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SPECIAL TOPIC

How Educational Theory Can Inform the Training and Practice of Plastic Surgeons

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Summary: It is important to optimize our current learning and teaching models, particularly in a climate of decreased clinical exposure. With technical advancements and clinical care now more accountable, traditional methods of skill acquisition need to be revisited. The past decade has seen changes in plastic surgery curricula. There has also been a shift toward competency-based training programs reflecting the growing emphasis on outcomes-based surgical education. This review explores the role of educational theory in promoting effective learning in practical skills teaching. Key models of educational theory are presented and their application to plastic surgery training to an expert level are highlighted. These models include (1) learning within communities of practice (Lave and Wenger's theory); (2) the role of the zone of proximal development and importance of the availability of expert assistance (Vygotsky's theory); (3) skill acquisition and retention (Dreyfus' and Dreyfus', and Fitts' and Posner's theories); (4) development of expertise after repeated practice and regular reinforcement (Ericsson's theory); and (5) the assessment of competence (Miller's triangle). Future plastic surgeons need to possess a thorough understanding of the technical and nontechnical skills required to manage patients effectively. Surgical educators are therefore compelled to develop practical training programs that can teach each of these skills in a safe, learner-centric manner. It is hoped that new approaches to surgical skills training are designed in light of our understanding of educational theory to optimize the training of the next generation of plastic surgeons. *(Plast Reconstr Surg Glob Open 2018;6:e2042; doi: 10.1097/GOX.0000000000002042; Published online 12 December 2018.)*

INTRODUCTION

The traditional model of surgical training has changed considerably over the last decade. The Halstedian model of graduated patient responsibility, established over 100 years ago, has been superseded by the concept of competence-based training with the documentation of progressive educational achievement.[1,2] Teaching of surgical skills can be modeled on established educational theory to optimize training.[3,4] The ultimate goal would be to achieve mastery within a complex clinical world.[3,5] Resident (trainee) educational reform and the need for more evidence-based educational initiatives in plastic surgery training has been postulated in the United States, in accordance with the Accreditation Council for Graduate Medical Education (ACGME).[6] The ACGME and American Board of Plastic Surgery undertook a joint initiative known as The Plastic Surgery Milestone Project (PSMP)[7] to set competence-based training goals. The PSMP describes the "knowledge, skills, attitudes, and other attributes for each of the ACGME core competencies," in plastic surgery.[7]

To better introduce reform and achieve educational milestones in improving plastic surgery training, the concept of educational theory relevant to plastic surgery training must be understood, explored, and integrated into day-to-day learning in light of current training. Kamali et al.[8] have recently reported the similarities and differences in residency training pathways in the United States and Europe, highlighting the pathways adopted and the heterogeneity among international programs. In

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the United Kingdom, the Intercollegiate Surgical Curriculum Programme (ISCP)[9] is a competence-based curriculum that highlights the syllabus for plastic surgery among 9 other postgraduate surgical specialities. It defined its goals in accordance with Good Surgical Practice,[10] as published by the Royal College of Surgeons. This syllabus includes structural components such as "standards for depth of knowledge," "standards for clinical and technical skills," and "standards for professional skills and leadership" within its plastic surgery syllabus, which was last updated in 2016.[9] This resonates with the CanMEDS physician competency framework as published by the Royal College of Surgeons and Physicians of Canada,[11] and the PSMP milestones such as "independently performs routine procedures" and "independently performs complex procedures."[7]

This article explores the educational theories behind contemporary competency-based surgical education, highlighting how an understanding of the principles of pedagogy and andragogy can aid this endeavor. It maps out current competency milestones as set by the ISCP in the United Kingdom and proposes how educational theory can be practically applied to the acquisition of technical and nontechnical skills in the everyday training of a plastic surgeon. This approach can be extrapolated into other training programs internationally, and the U.K. example has been used for illustration purposes based on the authors' experience. Senior surgical trainers have always delivered highly sought-after training based on key educational theory principles, possibly without being aware of the history of these theories and related nomenclature. Likewise, some trainees and residents may find certain approaches to their surgical skill learning more conducive, without the background knowledge as to why this may be the case. Therefore, this review intends to provide trainees and trainers with an understanding of core educational theory principles applicable to plastic surgery training. The aim is to familiarize trainees and trainers with relevant literature on educational theory, nurture the development of expertise within surgical training, and propose potential avenues to explore in plastic surgery training. Such an approach may cultivate future plastic surgeon educators to further advance surgical training in light of our understanding of educational theory, ultimately to improve patient care. It will begin by expanding upon relevant theory with examples, making reference to national curricula, and propose directions for future training. It makes recommendations for surgical educators using these theoretical principles to optimize the training of the next generation of plastic surgeons. In this article, the trainee surgeon is referred to as he or she interchangeably to resonate with the context of the text, to ensure gender equality and neutrality.

SITUATED LEARNING THEORY

The workplace remains the principal site of learning surgical practice. The historical model of technical skills acquisition, where a trainee learned by shadowing the master, has been replaced by a more modern view of apprenticeship. The "situated learning theory"[12] and that of "communities of practice"[13] highlight the importance of learning within a professional context.[3,14] The core defining component of learning, when viewed as a situated activity is the process of "legitimate peripheral participation." In the context of surgery, this means that surgical trainees (ie, learners), participate in communities of practitioners (including consultants/attendings and seniors in the department). To progress their skills, trainees are required to engage within "the community" and move toward full participation in the sociocultural practices of that community, to be seen as a legitimate enterprise within that community. The concept of communities of practice as described by Lave and Wenger comprises 3 structural elements: joint enterprise, mutual engagement, and shared repertoire.[13] Effectively they argue that learning is an inseparable and integral aspect of social practice, rather than a process of internalization of individual experience. Increased competency, knowledge, and involvement in the main processes of the community shift the newcomer toward the status of old-timer, or integral member. Once engaging appropriately, surgical trainees are offered meaningful activities commensurate with their ability, which can be progressively increased. This can be illustrated by a microsurgical fellowship and the case of abdominal-based free flap breast reconstruction. A fellow begins by assisting his/her consultants with flap raises and vessel anastomoses. He/she subsequently progresses to preparing the chest (internal mammary vessels) for anastomosis. As his skills increase and relationship with the consultants and trainers develops, he is given opportunities to perform the microsurgical anastomoses. With further number of joint procedures and mutual engagement, the trainee proceeds to raise the flap with the end-point of being able to carry out the procedure independently. This description recapitulates what happens on a daily basis in a teaching hospital or academic medical center. By appreciating the essence and background of such socio-educational theory, trainees and trainers can perhaps more effectively engage effectively within their communities of practice in other applicable scenarios.

INTRODUCTION TO CONSTRUCTIVIST THEORY: ACQUIRING CLINICAL SKILLS

Constructivist theories of learning are based on the premise that the act of learning is based on a process that connects new knowledge to preexisting knowledge.[15] It is derived from the work of Jean Piaget, a renowned psychologist (1896–1980).[16,17] Although his theories were originally described in the development of a child, he put forward learning as an act of "accommodation, assimilation, and equilibration." Individuals construct new knowledge and develop new skills based on their experiences. By assimilating, they incorporate the new experience into an already existing framework, which is improved with a facilitator instructing appropriately. This theory is widely relevant in teaching practical surgical skills in plastic surgery. For example, when teaching the principles of excision of a malignant melanoma on a limb or face, the opportunity can be used to discuss the pathophysiology of lesions, their respective oncological resection guidelines, and anatomical planes (eg, superficial musculoaponeurotic system (SMAS) on the face and muscle fascia on the limb). This enhances cognitive knowledge and intuitive problem-solving capabilities in addition to the technical skills involved in the excision of such a excision, particularly with a higher volume of more complex cases.

The zone of proximal development (ZPD), as described by the early 20th-century Russian psychologist Vygotsky,[18,19] is also useful to explore further as an underpinning constructivist theory. Although Vygotsky's core work was published in the 1930's in the Russian literature, translations of this plethora of work became available in the English language in the 1960s to 1990s.[20] The ZPD concept was described in the context of child development, as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers."[19] The ZPD concept has been extrapolated into adult learning models.[21,22] The ZPD provides a useful framework to understand how surgical trainees may further develop their practical skills learning. Each trainee's ZPD may vary, requiring different levels of peer-support and trainer-prompting, until eventually the skill can be mastered. Such approaches allow the learner to explore personal development while still in their comfort zone (ie, their ZPD), before progressing to the level of an expert, whether it be in a flexor tendon repair, microsurgical anastomosis, or flap raise.

In adult learning theory (andragogy), as described by Malcolm Knowles (1913–1997), the trainee is seen as an active and motivated learner, characterized by intrinsic self-direction and readiness to learn.[23–25] Applying Knowles's use of andragogy to surgical learning would place more of the responsibility for learning on the learner rather than on the teacher or facilitator. Plastic surgical trainees have already shown their desire and commitment to pursuing training, having passed generic surgical examinations and through a rigorous process, been successfully appointed nationally to highly competitive training programs.[26] In line with this model, the trainee takes responsibility for their own learning. The exemplary approach is known to trainees already; therefore, they prepare for the operation beforehand by doing background reading before a challenging or new procedure, to include the technique itself and recent literature around it, or practice microsurgical skills in a microsurgical skills laboratory before attempting anastomoses intraoperatively. Such approaches enable the trainee to maximize learning episodes and trainers more likely to delegate surgical training.

DEFINING THE DREYFUS MODEL IN PLASTIC SURGERY PRACTICE

In 1980, the American philosopher, Hubert Dreyfus, and his younger brother, Stuart Dreyfus, developed the Dreyfus Model of Skill Acquisition.[27,28] Their model was based upon the concept that students pass through 5 levels of competency as they acquire specific skills through formal education and practice: novice, advanced beginner, competent, proficient, and expert.[29,30] This concept has achieved increased recognition internationally in numerous learning models and is often referred to in the surgical education literature.[3,4] The implication is that our training pathway is holistic and continuous, and that as life-long learners our journey does not end when training is completed but continues further into our clinical practice as we aim to achieve the level of expertise.[31] There has been recent criticism of this model, as it describes performance in terms of implicit knowledge and intuition, with no real consideration of explicit knowledge,[29] which is beyond the remit of this review.

As this is a prominent model referred to in the surgical education literature,[3,4] it is noteworthy exploring it in greater depth, particularly as it has been tabulated into stages/levels that trainees can resonate with in plastic surgery.[32–34] In fact, the PSMP levels/milestones were guided by the Dreyfus Model.[33,35]

Table 1 summarizes this model with adaptations to different levels in the plastic surgery training pathway in the United Kingdom. Although reference is made to examples of stages (eg, stage 2 may represent ST4 or ST5 in the United Kingdom, which is equivalent to a second- or third-year resident in Plastic Surgery training in the United States), these are by no way prescriptive (as surgeons at the same training level may indeed be in different Dreyfus stages technically). Such examples are only indicative to enable the reader to resonate with the different stages.

MOTOR SKILLS: ACQUISITION AND RETENTION

Successful completion of a practical procedure is based on the acquisition and retention of psychomotor skills. Fitts and Posner[36] proposed a model of skill acquisition that centered on 3 stages. In their now-classic theory, performance was characterized by 3 sequential stages, termed the cognitive, associative, and autonomous stages.[37] In the cognitive stage, the learner intellectualizes the task; performance is erratic, and the procedure is carried out in distinct steps. For example, with a plastic surgical skill such as flexor tendon repair using a modified Kessler type repair (eg, 2 strand core grasping suture with buried knot and running epitendinous),[38] in the cognitive stage the learner must understand the mechanics of the skill—how to carefully hold the tendon ends avoiding fraying and avoiding "letting go," the sequence of steps for the core suture placement, and how to tie the knot with appropriate tension. With practice and feedback, the learner reaches the integrative stage, in which knowledge is translated into appropriate motor behavior. The learner is still thinking about where to place the needle and how to achieve good apposition of tendon ends but is able to execute the task more fluidly, without the need for corrections. In the autonomous stage, practice gradually results in smooth performance with excellent tissue handling and tendon apposition. The learner no longer needs to think about how to execute this particular task

Table 1. Acquisition of Skills Applied to the Development of a Plastic Surgeon According to the Principles of the Dreyfus and Dreyfus Model[27,28]

Level	Knowledge	Standard of Work	Autonomy	Coping with Complexity	Perception of Context
Novice (UK CT1/2; US Intern)	Minimal or "textbook" knowledge with minimal clinical context	Deficient, unless closely supervised	Rule driven, requires close supervision	Unable to cope with complexity	Tends to see actions in isolation
Advanced beginner (ST3-6; early year resident)	Working knowledge of key aspects of practice	Straightforward tasks satisfactory with supervision	Uses rules to decide what is relevant, supervision needed for overall task	Appreciates complex situations but only able to partially resolve complex situations	Sees actions as a series of steps
Competent (ST7/8; final year resident)	Good working and background knowledge of plastic surgery	Satisfactory, though may lack refinement	Able to achieve most tasks using own judgment	Copes with complex situations through deliberate analysis and planning	Sees actions at least partly in terms of long-term goals
Proficient (established consultant/attending)	Greater depth of understanding of the discipline and practice of plastic surgery	Fully acceptable standard routinely achieved	Able to assume full responsibility for own work and that of others	Deals with complex situations holistically, decision making more confident	Sees overall "picture" and how individual actions fit within it
Expert (senior experienced consultant/attending or distinguished professor)	Authoritative knowledge and deep tacit understanding of the discipline and practice of plastic surgery	Excellence achieved with relative ease	Able to take responsibly for going beyond existing standards and creating own interpretations	Holistic grasp of complex situations, moves between intuitive and analytical approaches with ease	Sees overall "picture" and alternative approaches; envisions what may be possible

CT, core trainee; ST, specialty trainee.

and can concentrate on other aspects of the procedure such as avoiding complications, following up the patient in clinic and assessing long-term postoperative hand function. Simulation has proven to be an excellent adjunct to surgical training[39] and has taken a prominent role in plastic surgery training.[40–42] It offers a safe environment in which learners repeatedly can practice a range of clinical skills without endangering patients. It has become one of the pillars of modern-day medical education, embracing a vast spectrum of materials and technologies.[40,41]

PLASTIC SURGERY EXPERTS: BORN OR MADE?

Expert performance represents the highest level of technical skills acquisition. Through extended experience, it is the final result of a gradual improvement in performance.[5,31,43–45] According to Ericsson,[43,44] most professionals reach a stable level of performance and maintain this status quo for the rest of their careers. In the context of surgery, experts can be defined as "experienced surgeons with consistently better outcomes" whereby they demonstrate superior performance in multiple skills compared with nonexperts.[5,31,45] Regular practice is an important determinant of outcome.[46] However, it is apparent that volume alone does not account for the skill level among surgeons because variations in performance have been shown among different surgeons with high volumes of cases. Ericsson[43] also argues that the number of hours spent in deliberate practice (with the specific intention and motivation to improve), rather than just hours spent in surgery, is an important determinant of the level of expertise. The key challenge for aspiring expert performers is to avoid the arrested development associated with automaticity. An interesting view of expertise proposes a juxtaposition of 2 different types of expert: Bereiter and Scardamalia[47] distinguish between the "true expert" and the "experienced nonexpert." Hatano and Inagaki[48] compare the "routine expert" with the "adaptive expert."[49] This latter concept explains the phenomenon when such experts are able to develop a unique solution (and "innovate an approach") to work for a complex problem, and the surgery ensues (as it appears to others) effortlessly. We are aware of novel advances in numerous subspecializations within our field of plastic surgery, which are regularly published in this journal and others—this perhaps is a display of the amount of dynamic expertise within our highly skilled specialty. The important consideration in these models of expertise is not how autonomous, routine, or intuitive the expert has become, but rather how they reinvest and allocate their freed-up attention to be in higher control of the cognitive processes involved to offer a bespoke service.[50]

Deliberate practice per se involves repeated practice along with coaching and immediate feedback on performance by the trainer. The attained level of expertise has been shown to be closely related to time devoted to deliberate practice in the performance of chess players, athletes, and expert musicians.[51] Studies of expertise in several domains have shown that it takes at least 10 years or 10,000 hours of deliberate practice for someone to demonstrate expertise in a specific domain.[50,51] Not everyone who performs this will necessarily become an expert; Ericsson argues that there must be motivation to excel and a determination to succeed, while having suitable support.[5,50,51] Thus, deliberate practice is a critical process requisite for the development of expertise, or mastery.

Growing evidence in medical domains suggest that the extent and nature of practice, as well as the practice structure, are critical to the development of complex motor skills.[29,37,45] First, the way in which the task is practiced, which is known as contextual interference (CI),[52] has been shown to influence how practice conditions. CI effects, initially demonstrated by Shea and Morgan,[52] are related to the sequential organization of the variations of a given task that has to be learned in a single training session. When the task variations are practiced in separate blocks of trials (blocked practice schedule), little CI is created. On the other hand, much CI occurs when the variations of the task change randomly from one trial to the next (random practice schedule). Blocked practice schedules lead to better performance during training than random practice schedules, although the latter result in better performance in retention and transfer tasks.[53] Second, the superiority of distributed practice (ie, regular teaching sessions) over massed practice (practice of a task continuously in a long teaching session) has been demonstrated.[54] Moulton et al.[54] performed a randomized-controlled trial to determine the effects of massed compared with distributed practice in a complex microsurgical anastomosis animal model. The authors found that the distributed group significantly outperformed the massed group on a retention test. This concept can also be extrapolated into daily teaching of microsurgical cases. For example, in autologous breast reconstruction, there are several operative components that can be performed in sequence and can be shared to improve training and efficiency.[55] By breaking the procedure down into its core steps: flap raise, vessel preparation, micro-anastomoses, flap inset, and donor closure, trainees can perform different parts of the operation repeatedly overtime, progressing appropriately within their ZPD (and Dreyfus and Dreyfus level for example), as opposed to trying to perform the entire operative procedure alone.[55] With regard to microsurgical anastomoses, deliberate practice in the simulation laboratory can enable trainees to become more fluid, allowing them to concentrate on the other core steps of a free flap procedure.

ASSESSMENT OF COMPETENCE

Surgical training can be assessed within the context of 4 domains: knowledge, judgment, technique, and professional skills. Within the ISCP, these domains are underpinned by explicit syllabus standards for the development of competent surgical practice. At the end of each stage of training, competence must be demonstrated in order for the trainee to progress. From an educational theory perspective, the model introduced by Miller[56] in 1990 provides a structure for assessing and planning learning experiences.[57] Miller's Pyramid describes a series of levels moving from factual knowledge (Knows), which serves as the base of the Pyramid, to applied knowledge (Knows how), to demonstration of performance in a structured environment (Shows how), and ultimately translating knowledge and skills into practice (Does). Thus, in every step toward competence, the trainee progresses through the necessary cognitive and behavioral steps that underlie the next step, building on knowledge that eventually underpins the execution of a specific skill.

Table 2 demonstrates the methodology used throughout the ISCP surgical curricula (for multiple surgical specialties) to define the relevant depth of knowledge

Table 2. Methodology Used throughout the Surgical Curricula to Define the Relevant Depth of Knowledge Required of the Surgical Trainee

Level	Definition	Characteristics
1	Has observed	• Has adequate knowledge of the steps through direct observation • Demonstrates that he/she can handle instruments relevant to the procedure appropriately and safely • Can perform some parts of the procedure with reasonable fluency
2	Can do with assistance	• Knows all the steps—and the reasons that lie behind the methodology • Can carry out a straightforward procedure fluently from start to finish • Knows and demonstrates when to call for assistance/advice from the supervisor (knows personal limitations)
3	Can do whole but may need assistance	• Can adapt to well-known variations in the procedure encountered, without direct input from the trainer • Recognizes and makes a correct assessment of common problems that are encountered • Is able to deal with most of the common problems • Knows and demonstrates when he/she needs help • Requires advice rather than help that requires the trainer to scrub
4	Competent to do without assistance including complications	• With regards to the common clinical situations in the specialty, can deal with straightforward and difficult cases to a satisfactory level and without the requirement for external input • The level at which one would expect a U.K. consultant surgeon to function • Is capable of supervising trainees

Adopted from ISCP, Standards for Training.[9]

Table 3. Advancing Competencies in Plastic Surgery in Line with the Level of Training (Proposed from the ISCP Syllabus in the United Kingdom)

	Trauma			Elective					
Level	Hand	Burns	Lower Limb	Skin Cancer	Hand	Breast (INC RECON)	Aesthetic Surgery	Craniofacial (INC CLEFT)	Trunk/ Urogenital
CT1-2 (early years training)	Nailbed repair, extensor tendon repair	Assess burn injury, use Lund-Browder chart, dressings care, small to moderate SSG	POP application, # reduction, direct closure, VAC dressing application, washout of collection/ hematoma	FNA/punch biopsy, shave excision, incision/excision biopsy, SSG/ FTSG	Approach to carpal tunnel release, excision of small superficial vascular malformations	FNA, punch biopsy of skin/ nipple, I+D breast abscess, cyst aspiration	Drainage of septal hematoma, nasal packing, steroid injection into keloid scar	Close coronal incision	Circumcision, artificial erection test, assessment of pressure sore (decubitus ulcer)
ST3-6 (intermediate years training)	Zone I-II flexor tendon repair, nerve graft harvest, ORIF of MC, thumb UCL repair, fingertip recon, eg, cross-finger flap	Burns resus <40% TBSA, large skin grafts, burn management, eg, z-plasty, flamazine/biobrane application, escharotomy, fasciotomy, plan and raise flaps	Compartment pressure measurement, systematic wound debridement, nerve repair, fasciotomy, planning + raising fasciocutaneous flaps, vein graft harvest	Incision/excision biopsies at difficult sites, local flap, z-plasty, wider excisions, more complex local flaps, regional flaps	Cubital tunnel release, trigger digit release, bone grafting, ganglion excision, fasciectomy with correction of MCPJ, PIPJ, arthrodesis, trapeziectomy	Benign lump excision, scar revision, insetting of flap, nipple eversion/reconstruction techniques, breast augmentation and reduction, excision of gynecomastia, raising LD flap	Upper lid blepharoplasty, scar revision (dog ears), liposuction, fat transfer, liposuction to the facial area, primary otoplasty, abdominoplasty, facelift, rhinoplasty	Grafts and local flaps, excision of accessory auricles, fat transfer, nerve repair	Meatotomy—trimming of skin envelope following hypospadias repair, raising local flaps, foreskin reconstruction.
ST7-8 (final years training)	Revascularization of digit, ORIF phalangeal fracture, Groin/radial forearm flap	Tracheostomy, limb amputation, burns resus >40% TBSA	Amputation, raising and anastomosis of free flap (ALT, RFF), sural nerve graft	SLNB, neck dissection, aesthetic subunit recon, oculoplastic techniques	Fasciectomy for recurrence of Dupuytren's, correction of syndactyly/ polydactyly	ALND, free DIEP/ TRAM flap, lipomodeling to reconstructed breast	Lower lid blepharoplasty, facelift, rhinoplasty	Orbital floor and frontal bone fracture repair, bone grafting	Snodgrass repair, Bracka repair

With ST7-8 (which may include a within-training fellowship period), certain competencies (eg, craniofacial and urogenital) would be for subspecialty interest. The ISCP proposes a graded advancement in each topic from early to final years training. Therefore each procedure (eg, breast reduction) theoretically will be present at each of the training levels, although the knowledge and skills required in early years training would be at a basic level, whereas more established training levels should develop intermediate and advanced knowledge/skills in these procedures. This table proposes in line with educational theory and the ISCP curriculum how plastic surgery procedures can be targeted with a build-up to potentially more complex cases. These examples are not prescriptive but are given to better illustrate the potential build-up of cases and competencies. At the end of each training level (eg, intermediate years), it is important to have developed advanced knowledge and skills in a range of procedures.

ALND, axillary lymph node dissection; ALT, anterolateral thigh; CT, core training; DIEP, deep inferior epigastric artery; FNA, fine needle aspiration; FTSG, full-thickness skin graft; I&D, incision and drainage; LD, latissimus dorsi; MCPJ, metacarpophalangeal joint; MP, metacarpal; ORIF, open reduction internal fixation; PIPJ, proximal interphalangeal joint; POP, plaster of Paris; RFF, radial forearm flap; SLNB, sentinel lymph node biopsy; SSG, split-thickness skin graft; ST, specialist training, ie, plastic surgery residency/training period; TBSA, total body surface area; TRAM, transverse rectus abdominus muscle; UCL, ulnar collateral ligament; VAC, vacuum-assisted closure.

required of the surgical trainee. Each topic within a stage has a competence level ascribed to it. For "knowledge," this ranges from 1 to 4, indicating the depth of knowledge required, whereby 1 is minimal and 4 is maximum (1 = knows of, 2 = knows basic concepts, 3 = knows generally, and 4 = knows specifically and broadly). As can be seen, this resonates with the principles of Miller's pyramid.

For the purposes of assessment at the end of the Intermediate Years period (ie, ST6), the level of competency deemed appropriate is level 3 (ie, 3 out of 4) for the specified Technical Competences and Procedures, and level 4 (ie, 4 out of 4) for Knowledge and Clinical Skills. The ACGME milestones describe performance levels residents and fellows are expected to demonstrate for skills, knowledge, and behaviors in the 6 clinical competency domains.[7,33] These 6 competences are: patient care; medical knowledge; practice-based learning and improvement; interpersonal and communication skills; professionalism; and systems-based practice. Each competency is made up of different milestones trainees are required to master at key stages of their medical training. They describe the learning trajectory within a subcompetency that takes residents or fellows from a beginner in the specialty or subspecialty, to a highly proficient practitioner.[7,33] The ACGME system adopts 5 levels to grade trainees (versus 4 in the ISCP/UK system), where levels 1 to 4 are comparable and virtually identical. Level 4 is a graduation target but not a requirement in the ACGME milestone setting, whereby level 5 (only present in the ACGME grading system) is set for trainees who have surpassed the residency requirements (and only a few exceptional residents achieve this level per se). Table 2 therefore also resonates with the ACGME PSMP. There is growing evidence that competency-based surgical education is this century's Flexnerian revolution.[58,59] By the objective, subjective, and global assessment of competence, it is hoped that trainees can be more effectively and efficiently be trained, improving the care they provide to patients and the public, while establishing a lasting model of lifelong, self-motivated learning.[58,59]

Oregon Health and Science University[4] began to adopt the Dreyfus model of clinical skills acquisition in the evaluation and assessment of their trainees in vascular surgery, based on established educational theory.[4] Institutional proficiency levels for each stage were determined, and resident performance measured against these. Assessments were undertaken to inform feedback so that lack of progression allows for early intervention to optimize training, depending on when a trainee lies in their ZPD and Dreyfus level of competence.[3] In Table 3, we propose an example of how this could be applied in plastic surgery, in line with curricula goals from the ISCP in the United Kingdom, but which could be extrapolated into plastic surgery curricula internationally in line with their respective syllabi. The aim is to better explain how training goals are set, based on the coalescing of theories described in this article. It must be noted, however, that success requires dedication and unparalleled commitment and reflection.[60]

CONCLUSIONS

Educational theory may predict how practical skills teaching and learning in contemporary plastic surgery training can be effective. The constructivist theory is an umbrella under which many models share common ground, highlighting the importance of the learner-facilitator interaction, motivation, reflection and deliberate practice during the learning process, all of which are necessary to become an expert plastic surgeon. It is interesting how classical theory is also applicable to the modern-day training of a surgeon. Plastic surgery training is continually evolving in response to the needs of society and surgical innovation. It is hoped that the new approaches to plastic surgery practical skills teaching and learning are designed and implemented on a background of educational theory principles, allowing us to optimize the training of the next generation of plastic surgeons, with expert performance as our benchmark.

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