Review

Acquiring surgical skills

J. M. Hamdorf and J. C. Hall

Department of Surgery, University of Western Australia, Perth, Western Australia, Australia
Correspondence to: Professor J. C. Hall, University Department of Surgery, Royal Perth Hospital, Wellington Street, Perth, Western Australia 6000, Australia

Background: Technical competence is the bedrock of surgery, yet it has only recently been viewed as a valid area for either critical evaluation or formal teaching.
Methods: This review examines the teaching of surgical skills. The core is derived from a literature search of the Medline computer database.
Results and conclusion: The impetus for surgical change has generally related to the introduction of new technology. Advances initially allowed for open operation within the main body cavities; more recently minimal access surgery has appeared. The latter was introduced in an inappropriate manner, which has led to the evolution of teaching of technical skills away from an apprenticeship-based activity towards more formal skill-based training programmes. There is now a need for a solid theoretical base for the teaching of manual skills that accommodates concepts of surgical competence.

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Introduction

Surgery has a long tradition of passing down skills to apprentices. With time, simple apprenticeships, involving family or friend, gave way to more organized arrangements with formal rules. For example, in Edinburgh during the 16th century, the Master was 'obliged himself to teach and instruct' and had the obligation not to 'transfer his Prentice to another Master'[1]. Such arrangements eventually merged with the residency system.

It is from this historical base that we will approach current efforts aimed at the teaching of manual skills. This will be followed by an outline of how technical skills are learned, an overview of present training programmes, and an account of the methods currently available for teaching and learning surgical skills.

Historical background

At the end of the 19th century the cranium, chest and abdomen were still sanctuaries, only to be entered by the most adventurous[2]. It was only after the introduction of anaesthesia and the promotion of antisepsis that surgery involving the body cavities became practical on a widespread basis, and this era was associated with a shift away from the apprenticeship system towards more formal training (*Table 1*).

William Halsted spent some of his formative years in Germany before returning to the USA, where he established the 'school for safety in surgery', which was characterized by the careful handling of tissues and meticulous attempts at haemostasis[3]. Accompanying this was the importation of the German system of residency training, with its strong emphasis on graded responsibility. A key event was a lecture delivered by Halsted at Yale in 1904 on the training of surgeons[4,5]. The German concept gained support and in 1928 the house of delegates of the American Medical Association approved the principles underlying approved residencies and fellowships[6].

Within the UK the residency system evolved from much deeper traditions. The apprenticeship system promoted the cult of the individual with the emergence of doyens who

Table 1 Comparison between an apprenticeship and participation in a structured programme

Apprenticeship	Structured programme
Art and craft	Science and craft
Long working hours	Shift work
Low technology, low cost	High technology, high cost
See and do	Formal skills training
Problem-driven accountability	Evidence-based accountability
Moderated by peer pressure	Moderated by peer pressure
Mentor evaluation	Objective evaluation
Assessment based upon traits	Competency-based assessment

established 'schools of surgery'. Reputations were promoted through publication. Sir Frederick Treves was one of many who wrote with verve; in 1891 he commented that 'it may be said literally of some intestinal operations, that their success hangs upon a thread'[7]. More than ever before, techniques were being learnt by example rather than by trial and error.

Through most of the 20th century there has been a lack of any systematic approach towards the teaching of basic surgical skills. For example, such matters occupy only the first few pages of the 1972 edition of Farquarson and Rintoul's text[8] on operative surgery, which consists mainly of pithy vignettes. When discussing the tying of knots, the author comments that every time this is done 'two foreign bodies are introduced – the ligature itself and strangulated tissue beyond it'. Another favoured text was written by Arnold K. Henry[9], and this may have been for the writing as much as the content: 'Exposure that will vie effectively with the "great arsenal of chance" must be a match for every shift, and therefore have a range, *extensile*, like the tongue of the chameleon, to reach where it requires'.

A surgical training programme was started in Guy's Hospital, London, in 1972 in 'an attempt to meet the needs of surgical registrars by giving them more security and guidance within a systematic programme leading to consultancy at an early age'[10]. The emphasis was on an adequate range and volume of surgery. In particular, it was appreciated that assisting does not confer the type of knowledge that is required to do an operation. From then until now, surgical training has been seen as a structured and monitored process. However, the formal teaching of manual skills is a recent development.

Reasons for change

The undisciplined introduction of laparoscopic techniques during the early 1990s led Cuschieri[11] to comment about the 'uncontrolled expansion of surgical endoscopic practice which amounted to the biggest un-audited free-for-all in the history of surgery'. In the past, surgical procedures have sometimes been introduced without evaluation and then later abandoned as either useless or frankly dangerous, for example nephropexy for 'floating-kidney', colectomy for epilepsy, ligation of the internal mammary artery for angina pectoris, and prefrontal lobotomy for schizophrenia[12]. However, these historic interventions received much less attention than laparoscopic procedures because they occurred on a different magnitude, in a less demanding era, and were driven by neither the expectations of patients nor commercial interests.

The teaching of operative skills is constrained by the complexity of procedures and medicolegal concerns. Teaching in the operating theatre also takes time and this is in conflict with the need for fiscal restraint and the move towards more civilized hours of work for doctors in training. There is now little opportunity for either reflection or practice during a procedure and this has created the need for formal training outside the operating theatre[13,14].

Another defining factor is an appreciation that the present period of 'open cavity surgery' is finite[15]. We are already witnessing a blurring of the demarcation between the activities of interventional radiologists, physicians who perform clinical procedures, and surgeons. It is becoming evident that those who wish to become surgeons must hold more than the skills that are required for open operation and that the advancing pantechnicon of minimal access surgery will have a profound effect on surgical training. This is consistent with modern organization theory, as espoused by the Drucker Foundation, that it is new technology, rather than politics or social circumstances, that drives change[16].

The acquisition of manual skills is increasingly viewed as a cross-disciplinary exercise. However, it is not always easy to cross professional boundaries. In 1996, Barnes and Ernst[17] compared the opinions of programme directors about vascular surgery training for general surgery residents. Not surprisingly, general surgery programme directors considered that general surgery graduates were fully competent in vascular surgery, should be exposed to more complex vascular surgery during training, and should be granted unlimited vascular surgical privileges on entering practice. The vascular surgery programme directors believed that general surgery graduates lacked competence in vascular surgery, should be exposed to less complex vascular surgery during training, and should have limited vascular surgery privileges in practice.

How surgical skills are learned

The time spent during surgical training should provide the background and personal resources for continuous learning and the acquisition of new areas of expertise[18]. This applies just as much to manual skills as to cognitive and knowledge-based abilities. It is therefore important to have an appreciation of the issues that underpin the attainment of technical competence.

Psychomotor skills

Fleishman and Quaintance[19] have suggested that there are two types of identifiable and measurable motor abilities: perceptual motor abilities and physical proficiency abilities (*Table 2*). Although the general literature contains extensive inventories that detail specific skills, until recently little

Table 2 Types of motor abilities

Perceptual motor abilities	Examples include the coordination of a number of limbs simultaneously, rapidly selecting an appropriate response to an event, aiming precisely at small objects and manipulating objects with speed
Physical proficiency abilities	Examples generally relate to gross physical performance, for instance the ability to coordinate actions while running or to generate bursts of intense muscular effort

work had been performed to identify the perceptual motor abilities that are required during surgery.

Hanna, Cuschieri and co-workers have evaluated a number of motor skills that come into play in laparoscopic surgery. Examples include an ergonomic assessment of the instrument–needle–tissue relationship on efficiency and accuracy of laparoscopic suturing[20], the influence of image display location on aspects of performance such as execution time and knot quality[21], and the effects of reverse alignment displays by the monitor[22]. Such studies should result in a more detailed appreciation of both the taxonomy and components of the psychomotor skills that are employed during surgery.

Hanna *et al.*[23] have also evaluated the ability of right- and left-handed individuals to perform a variety of endoscopic manipulations. They assessed the ability of medical students to negotiate target holes with a probe. Right-handed subjects had a lower error rate when the evaluation involved either the dominant or non-dominant hand, but such differences reflect innate abilities rather than the capacity to improve with training.

Sex influences perceptual and reactive abilities[24]. Women are more proficient than men in finger dexterity and inverted-alphabet printing. On the other hand, men are better at pursuit tracking, repetitive tapping, maze learning and reaction-time tasks. It is thought that some of these differences may result from unequal opportunities and other culturally conditioned influences.

Acquiring motor skills

Dexterity is an important component of psychomotor skills. Manual dexterity has a number of components such as aiming ability, arm–wrist speed and fine finger dexterity. *Table 3* outlines the three stages that occur during the acquisition of a motor skill[25]. The first stage (cognition) is an understanding of the task: individuals who are provided with a clear description and a demonstration of the task are more likely to master a new skill than those who are not. In the second stage (integration), motor skills unique to the task are applied to avoid inefficient movements. In the final stage (automation), the skill becomes automatic so that there is no need to think about each step or rely upon external cues.

Table 3 Stages in the acquisition of motor skills

Phase	Psychomotor element	Focus of instruction
1	Cognition	Perceptual awareness
2	Integration	Comprehension of mechanical principles
3	Automation	Speed, efficiency and precision

The neurological basis for the phase of automation, which underpins technical competence, is the 'hot-wiring' of a map of the whole performance into neural circuits. This is why it is sometimes difficult for experts to demonstrate the components of a task to others, for instance the tying of knots. Kirk[26] has pointed out that the skills of an experienced surgeon are not always easy to identify, and complex actions can be learnt at a subconscious level by imitation and may be difficult to break down into component parts. Nevertheless, it is necessary to deconstruct skills so that they can be taught to others.

The kind of formal instruction that best aids the development of motor skills differs between the early and later stages of acquisition. During the initial stages, the most essential factors for learning are perceptual awareness, with an understanding of spatial relations, and a comprehension of the underlying mechanical principles. Later, motor abilities involve speed, efficiency and precision.

As a general principle, repetitive performance of a specific task results in a much better performance of that task than does general training in a variety of skills[27]. This is analogous with problem-solving abilities; the ability to solve specific problems does not have a flow-on effect related to the solving of all problems. It should also be evident that the ability to learn specific manual skills to the point of automation is not indicative of enhanced dexterity. Indeed, it has even been claimed that physicians may be just as dextrous as surgeons[28]. Retention of motor skills appears to be most dependent on the degree to which the skill was perfected, rather than on variables such as the environment. This is a critical point because it implies that many of the basic skills required for surgery can be acquired away from the operating theatre.

The amount of transference of skills between tasks depends on the similarity between the two tasks. This implies that appropriate skills learnt in an inanimate trainer can be carried with advantage into the operating theatre. However, a critical deterrent to securing the transfer of skill is incomplete initial learning of the original task. This raises questions about the value of attendance at an isolated workshop without allowance for the subsequent reinforcement of the relevant skills.

Neuropsychological tests

There is a lack of convincing evidence that neuropsychological tests predict technical competence[29,30]. Schueneman *et al.*[31] tested 120 general surgery residents with a battery of neuropsychological tests and then compared the results with ratings of surgical skills provided by attending surgeons during the course of 1445 operations. Academic predictors, such as the National Board scores and the Medical College Admission Test scores, did not correlate with the surgery ratings, and this was particularly so for complex visuospatial organization, stress tolerance and psychomotor abilities. There is a need to develop neuropsychological tests that are predictive of the ability to acquire surgical skills.

Judgement

Operative skill is a double-edged weapon. As Babcock[32] commented in 1928, 'Brilliantly performed operations may be unnecessary, unwisely selected, or untimed for the particular condition'. Surgical skills require the integration of decision making and mechanical processes. A common criticism of surgical trainees is that 'their hands work faster than their brain does'. Spencer[33] has commented that about 75 per cent of the important events in an operation are related to making decisions and about 25 per cent to manual skill. He has stressed that decision making and dexterity are very different processes. Decision making is a higher intellectual function, whereas manual skills are eye–brain–hand reflexes. Nevertheless, judgement cannot be divorced from technical skill, as evidenced by the concomitant evolutionary development of higher cortical function and dexterity (by reduced thumbs and the ability to carry out precise movements with fingers and opposing thumb).

The learning curve

The concept of a learning curve is useful when applied to surgical skills. It can be applied to experienced surgeons who wish to learn a new procedure as well as to undergraduates and surgical trainees. It is usually constructed in retrospect, rather than being applied as a continuous assessment based on predetermined criteria.

It is possible to estimate the dimensions of a learning curve. For example, experience with laparoscopic cholecystectomy has resulted in changes relating to the operating time, the selection of patients, the conversion rate and the incidence of adverse events[34,35]. Yaegashi *et al.*[36] relied upon operating time and blood loss when suggesting that gynaecology residents need to perform more than 75 hysterectomies to achieve proficiency. In addition, both Meehan and Georgeson[37] and Watson *et al.*[38] have presented evidence that surgeons can become proficient after performing about 25 laparoscopic antireflux procedures. In an ideal world, one would measure and document learning curves for all trainee surgeons.

There is little information available on the relationship between learning styles and surgical decision making, but it is appreciated that there are many different styles of learning: concrete experience, abstract conceptualization, active experimentation and reflective observation[39]. Lynch *et al.*[40] have stressed that clinical performance 'requires additional cognitive skills and abilities, and behaviours that are not adequately reflected in objective measures of academic performance'. It seems that common sense never goes out of fashion.

Current deficiencies in teaching and training

In 1993 the Calman Report[41] promoted the need for standardization in the teaching of basic surgical skills. There were also concerns about trainee surgical staff carrying out unsupervised operations that they had never previously performed. In 1997 Wilson[42] surveyed 276 trainee surgeons and young consultants in the UK. The incidence of first-time unsupervised procedures was alarmingly high in general surgery. Junior trainees (senior house officers) undertook submandibular gland excision, repair of femoral hernia, surgery for testicular torsion, partial gastrectomy, splenectomy and cholecystectomy while their senior colleagues were absent from the hospital. Registrars' unsupervised hepatobiliary procedures included triple bypass for pancreatic carcinoma, common bile duct exploration, laparotomy for liver trauma and a Whipple procedure. As might be expected, many first-time unsupervised procedures are undertaken as out-of-hours emergencies.

Undergraduates

The purpose of undergraduate education is to prepare the student for the practice of medicine. However, a review of doctors in training in New South Wales teaching hospitals found that about one-third considered themselves to be incompetent in technical skills[43]. It is of interest that such comments do not always relate to complex procedures; there has been a failure to instruct students in simple tasks such as gloving and gowning, and the removal of sutures[44]. Ward *et al.*[45] surveyed 205 medical students and trainees in Leicester, UK, and found that the most valued skills were venepuncture, intravenous cannulation and urinary catheterization. *Table 4* lists some examples of the components of a skills programme for undergraduates. There has also been a neglect of manual skills training for doctors during their preregistration period[46–48].

Table 4 Examples of components of an undergraduate skills programme

Behavioural skills	
Theatre etiquette	Gowning and gloving
	Infection control
	Universal precautions
	Teamwork
Patient counselling	Consent
	Breaking bad news
Non-integrated skills	
Instruments	Use of scalpel, scissors, artery forceps
Simple tasks	Removal of sutures
	Application of dressings and bandages
Simple integrated skills	
Surgical tasks	Suturing simple wounds
	Application of plasters
Ward procedures	Venepuncture and intravenous cannulation
	Insertion of nasogastric tube
	Insertion of urethral catheter

General practitioners

Within the UK, the introduction of a contract for general practitioners in 1990 has resulted in an increase in the number of minor surgical procedures performed in general practice[49]. Concerns have been expressed about the level of training that is provided to general practitioners; poor training has been claimed to result in a drop in standards, as monitored by events such as the incomplete excision of skin cancer[50]. In 1997, it was reported that 43 per cent of the general practitioners working in the Scottish Highlands and Western Isles considered that they had inadequate training in minor surgery[51]; of the 86 per cent who wished to attend a training course, more than half believed that it was desirable to have their technical competence assessed by a hospital consultant.

Surgeons

Surgeons have been criticized for not pursuing more vigorous methods of evaluating their clinical practice[52]. It is evident that the credentialing of surgeons for new and innovative procedures is a matter of great concern and that re-skilling in the future may require more than attendance at short courses or 'masterclasses'[53]. There is no agreement about the best way of assessing competence. Indeed, the Executive Director of the American Board of Surgery has commented that the definition of incompetence is elusive[54]. As van der Vleuten[55] has commented, the 'current state of the art in the assessment of professional competence is unfortunately more complex than a recipe book of agreed testing technology options'. Early detection of the 'failed' surgeon still remains a difficult issue.

Teaching surgical skills

The first British skills workshop was held at The Royal College of Surgeons of England in 1977. It was led by David Williams on microsurgery and during the next year Alan Apley held a course on the fixation of fractures[56]. Bevan[57] later held an anastomosis workshop at the Buckston Browne Research Laboratories at Downe, UK, using pig viscera collected fresh from an abattoir. Much has changed since then. The surgical royal colleges in the British Isles have played a key role in formalizing the teaching of surgical skills and have helped to introduce programmes into many countries, including South Africa, Saudi Arabia, Kuwait, Pakistan, India, Zimbabwe, Hong Kong and Australia[58–60].

The current intercollegiate basic surgical skills course is now a mandatory part of surgical training in the British Isles. It consists of 3 days of highly structured laboratory work that includes both formative and summative assessments. It deals with gowning, gloving, draping, knot tying, suturing, basic anastomotic technique, basic orthopaedic techniques and basic endoscopic surgical techniques. This course has proven to be a substantial innovation in basic surgical training.

In the USA, the need for psychomotor skills training in orthopaedic surgery was recognized in the mid-1960s, and in 1975 Lippert *et al.*[61] from the University of Washington School of Medicine held an 18-h course on motor skills for orthopaedic residents. More recently, Reznick's group from Toronto, Canada, has provided a systematic approach to the teaching and assessment of surgical skills. In 1992 it reported on a technical skills programme for first-year residents in general surgery[62]. The programme consisted of introductory didactic sessions and 'wet labs'. The latter included instruction on preparation of the patient and draping, aseptic technique, the principles of bowel anastomosis, incisions, the use and handling of instruments, principles of haemostasis, intraoperative surgical emergencies, surgical assisting and theatre etiquette.

A variety of laboratory-based models has been used to teach basic skills, such as the suturing of skin and the performance of visceral and vascular anastomoses[63–66]. Latex tubing and Penrose drains allow experience in suturing, knot tying and haemostasis. Pigs' feet simulate human skin and have been used for suturing, teaching basic plastic surgical techniques, and exercises in skin incision and the excision of lesions. More complex models relate to aortic aneurysm repair, lung resection, closure of incisions in the abdominal wall, fracture fixation and joint replacement, arthroscopy and simulation of the pelvis for colorectal surgery. A headlamp video camera allows the unobtrusive recording of events, with the videotapes providing a means of assessing progress.

Lossing and Groetzsch[67] performed a controlled trial on the teaching of skills to fourth-year medical students at the University of Toronto. A simulated appendicectomy model was used to teach and test skills related to scrubbing, gowning, gloving, instrument handling (right and left hand), suturing, cutting, use of cautery and stapling. This occurred at both the beginning and the end of the 8-week surgery term and the students were provided with a reference manual. The students in the evaluation arm of the trial had superior skills to those in the control group, who attended another hospital but received the same pre- and post-tests.

Animals

Animal laboratories have the benefit of providing living simulations that mimic operative reality[68]. For example, a canine model has been used to instruct vascular residents in the *in situ* vein bypass technique (a segment of cephalic vein was used to construct a bypass between the brachial and the ulnar arteries)[69]. Improvement in technique is indicated by a decrease in the number of technical complications (missed valves, missed arteriovenous fistulas, poorly constructed anastomoses) and improved patency rate. More recently, young pigs have been used to gain experience in laparoscopic cholecystectomy[70]. The main difficulties with live animal models are moral issues, substantial cost and concern about infectious disease.

A continuing issue is the need to develop substitutes for the use of live animals. Stotter *et al.*[71] have described a model for intestinal anastomoses using γ-irradiated lyophilized porcine or bovine tissues in combination with a purpose-designed holding jig. Because the tissues are sterile, health hazards are avoided and no special laboratory facilities are required. On the basis of considerable experience, Thomas *et al.*[72] have concluded that synthetic tissues can 'provide a useful and functionally reproducible means for learning' basic surgical skills. By way of example, a recent report details a jig simulating the abdominal wall and peritoneal cavity which can be used to teach the techniques of abdominal wound closure and stoma formation[73]. There is now a growing industry involved with the commercial production of such models. The benefits of bench models include lower cost, portability and easy availability.

Minimal access surgery

The learning of laparoscopic surgery does not lend itself to the traditional 'hands-on' apprenticeship model. However, Rosser *et al.*[74] have concluded that basic skills relevant to laparoscopic performance 'can be acquired with a high level of competence in a brief course unrelated to prior surgical experience, sex, or age'. This implies that formal training programmes do have a valid role to play when new technology is being introduced into the surgical community.

The core skills underlying laparoscopic surgery have been identified. Derossis *et al.*[75] from Montreal, Canada, have developed a model to evaluate laparoscopic skills involving a series of structured tasks (peg transfers, pattern cutting, clip and divide, endolooping, mesh placement and fixation, suturing with intracorporeal or extracorporeal knots). The initial laparoscopic cholecystectomy training programme at the University of Maryland in the USA included the use of a jig that enabled the trainee to practise laparoscopic suturing, knot tying and clip application[70].

The skill and the ergonomics of surgeons performing minimal access surgery can be evaluated using set tasks. Hanna *et al.*[76] have established an objective method for assessing the quality of intracorporeal knots based on a study of 2700 such knots. Each knot was evaluated using a tensiometer and a computerized system analysed force–extension curves. A knot-quality score was obtained from the product of the knot-breaking force and the integrated force, expressed as a percentage of the product for the untied ligature. It was found that the breaking force is not a discriminative variable of knot quality and that measuring the breaking force does not reflect the degree of knot tightening. However, the knot-quality score provides a reliable assessment of knot security, and reflects the strength and degree of tightening of the knot.

Simulated operations

Advances in computing, imaging and information transfer have allowed the use of virtual reality in the performance and teaching of surgery[77]. For example, the minimally invasive surgery trainer – virtual reality (MIST-VR) system allows suitable tasks to be performed using standard laparoscopic instruments linked to a computer, which enables the movement of the instruments to be both measured and translated into a graphical display[78]. It is of interest that MIST-VR is based on abstracted graphics so that surgeons are not distracted by the appearance of virtual organs.

Another advance in the acquisition and assessment of manual skills is the Advanced Dundee Endoscopic Psychomotor Tester (ADEPT), which can be used to evaluate clinical competence in endoscopic manipulations[79]. ADEPT was evaluated by having ten senior trainees (specialist registrars) complete 200 structured tasks involving the manipulation of switches and dials using standard endoscopic imaging and surgical instruments[80]. The overall performance on ADEPT correlated well with independent blind assessment of clinical competence. The system is also able to identify innate abilities, for instance aspects of performance that do not improve with practice. Systems such as ADEPT therefore offer the prospect of predicting the maximum level of skill acquisition. Such tests of aptitude may eventually play a role in the selection of trainees.

Computer-assisted learning has the capacity to reduce the need for staff time, but lacks the important ingredient of immediate feedback. Rogers *et al.*[81] found that computer-assisted learning was less effective than a lecture and feedback seminar for teaching medical students how to tie a two-handed square knot. Aspects of Minor Oral Surgery is a highly interactive software program that was commissioned by the Department of Health in the UK as part of the continuing education opportunities for general dental practitioners. The quality of the images of surgical procedures was judged to be a weakness[82].

Teamwork

Teamwork is a neglected component of skills. Attempts to enhance skills performance can be criticized because of the overt concentration on 'singular, unidimensional constructs', that is the mechanical task performed by the surgeon[83]. There is a need to look at other issues, such as sustained attention and the various components of teamwork. One advance, led by anaesthetists and adopted from the airline industry, is the use of simulated operating theatres. It is evident that team dynamics and the attainment of cohesive groups are areas worthy of consideration.

Training the teachers

A 'training the trainers' programme started in the UK in 1994[84]. In a sentinel publication, Peyton[85] has outlined the application of basic educational theory to the teaching of surgical skills. A key feature is an emphasis on the four-stage approach to the teaching of manual skills (*Table 5*). Although this topic has relevance for all surgical educators, further discussion is beyond the scope of this review and interested readers should consult Peyton's book[85].

Table 5 Stages in the teaching of a manual skill as described by Peyton[85]

Phase	Task	Action
1	Demonstration	Instructor demonstrates the skill at normal speed
2	Deconstruction	Instructor demonstrates the skill by breaking it down into simple steps
3	Formulation	Instructor demonstrates the skill while being 'talked through' the steps by the student
4	Performance	Student performs the skill and describes the steps

Assessment

The introduction of a mandatory intercollegiate basic surgical skills course by the surgical royal colleges in the British Isles underlines the need for objective methods of assessment. Although a variety of techniques has been proposed to assess technical skills[86], it is evident that, if the objective is competence-based assessment under realistic conditions, a structured evaluation of performance within the operating theatre is essential. Otherwise one is assessing traits in the absence of either their definition or components. In words that embrace the current jargon, the 'trait' approach to competence has been replaced by the 'person-by-situation interaction paradigm'[87].

Reznick *et al.*[88] from the University of Toronto have applied validity theory to the assessment of technical skill. They point out the inadequacy of comments such as 'a good pair of hands' and stress the need for assessments that are feasible, reliable, relevant and psychometrically sound. They have pursued that goal by developing a programme of objective structured assessment of technical skill[89,90]. Trainees rotate through a number of stations and are assessed performing specific tasks using bench-top simulations, for example abdominal wall closure, control of haemorrhage from the inferior vena cava and tracheostomy. Residents have been assessed using two methods of scoring, task-specific checklists and global rating scales (it appears that global rating is the better method). It has also been concluded that bench model simulation gives equivalent results to the use of live animals. The overall inference is that the objective structured assessment of technical skill programme can assess surgical skills with reliability and validity.

Some studies have concentrated on instrument-related measurements as a form of assessment. Seki *et al.*[91]

Table 6 Steps in the evaluation of a skills exercise

Objectives	Did the participants understand the objectives?
Coverage	Did the course cover the objectives?
Relevance	Will the acquired skills be useful?
Feedback	What did the participants like about the course? How could the course be improved?
Changes	What changes should be introduced?

evaluated technical skill in suturing by analysing actual suture tracts; ideal suturing was defined as advancing a needle along its curvature in combination with correct placement. For endoscopic procedures there have been attempts to replace subjective assessments with all-electronic evaluations: distance travelled by instrument tip, number of movements, speed of movement and time.

As early as 1971, Kopta[25] stressed the fact that deficiencies in the teaching and learning of motor skills are unlikely to be corrected unless there is some mechanism to provide reliable and systematic feedback. Such formative assessment, which is used just to provide helpful feedback, contrasts with summative assessment, which is used to award a grade. In addition, feedback from students is an important ingredient when evaluating courses (*Table 6*).

Conclusion

The haphazard introduction of laparoscopic procedures emphasized the need for a more structured approach towards the attainment of technical competence. Such efforts have commenced and seem likely to expand in the future. With the advent of clinical governance, the prospect of revalidation means that the learning of surgical skills and the assessment of clinical competence are now topics in which every practising surgeon has been forced to take an interest.

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