from an important source. Thus when giving feedback, it depends on the way you do it and your relationship with the trainee.

7.4 <u>Summary</u>

Feedback is crucial in bringing about professional development and overall improvement in trainees. It provides learners with information their prior performance so that future performance can be improved. In the absence of feedback, good performance is not recognized and performance that needs improvement goes uncorrected. In view of recent changes in working patterns, we have to generate newer opportunities to observe trainees and hence provide specific & timely feedback to facilitate learning. The notion of deliberate practice (75) concentrates on learning outcomes, feedback, mentoring and reflection for the achievement of training milestones. As the model also promotes continuous learning and improvement, regular ongoing feedback is essential to promote the highest quality medical care and professional satisfaction.

8. USE OF SCRIPTS IN TEACHING AND LEARNING

Scripted teaching has always been encouraged for schools where teachers have had insufficient educational training and also seen as way to standardize the quality of teaching (128). Critics argue that scripted teaching suffocate teachers' creativity, and undermine their proficiency; however, supporters see it as the easiest way to provide teachers with the essential elements of effective instruction (129). Scripted teaching is a form of direct instruction intended to standardize teaching, to sustain consistency in educational strategies in the hopes of eliminating the risk of poor instruction by inexperienced teachers (129, 130).

Teaching scripts are not designed to reduce the amount of preparation by the teacher, however, they are to be used as a framework for teachers to guide them through the teaching process using the best educational practices. When used properly, teaching scripts can be utilized as a cognitive aid from which teachers can add and subtract parts of the structure to create a learning environment that promotes effective teaching individualized to the needs of the learner (131). They are also meant to be used as an adjunct, to assist the teacher in the development of their own teaching style and give them confidence in their teaching skills (129, 132).

A common misconception to the use of scripts to aid in the process of teaching is that teachers tend to feel held back from using their own knowledge and experience when they are required to follow an external script (129). This also makes them feel unable to act when student goes out of the script (133). Nevertheless, teachers who are experienced in scripted teaching find a way to build on the unusual answers and find their way back to the script. As per Schulman and Grossman:

"Experienced teachers have an extremely extensive and interrelated knowledge of teaching organized in the form of "scripts." These teaching scripts help teachers anticipate learners' actions and enable them to respond quickly during an instructional episode. Just as movie scripts contain detailed information about dialogue, character traits, and staging, teachers' internalized scripts contain detailed information about the learner, the goals of a session, specific teaching points for given topics, and effective educational strategies keyed to different learner levels," (134, 135).

9. IN SUM

While the importance of teaching is widely recognized there appears to be inconsistency in the amount, type and timing of deliberate instruction received in clinical practice (10-12), predominantly in surgical skill training (3, 13). This could be explained by the duty hour restrictions that limit the exposure the residents have to the operating room. In addition, when present, teaching in the operating room happens with less deliberation and less frequency that allow for ideal learning (128). Teaching between surgeon and resident rarely includes discussion of operative planning or the surgeon's experience with the condition in the past (128). In addition, many of us clinicians lack formal training as professional educators. As a result, it is difficult for the learner to identify specific learning points that would lead to permanent change in their behavior from the unfocused stream of talk that we have in the operating room.

Given the importance to make use of every surgical encounter, there's a need for a more deliberate approach to surgical skill teaching. A good model for deliberate teaching in the operating room would focus the teacher on setting objectives for the learner's performance before the teaching encounter, providing immediate and specific feedback during the encounter, and finally providing guidance for future practice. The ideal model would allow surgeons to achieve these educational goals within the context of their already existing practice, by utilizing the naturally existing observation and teaching opportunities available in the operating room.

We propose a model for teaching in the operating room that supports the best teaching practices. This model is founded on key educational theories supported by the literature, and the rising evidence for use of standardized scripts in the improvement of learning outcomes(129, 130). We propose a structured, brief approach to teaching of surgical skills effectively in the operating room - a teaching rubric by the name of NODOFF. This novel teaching tool outlines for the instructor the use of Needs, Objectives, Demonstration, Observation, and Feedback for the teaching of surgical skills. The creation of this tool was based on a comprehensive literature search of the best practices to teaching of surgical skills and giving effective feedback. The theoretical basis for such a tool has been reviewed. It is a practical guide founded on educational theories of constructivism (22, 23), scaffolding (30, 31), adult learning theory (41, 42), and the stages of motor skill acquisition of Fitts and Posner (62). We outlined the details of its creation and design in the methodology section of the manuscript.

SECTION 2:

HYPOTHESIS

STUDY HYPOTHESIS:

Given the importance of delivering education with the best teaching principles and knowing that many instructors may not be delivering the most effective teaching practices, we propose a novel surgical skill teaching cognitive aid and hypothesize that it will be more effective than the traditional form of teaching surgical skills. This effectiveness will be measured by assessing the acquisition and retention of surgical skills among medical students taught by two groups of instructors; one group using a cognitive aid and one group using a conventional approach.

SECTION 3:

MANUSCRIPT

The Use of a Novel Teaching Rubric Improves Technical Skill Acquisition and Retention

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Abstract

Objective: The purpose of this study was to develop and test a teaching rubric designed to improve the acquisition of surgical skills by providing instructors with a cognitive aid based on best practices for skills instruction.

Summary Background Data: Given that many clinicians lack formal training as educators, there is a need for a more deliberate approach to surgical skill teaching to maximize learning. In the present study, we developed a teaching rubric which outlines use of Needs, Objectives, Demonstration, Observation, and Feedback (NODOFF).

Methods: Sixty-five medical students were recruited to participate. They completed a basic surgical skills pre-test at the simulation center. They were then randomly assigned to a blinded 90-minute skills session with an instructor trained to use NODOFF (intervention) or a standard instructor (control). Afterwards, students completed a post-test, followed by a 1-month retention test. All tests were videotaped and scored by two blinded raters. Students and instructors completed questionnaires on the use of NODOFF.

Results: Improvements in surgical skills performance was significantly higher for intervention than control group $F(1,60) = 35.37$, $p < .001$ (suturing), $F(1,60) = 18.42$, $p < .001$ (knot-tying). The intervention group continued to perform significantly better at 1-month follow up than control for suturing, $F(1,12) = 12.91$, $p < .01$. Qualitative analyses revealed the tool was easy to follow and improved instructors' teaching and feedback.

Conclusion: The use of NODOFF resulted in a significant improvement in skills learning and retention. Hence, it can be used as a practical teaching tool for surgical skills training.

Introduction

Teaching surgical skills is a core component of surgical education and feedback is a fundamental aspect of that component (1-3). Performance-based feedback helps reinforce good skills and correct faulty technique (4, 5). As Ericsson explains, performance-based feedback, i.e. 'deliberate practice', involves instructor directed performance improvement by receiving detailed, immediate feedback on the performance; and having multiple opportunities to practice the performance (5). Although the long-standing apprenticeship, "learn by doing", approach allows multiple opportunities for practice (6, 7), deliberate practice is critical in the sense that without the focus and the feedback, learning will be haphazard at best (8). In addition, Mayer has suggested that practice without feedback is ineffective and inefficient, and does not guarantee that students will even come in contact with the needed learning opportunities (9). Students guided through the learning phase using a structured and deliberate approach learn more quickly, more accurately, and are more likely to remember what they learned, than those who used unguided discovery learning (8-11).

Although the importance of deliberate instruction is widely recognized, its clinical application appears to be inconsistent (12-14), particularly in surgical skill training (3, 15). Clinical skills are infrequently or poorly observed, and if they are, feedback is often not communicated to trainees (16). In the absence of feedback from teachers, learners have to rely on self-assessment, which does not consistently help learners to identify their own strengths or weaknesses. Learners may also interpret an absence of feedback as implicit approval of their performance. Medical students and residents have stated that feedback, when given effectively, helps to gauge performance and plan for improvement (1, 17-19). Yet, trainees report that feedback is given infrequently and/or ineffectively, whereas teachers themselves believe that they provide frequent and adequate feedback (20-22).

Given the shift towards competency-based education and milestones, it is crucial to optimize our current learning and teaching methodology and make use of every clinical encounter and operative opportunity. In order to improve training opportunities, we have recently focused much effort on providing surrogates of clinical exposure such as simulation (23). However, less effort has been made to improve the ability of instructors to teach technical skills and maximize learning encounters. As much as there is rising evidence for the use of checklists to reduce error and optimize patient care (24, 25), there is also evidence for the use of standardized scripts and rubrics as teaching aids to improve learning outcomes for non-technical skills (26-29). We therefore, hypothesized that one method to improve deliberate technical skills instruction and therefore learning would be to create a teaching rubric which would be based on recognized best practices for improving skill acquisition. Given that many surgeons lack formal educational training, this rubric would need to be simple to follow and be able to guide the instructor during the teaching process. Previous work by others have focused on the general theory and approach to teaching technical skills; *Seven Principles for Teaching Procedural and Technical Skills* (30) and the *Briefing, Intraoperative Teaching, Debriefing Model for Teaching in the Operating Room* (8) are two such models. Although these models incorporate best educational practices, to our knowledge, these general principles have not been condensed, evaluated, and tested as a teaching rubric to be used as a cognitive during active skills instruction.

Hence, the purpose of this study was to design and test a structured, brief rubric for surgical skills teaching and feedback. This rubric is based on a comprehensive literature search of the most effective methods for surgical teaching and feedback. This process is described in more detail in the methodology. This rubric outlines for the instructor the use of Needs assessment, setting of Objectives, Demonstration of skill, Observation, and Feedback for technical skills training. We hypothesized that NODOFF will improve instruction and learning, and therefore, improve basic surgical skills acquisition and retention.

Methods

Participants

Students. Sixty-five third year medical students were recruited to participate in this study prior to their surgical clerkship training. Their mean age was 24.21 (SD = 2.28). 18.97% participants reported that their desired field of training for the future was a surgical specialty; 55.17% indicated a desired field outside of surgery; 25.86% reported that they were undecided. 81.36% reported that they had received some degree of surgical skill training prior to the study.

Instructors. There were 10 instructors (5 intervention and 5 control) from the following specialties: general surgery, cardiac surgery, urology and orthopedic surgery. Mean age was 32 years-old (SD 7.41). In terms of experience, instructors ranged from PGY-2 to staff (3 PGY-2, 3 PGY-3, 1 PGY4, 1 fellow, 2 staff). 33.33% reported some prior training in surgical skills training.

Materials

The Teaching Rubric. NODOFF is a structured teaching rubric that fits in a pocket size card (fig. 1). All the elements of the teaching rubric were gathered after a comprehensive PubMed search: (("Specialties, Surgical"[Mesh] OR "surgery"[tiab])) AND (((("Internship and Residency"[Mesh] OR "residency" OR "residents")) AND ("Feedback"[Mesh] OR "feedback" Or "guidance" Or "briefing")) AND ("Surgical Procedures, Operative"[Mesh] OR "surgical skills" OR "technical skills")), bringing us 249 articles to review. We included a combination of empirical and theoretical articles that describe the most effective methods for teaching and feedback in surgery, which we developed the teaching rubric, NODOFF. Many elements can be found in previously published models as previously mentioned above (8, 30), as well as the BEME best practice guides (31) and the Kern model for effective curricular development (32). The use of NODOFF prompts the instructor to utilize the most effective teaching and feedback principles to maximize the effectiveness of the teaching encounter. In the needs assessment section, there is a short interaction in which the instructor evaluates the *needs* of the learner. The purpose is to encourage the learner to assess his/her own learning *needs* and jointly establish learning objectives to guide both the learner and the teacher (33, 34). Including learners in objective-setting allows them to deliberately identify areas requiring practice and also helps to focus the teaching session (8, 33). The instructor may not be familiar with the learner nor their ability. The needs assessment sets the stage. The setting of objectives makes the purpose of the encounter explicit (35). The teacher will then *demonstrate* or review the technique (36, 37) while the learner is *observing* and noting or verbalizing the steps (38). The demonstration stage defines the expectations of the instructor (39). This needs to be explicit. While the learner is performing the technical skill, the instructor will give specific performance-based *feedback-in-action (33, 35, 40, 41).* After the teaching session, ideally during the closing, the instructor and the learner debrief about the encounter (i.e., *feedback-after-action)*. The debriefing consists of four elements: learner's self-assessment, reinforcement of what was done correctly, correction of mistakes and areas to improve in the future (9, 41, 42). Generally kept to two areas, as in the objectives.

Demographic Questionnaire. The students were asked to report their age, gender, desired field of training, and whether they had prior exposure to basic surgical skill training (fig. 3a). Instructors were also asked to report their age, gender, field and year of training as well as whether they had any prior experience or training in surgical skill teaching or debriefing (fig. 4a and 5).

Technical Skills Rating Scales. Technical skills were assessed using the Royal College (England, Scotland, Canada) assessment tools for two-handed knot-tying and vertical-mattress suturing. The rating scale scored each step of the skill separately; then, the instructor evaluated the student's overall performance using a global rating scale, yielding a maximum score of 11 for knot-tying and 21 for suturing. We used these rating scales in particular because they precisely evaluated each component of the procedure, and hence, differentiated between exert, intermediate and novice. Inter-rater reliability (IRR) was assessed using the intra-class correlation coefficient (ICC) 2-way mixed effects model, with the absolute agreement definition (43). Inter-rater reliability of the royal college rating scale, as evaluated by intra-class correlation coefficient was 0.99, indicating that assessment of performance was consistent across raters.

Student Feedback Questionnaire. Students were asked to rate the extent to which instructors implemented instructional practices relating to each component of the teaching rubric using a five-point Likert scale (ranging from strongly disagree to strongly agree). Sample questions included: "Did the instructor set objectives prior to the teaching session?". The questionnaire also contained open-ended questions prompting students to describe what they liked about the instruction and what they would like to see improved (fig. 3a, 3b and 3c).

Instructor Feedback Questionnaire – Intervention group. Instructors in the intervention group were also asked to rate the extent to which they implemented instructional practices related to each component of the teaching rubric using a five-point Likert scale (ranging from strongly disagree to strongly agree). Sample question includes: "You did a needs assessment prior to setting of objectives for the session". The questionnaire also contained open-ended questions prompting instructors to describe how they feel about the teaching rubric, whether it changed the way they taught and what what they would like to see improved (fig. 4a and 4b).

Instructor Feedback Questionnaire – Control group. Instructors from the control group were asked to describe what they thought were the most important principles teaching a technical skill and what were important elements of giving effective feedback, in terms of open-ended question (fig. 4b).

Procedure & Design

The study was approved by an institutional research ethics board at the university in which participants were recruited. The study was a prospective, randomized, 2-arm study conducted at the Arnold and Blema Steinberg Medical Simulation Centre, Montreal, Canada. Prior to participation, participants provided informed consent. Upon enrolment, all students were pretested on knot-tying (3 square throws on a knot-tying board using two-handed knot-tying technique) and vertical-mattress suturing on a pig's foot (fig. 2a and 2b). All students were subsequently randomly assigned to two practice conditions: (1) technical skill teaching and feedback by an instructor trained to use the teaching rubric, NODOFF (intervention) or (2) standard technical skill teaching and feedback from an instructor without use of NODOFF (control). Students were blinded to the intervention. The intervention group instructors received a ten-minute brief overview on how to use the teaching rubric right before the skills sessions. All students participated in a 90-minute skills session in which they were taught one-handed and two-handed knot-tying skills on the knot-tying board, as well as horizontal- and vertical-mattress suturing on the pig's foot. During this skills session, an observer took field notes on instructor-student interactions and use of NODOFF. Immediately after the skills session, students performed a post-test. A delayed retention-test consisting of the same knot-tying and suturing skill was held after a 1-month rest period. No feedback was provided during the testing trials. All tests (pre, post, retention) were video-recorded and assessed post-hoc by two raters blinded to the experimental condition using validated Royal College performance rating tools specifically designed for assessing two-handed knot-tying and vertical-mattress suturing. After the practice sessions, instructors and students completed a demographic questionnaire and feedback questionnaire on the feasibility and practicality of using NODOFF.

We chose novice learners because we assumed that this group will have the most learning effect and hence, we will be able to assess the effectiveness of our tool. Knot-tying and suturing skills are consistent with novice learners and are taught by almost all surgical instructors. Moreover, the simulated environment as opposed to the operating room makes it logistically much easier to organize our research. It allows for us to recruit large numbers of learners, use a standard model and video tape the procedure without need for patient consent.

Coding of Field Notes

The observer identified key events and interactions during the skills sessions that related to the nature and quality of feedback delivery, instructional approach, and student-instructor interactions using a field note guide. This guide included prompts for observations of key events, such as: adherence to NODOFF tool (e.g., which component was implemented?), the nature of the delivery (e.g., was feedback specific or general?), the affective delivery of the message (e.g., was feedback evaluative or neutral in tone?). Given that participants rotated through different tasks and stations, there was opportunity to observe at least one control and intervention group for both the suturing and knot-tying tasks during each session of data collection. Observations were conducted on three separate occasions of data collection. On the first occasion, two observers were present to conduct observations and calibrate key events identified. After discussion between observers, minor changes were made to the field note guide to aid future observations. Subsequently, one observer continued observations for the remaining data collection sessions. Key patterns were identified through qualitative thematic analysis (44) of field notes and reported to the experimenter.

Results

Data were analyzed using SPSS 12.0 for Windows (SPSS, Inc., Chicago, IL). Significance was set at p less than .05 (two-tailed).

Baseline Surgical Skills

Two one-way analysis of variance (ANOVAs) were conducted to determine whether there was a significant difference between control and intervention performance scores (suturing and knot-tying) at baseline and whether variance between the groups was equal at baseline. Results revealed that were no significant differences in performance between the control condition and intervention condition at pretest $F(1, 60)=.16$, $p>.05$, and the assumption of equal variances between the groups was also met. Levene's test of homogeneity of variances was not significant as well for suturing at baseline, $p > .05$ and knot-tying at baseline, $p > .05$.

Measure of Technical Skills Acquisition

Two repeated measures ANOVAs were conducted using a 2X2 mixed factorial design with feedback condition (intervention vs. control) as the fixed between-subjects factor and time (pre vs. post) as the repeated within-subjects factor to determine whether there was a significant difference between control and intervention performance scores for suturing and knot-tying. Results from the first repeated measures ANOVA (examining the effect of feedback condition on pre-post suturing performance) revealed a significant effect of time on performance, $F(1, 60) = 298.12$, $p < .001$, partial $\eta^2 = .83$ (power = 1.0), a significant effect of condition on performance, $F(1, 60) = 21.55$, $p < .001$, partial $\eta^2 = .26$ (power = 1.0), and a significant interaction effect, $F(1, 60) = 35.37$, $p < .001$, partial $\eta^2 = .37$ (power = 1.0). In other words, suturing performance improved for all participants after training; however, the increase in post-training performance was significantly higher for those in the intervention group compared to the control group (fig. 6). Results from the second repeated measures ANOVA (examining the effect of feedback condition on pre-post knot-tying performance) revealed a significant effect of time on performance, $F(1, 60) = 146.85$, $p < .001$, partial $\eta^2 = .71$ (power = 1.0), a significant effect of condition on performance, $F(1, 60) = 10.67$, $p < .01$, partial $\eta^2 = .15$ (power = .90), and a significant interaction effect, $F(1, 60) = 18.42$, $p < .001$, partial $\eta^2 = .24$ (power = .99). In other words, knot-tying performance improved for all participants after training; however, the increase in post-training performance was significantly higher for those in the intervention group compared to the control group (fig. 7).

Measure of Technical Skills Retention

Two one-way ANOVAs were conducted to determine whether there was a significant difference between control and intervention students' retention skills 1-month after training. Results revealed that that there was a significant effect of condition on suturing skills retention, $F(1, 12) = 12.91$, $p < .01$ (power = .91) but no significant effect of condition on knot-tying retention skills, $F(1, 12) = .94$, $p > .05$ (power = .15). Students in the intervention condition continued to perform significantly better at 1-month follow-up than students in the control condition for the suturing task but not for knot-tying (fig.2,3).

Students' Perceptions toward Instructor Teaching and Feedback

A one-way ANOVA was conducted to determine whether there was a significant difference between control and intervention students' perceptions towards instructor feedback delivery (i.e., students' perceptions of instructor adherence to NODOFF rubric). Results revealed that there was a significant effect of condition on student perceptions toward instructor feedback, $F(1, 51) = 11.72$, $p < .01$. Students in the intervention group reported that the instructor exhibited behaviors that were more consistent with the NODOFF feedback tool than students in the control group.

In terms of the qualitative analysis of students' open-ended responses regarding the learning experience, it was noted that students typically provided positive response across both groups (e.g., "good", "great", "appreciative" "encouraged", "motivated", "satisfied"). Those in the intervention group in particular, commonly noted that they found the feedback to be constructive and useful for identifying areas in need of improvement. Specific elements students liked about the feedback across both groups included: the non-judgmental and constructive nature of delivery, the specificity and individualized nature of feedback, and the value of identifying weaknesses/areas in need of improvement. Suggestions for improving feedback across both groups included a: increased specificity and constructive comments (i.e., identify weaknesses and strategies for improvement), as well as requests for more time for feedback and individualized attention. However, the majority of participants noted that modifications for improvement were not necessary.

Instructors' Perceptions toward the Teaching Rubric

Analyses of instructor questionnaire responses revealed that all instructors trained to use NODOFF felt the teaching tool was easy to use (agree/strongly agree), 60% felt they did not need instruction to use the teaching tool (disagree/strongly disagree), and 80% felt the teaching tool changed the way they normally provide feedback (agree). On average, instructors agreed that they implemented each component of the teaching tool) as follows: 100% reported they conducted needs assessment prior to setting objectives, 80% set session objectives according to students' needs assessment, 80% provided specific feedback based on students' performance, 100% reinforced technique performed correctly, 100% emphasized and corrected technique performed incorrectly, 100% provided students with 2-3 tips to work on in the future. Qualitative analyses of instructor open-ended responses revealed that instructors found the teaching rubric to be "very useful, very comfortable", it "helped structure the teaching encounter", "was especially useful if you have no experience giving feedback", "was good and very easy to follow", "easy to use and instructive, however sometimes took away from the flow of the session- also did not have enough time to give each learner individualized feedback". They also noted that it helped structure their teaching session and helped them incorporate the most important elements of teaching and feedback in their teaching sessions. When asked about modifications that they would add to the tool, one instructor suggested to add a specific milestone to each task that the instructor and student jointly check off, adding that: "this will give them the sense of being part of their own training." Another instructor suggested adding more time allocated per task to allow more time for individualized feedback. When finally asked to describe the tool or to teach somebody how to use it, instructors typically responded positively (e.g., "Follow the steps, its easy!"; "Exactly what is on the card,"; "Here is a structured objective way to organize your teaching of this task,").

Observer Field Notes Analyses

There were typically three key phases for the tasks: 1) introduction and instructional explanation 2) instructor modeling and student observation 3) student participation and feedback. The intervention instructors more consistently asked students about their prior knowledge and experience of techniques at the beginning of the session (needs assessment). Objectives for the tasks were also consistently set. Intervention instructors continued to observe each student as they were practicing to provide individual feedback in action. In addition, feedback after action was consistently implemented. Instructors from the intervention group would typically step aside with each student near the end of the session to provide individualized feedback and suggestions for improvement (while other students continued practicing). They also used this opportunity to encourage students to self-assess (e.g., "how did you feel you were doing? What did you do well? What do you need to improve on?") Other notable instructional strategies that emerged included the use of summaries to remind students of the procedural steps, providing explanations for strategies, monitoring students' understanding and confidence (e.g., "do you feel comfortable with this?"), setting benchmarks to develop skills (e.g., "it's the sign of a novice…) and making comparisons to real-world practice (e.g., "once you start applying it to the actual sutures…"). There were also instances of prompts to encourage students to recall steps and principles (e.g., "how do you tie? Does anyone remember? Can anyone demonstrate?").

In contrast, instructors from the control group did not consistently provide individualized feedback after action, ask students to self-assess their performance, or prompt them to recall the steps of a procedure. However, they continued to provide demonstrations, observe students, and provide feedback based on observation. Overall, rapport seemed to be established across both conditions through encouragement and non-judgmental messages. The key difference appeared to be that students in the intervention groups received individualized attention and feedback more consistently (both *in* and *after* action) and were prompted to self-assess and share their understanding and experience. From a fidelity perspective, the field notes provide evidence that intervention instructors implemented the majority of components from the NODOFF tool during the training sessions.

Discussion

Teaching practical skills is a core component of undergraduate and postgraduate surgical education. It is essential to optimize our current learning and teaching opportunities, particularly in a stage of decreased clinical exposure. The successful completion of a surgical procedure is dependent on successful acquisition and execution of psychomotor skills. Fitts and Posner, the 3-phase theory of motor skill acquisition, is very well-known in the surgical and motor skills literature (45). It is composed of 3 phases: the cognitive phase (when the skill is learned), the associative phase (when performance is becoming skilled), and the autonomous phase (when the skill has become entirely automatic and can be performed without much thought) (36). Deliberate practice is critical to move learners from the cognitive phase (first stage of learning skill) to autonomous stage (when skill has become automated) (42); however, feedback is a critical part of this process as it helps to accelerate skill acquisition(40, 42). To date, limited research has empirically tested the utility of practical interventions designed to promote more effective feedback among surgical instructors and enhance skill acquisition among learners. The present study addressed this gap by focusing more on the importance of the instructor. It is the instructor, through feedback, and guided methods for learner improvement, as outlined in NODOFF, which allows one to improve. Implemented over the years, this leads to expertise.

NODOFF as a novel tool for teaching in surgery combining the best of several existing approaches to teaching in surgery (8, 18, 30, 36, 37, 40, 45-48). Many clinicians lack formal training as professional educators (48); hence, we developed this novel tool to be used as a cognitive aid to help guide their teaching encounter that practicing surgeons can adopt in their daily practice. Our model incorporates fundamentals of teaching that are demonstrated to improve learner performance. Specifically, beginning the encounter with an agreed upon objective creates a shared understanding of the educational purpose and focuses the learner's attention and performance, which is a key element of deliberate practice (5, 42, 49). Creating an objective provides the learner with an incentive to focus the learning opportunity and provides the teaching surgeon an opportunity to assess the needs of the learner (8, 40, 47). The learner's stated objective gives understanding into the learner's depth of comprehension and perception of their progression to date(8, 19, 48). Restricting the emphasis to a single learning objective will also increase the probability that a lasting change in the learner's performance will follow and will help to focus the surgeon's teaching during the procedure (8). These instructional approaches, combined with structured debriefing and the opportunity for repeated practice, fulfills the essentials of deliberate practice (40, 47, 48). In addition, during feedback-after-action, learners' own self assessments allow the attending surgeon insight into how the learner understands her performance, which provides an opportunity for the attending surgeon to refocus and guide learner's interpretation as necessary by reinforcing good action and providing a specific suggestions and strategies for further development in the future(9, 19, 48).

Our teaching tool, when tested in the simulated setting, led to improvement in basic surgical skill acquisition and retention. The results from the intervention demonstrated that for both basic skills, suturing and knot-tying, the increase in post-training performance was significantly higher for those in the intervention group compared to the control group. Moreover, students in the intervention condition continued to perform significantly better at 1-month follow-up than students in the control condition for the suturing task but not for knot-tying. Given the inadequate level of power for the knot-tying retention analyses, an increased sample size may help to detect significance (if this effect exists).

Qualitative and quantitative analysis of instructor questionnaires revealed that the majority of instructors felt the teaching tool was easy to use without requiring prior instruction. The majority felt the teaching tool helped improve the training session by ensuring that they incorporated all important elements to effective teaching. Learners who participated in the intervention also reported that it was helpful to have a focus for the procedure. The majority also noted that they found the feedback to be constructive and useful for identifying areas in need of improvement.

Guided discovery learning (9) and deliberate practice (5) have been shown to lead to more efficient and effective performance improvement for learners at all levels of expertise (2, 4, 5, 9, 42). Will focused intraoperative teaching with performance specific feedback lead to more efficient learning and performance improvement residents? Both the learners and instructors thought the tool supported more memorable teaching and cultivated better learning. Moreover, NODDOFF demonstrated improvements in skill acquisition and retention of basic surgical skills in the simulated setting. Further work is need to empirically test its effectiveness within the operating room. A broader sample of surgical skills would also provide an opportunity test its utility for more complex procedures. In addition, retaining a larger sample size for the retention test would allow us to examine the lasting effects of this intervention.

Conclusion

The use of the simple cognitive aid, N.O.D.O.F.F., to help instructors, resulted in a significant improvement in skills learning and retention in a novice cohort. Hence, it can be used as a practical teaching tool for surgical skills training. In future work, we plan to test its use in the operating room.

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FIGURES

Figure 1: The Surgical Teaching Rubric, N.O.D.O.F.F.

SURGICAL TEACHING RUBRIC

Needs Assessment

Objectives

Demonstrate

Observe

Feedback in Action

Feedback after Action

NEEDS ASSESSMENT

Knowledge of procedure and Experience

- Have you done it before?
- How many times?

OBJECTIVES

Expectations

- Define learning objectives
  - ✓ What would you like to work on today? OR
  - ✓ Today I would like you to focus on…

DEMONTRATE TECHNIQUE

- Demonstrate technique if first time **OR**
- Ask learner to verbalize steps of procedure

OBSERVE TECHNIQUE

FEEDBACK IN ACTION

- Relate to preset objectives
- Base feedback on direct observation
- Be specific and explain why
- Use neutral language to focus on performance

FEEDBACK AFTER ACTION

- Reactions (Learner's Self-Assessment)
- Reinforcement
  - ✓ Reinforce what was correctly done. "You did well at …"
- Correction
  - ✓ Correct mistakes. "Next time, I would recommend…"
- 2 to 3 rules to guide the future
  - ✓ Teach general rules. "For next time, I would like you to…"

Figure 2a: Two-handed knot tying demonstrated by participant #17, while being video recorded by a head-mounted camera in the simulation center.

Figure 2b: Vertical-mattress suturing demonstrated by participant #10, while being video recorded by a head-mounted camera in the simulation center.

Figure 3a: Student Questionnaire – Parts A & B

Student Questionnaire:

The Surgical Skill Teaching Rubric: Does a structured surgical teaching model improve technical skill acquisition and retention?

PLEASE NOTE THAT THERE ARE NO RIGHT OR WRONG ANSWERS!

PART A

Participant ID#:____________________ **Session #:**________

Demographics:

1. Age:_______

2. Gender: ☐ M ☐ F

3. Desired field of training in the future: ____________________ OR ☐ Undecided

4. Have you had any prior surgical skill training? Yes ☐ No ☐ If Yes, please give more details below.

____

____

PART B

To what extent do you agree or disagree with the following statements.

	Don't Know	Strongly Disagree	Disagree	Agree	Strongly Agree
1. The teaching session was structured/organized.					
2. You were asked about your prior knowledge/experience with the assigned technical skill task at the beginning of the session.					
3. The instructor set objectives prior to the teaching session.					
4. The objectives set at the beginning of the session were covered during the teaching session.					
5. The feedback given was specific to your performance during the session.					
6. The instructor asked you for your own self-assessment after task completion.					
7. The instructor reinforced what you did correctly.					
8. The instructor corrected what you did incorrectly.					
9. The instructor gave you 2 to 3 things to work on for the future.					

Figure 3b: Student Questionnaire – Part C

PART C

1. **Please describe the feedback you received.**

____

____

____

2. **How did you feel in response to the feedback?**

____

____

____

3. **What did you like about the feedback?**

____

____

____

4. **What did you not like about the feedback?**

____

____

____

5. **What if anything would you change about the feedback?**

____

____

____

6. **In your opinion, what elements are important for effective feedback?**

____

____

Figure 3c: Student Questionnaire – Part D

PART D

Using the scale below, please indicate how you currently feel in response to the feedback you received. For each emotion, please indicate the strength of that emotion by selecting the number that best describes the intensity of your emotion. Due to the feedback I feel:

	Not at all (1)	Very little (2)	Moderate (3)	Strong (4)	Very strong (5)
1. Hopeful					
2. Relieved					
3. Anxious					
4. Proud					
5. Hopeless					
6. Happy					
7. Ashamed					
8. Relaxed					
9. Envious					
10. Grateful					
11. Angry					
12. Curious					
13. Confused					
14. Surprised					
15. Disappointed					

PART E

Using the scale below, please indicate to what extent you agree or disagree with the following statements.

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)
1. I was satisfied with my performance overall					
2. I felt the feedback was valuable					
3. I felt the feedback was useful					
4. Due to the feedback I feel more in control of my future performance					
5. Due to the feedback I value the technical procedures more					
6. I feel confident that I can succesfully perform these technical procedures					

THANK YOU FOR PARTICIPATING IN THIS STUDY!

Figure 4a: Instructor Questionnaire – Intervention Group - Part 1

Instructor Questionnaire:
The Surgical Skill Teaching Rubric: Does a structured surgical teaching model improve technical skill acquisition and retention?

Session #:________

Demographics:

1. Age:______
2. Gender: ☐ M ☐ F
3. Post-graduate year of training:
   ☐ PGY-2 ☐PGY-3 ☐PGY-4 ☐PGY-5 ☐PGY-6 ☐Fellow ☐Staff
4. Your training program is:
   ☐ General Surgery ☐Cardiac Surgery ☐Plastics Surgery ☐Otolaryngology
   ☐ Orthopaedic Surgery ☐ Vascular Surgery ☐Urology ☐ Neurosurgery
   ☐ Obstetrics/Gynaecology ☐Other:____________________
5. Have you had any prior training in surgical skill teaching? ☐ Yes ☐ No
6. Have you had any prior training in feedback or debriefing? ☐ Yes ☐ No

To what extent do you agree or disagree with the following statements:

	Don't Know	Strongly Disagree	Disagree	Agree	Strongly Agree
1. The teaching tool was easy to follow.					
2. You needed prior instruction on how to use the teaching tool before using it.					
3. The teaching tool changed the way you normally teach or give feedback.					
4. You did a needs assessment prior to setting of objectives for the session.					
5. You set your session objectives according to the students needs assessment.					
6. You gave specific feedback based on the student's performance.					
7. You reinforced technique that was done incorrectly.					
8. You emphasized and corrected technique that was done incorrectly.					
9. You gave the students 2 to 3 tips to continue working on for next time.					

Figure 4b: Instructor Questionnaire – Intervention Group - Part 2

1. How did you feel overall about the teaching tool?

2. Did it change the way you give feedback? If yes, how?

3. In what instances did you feel you have to pick up the tool and use it?

4. What modifications would you add to this tool?

5. Pretend you are going to teach somebody on how to use this tool, what would you tell them?

6. In your opinion, what are the important principles or steps of teaching a procedure/technical skill?

7. In your opinion, what are important elements of giving effective feedback?

Figure 5: Instructor Questionnaire – Control Group

Instructor Questionnaire

The Surgical Skill Teaching Rubric: Does a structured surgical teaching model improve technical skill acquisition and retention?

Session #:______

Demographics:

1. Age:______

2. Gender: ☐ M ☐ F

3. Post-graduate year of training:

☐ PGY-2 ☐ PGY-3 ☐ PGY-4 ☐ PGY-5 ☐ PGY-6 ☐ Fellow ☐ Staff

4. Your training program is:

☐ General Surgery ☐ Cardiac Surgery ☐ Plastics Surgery ☐ Otolaryngology

☐ Orthopaedic Surgery ☐ Vascular Surgery ☐ Urology ☐ Neurosurgery

☐ Obstetrics/Gynaecology ☐ Other:____________________

5. Have you had any prior training in surgical skill teaching? ☐ Yes ☐ No

6. Have you had any prior training in feedback or debriefing? ☐ Yes ☐ No

7. In your opinion, what are the important principles or steps of teaching a procedure/technical skill?

8. In your opinion, what are important elements of giving effective feedback?

Figure 6: Results of Repeated-Measures ANOVA on Pre-, Post- and Retention Vertical-Mattress Suturing Performance across Groups.

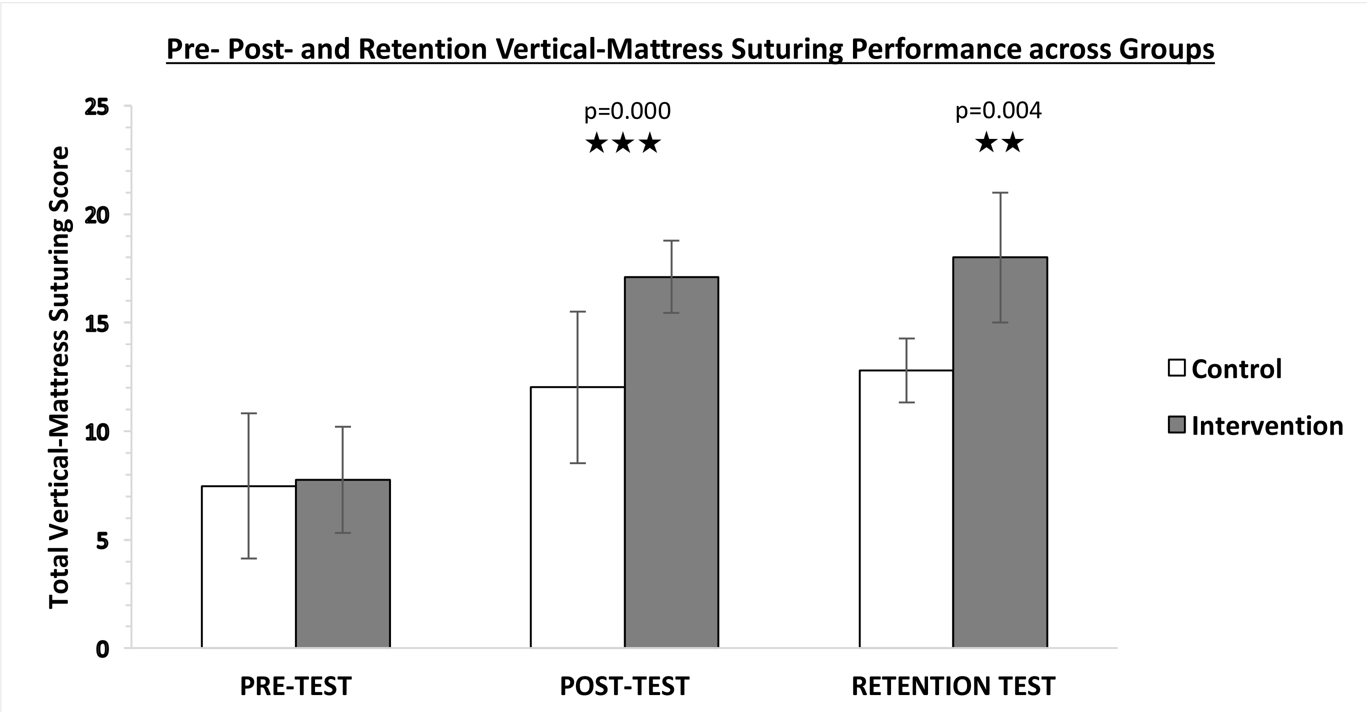
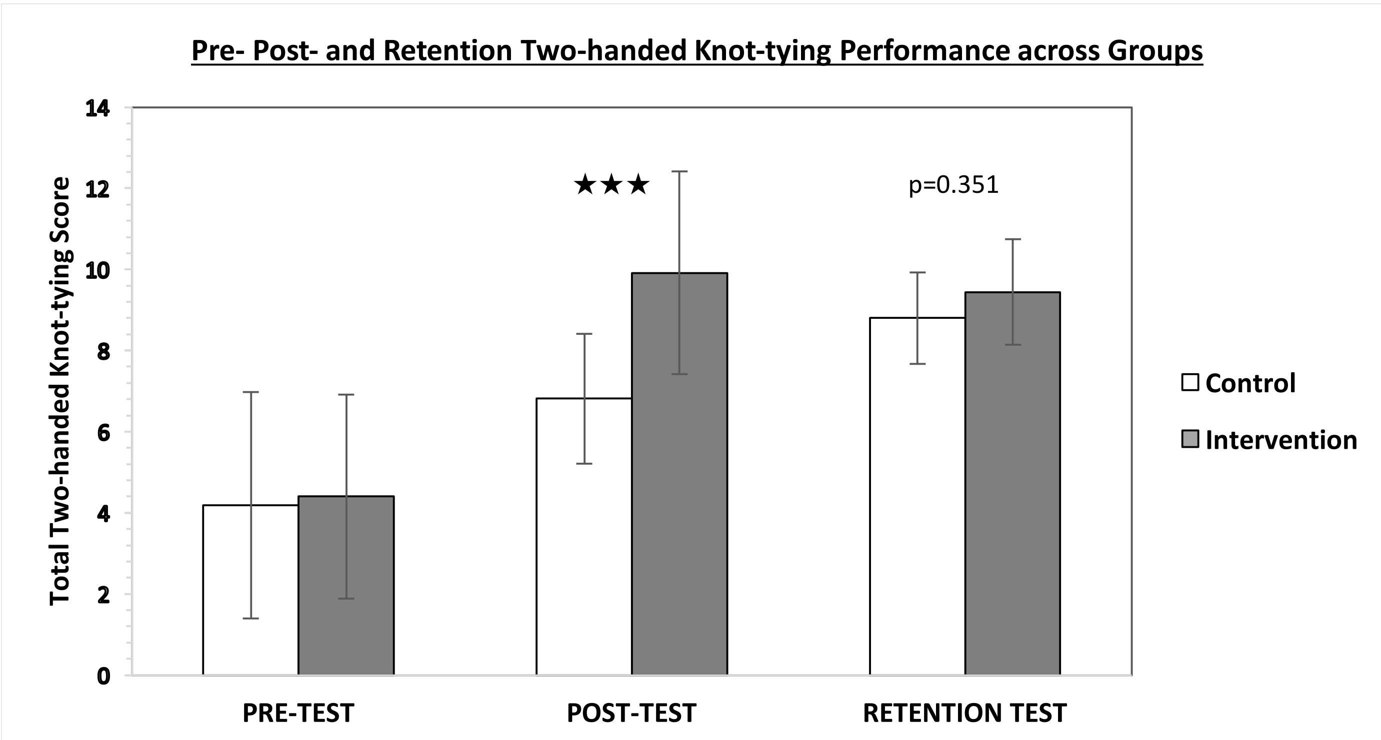


Figure 7: Results of Repeated-Measures ANOVA on Pre-, Post- and Retention Knot-tying Performance across Groups.



SECTION 4:

CONCLUSION & FUTURE WORK

CONCLUSION

In conclusion, our goal was to create a feasible, educationally-sound teaching tool that can be easily incorporated into surgeons daily busy schedule to aid surgical skills instruction. Existing research on guided discovery learning demonstrated the importance of expert verbal and manual guidance during the teaching experience to enhance learning efficiency and outcomes (9, 35, 38). Literature on deliberate practice further convinced us that the model should contain specific steps to guide the actions of both the teacher and the learner (5, 8, 33, 34, 42). Research on memory and learning showed that the learner must have an active role in shaping the learning encounter (8, 40).

The scripted teaching model adopts the principles of deliberate practice by focusing both teacher and learner on one objective, which guides the teaching experience. The teaching session, using NODOFF, will be directed by specific learning objectives set as per the learner's needs, and will consist of immediate and specific feedback during the learning of the skill followed by debriefing, reinforcement and guiding rules for the future. The debriefing element solidifies the learning that occurred in the teaching session through the learner's self-assessment. It guides future practice through reinforcement, correction, and generation of rules to guide future practice.

Accordingly, the rubric designed in this research was informed by evidence demonstrating the utility of specific instructional approaches for learning and skill acquisition. As such, this novel rubric provides a practical resource that can be easily integrated into the teaching surgeon's existing practice, and most importantly, has led to improvement in technical skill acquisition and retention. In our future work we plan to test it’s use in the surgical learning environment – the operating room – on a more complex set of skills.

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