4 Enabling Lifelong Learning and Team Skills to Support Arthroscopic Performance

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Now, here, you see, it takes all the running you can do, to keep in the same place – The Red Queen

Take-Home Messages

- The integration of medical knowledge, team skills and psychomotor skills is a prerequisite for high-quality operating room performance.
- Arthroscopic surgeons need to possess knowledge acquisition skills to support lifelong learning.
- Well-designed and implemented digital learning tools can support lifelong arthroscopy learning.
- Cognitive apprenticeship offers a holistic training approach well suited to prepare the resident for continued learning in the operating room

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4.1 Definitions

Learning We offer the following definition of learning: an increase in behavioural repertoire or knowledge, resulting from personal experience or transmission of knowledge.

Education When people learn in conditions that are created to optimise and to standardise learning, this is called education.

Metacognition is the ability to recognise one's need for additional learning and training, to seek out opportunities for such learning and to critically reflect on one's progress towards self-set learning goals (Paris and Winograd 1990).

Crew resource management entails a set of training procedures for use in environments where human error can have devastating effects.

4.2 Introduction

As outlined in previous chapters, arthroscopic skills training is increasingly moving away from the operating room, due to patient safety concerns, the need to increase training efficiency and the need to limit costs (Dawson and Kaufman 1998). However, psychomotor arthroscopic skills need to be complemented with team skills and a relevant body of arthroscopic knowledge, before the resident can start integrating knowledge *and* skills in the operating room (Georgoulis and Randelli 2011).

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In this chapter, we will first discuss learning and the requirements for designing a successful knowledge course based on state-of-the-art digital technology. Subsequently, we will discuss team skills such as crew resource management (CRM), communication skills, leadership and situation awareness and how to train such skills using simulation.

4.2.1 Learning and Education

Early paradigms in education emphasised producing desired behaviour by reward and punishment or viewed people as analytical, information processing entities that can be trained to apply conditional rules to situations (Omrod and Davis 2004). Recognition that people are individual, intentional agents (Jonassen 1999), the currently predominant educational paradigm of constructivism has spawned a number of approaches that build on and go beyond these earlier paradigms.

Constructivism is the umbrella term that covers most contemporary approaches to education and educational research. It emphasises learning in a 'realistic' environment, the need to engage trainee motivation and the student's capacity to self-direct learning. Constructivist approaches relevant to the aims of this chapter are problem-based learning (Hmelo-Silver 2004), lifelong learning (Merriam et al. 2012) and cognitive apprenticeship (Brown et al. 1989).

4.2.2 Problem-Based Learning

Classical classroom education has a tendency to create 'hurdlers', students for whom passing a series of pass or fail tests is driving learning (Amrein and Berliner 2002). There is a discrepancy between such short-term goals and the patient-centred goals we want our professionals to adopt. Problem-based learning aims to alleviate this problem by providing trainees with learning materials based on real-world cases (Omrod and Davis 2004). In this way, knowledge can be gained in a patient-based learning framework. Students work in groups and have to develop both problem-solving strategies and content knowledge. The educator takes on the role of facilitator in this approach. Rather than training courses culminating in pieces of paper with grades on them, students develop a portfolio to document their experience and skills.

4.2.3 Metacognition for Lifelong Learning

In arthroscopy as in most fields of medicine, knowledge, technology and procedures are changing with increasing speed. The modern professional cannot expect to learn once and perform ever after. Arthroscopic surgeons need to learn how to be lifelong trainees in order to stay up to date and remain competitive in an increasingly consumer-driven marketplace. Implementing problem-based learning early in the curriculum can ease the transition from learning in an educational setting to lifelong learning.

After initial knowledge is gained, modern professionals need to make the transition to becoming lifelong learners. This is contingent upon the trainee developing metacognition (Paris and Winograd 1990). Lifelong learning is recognised by amongst others the European Union as a prime directive in maintaining a flexible workforce (Commission of the European Communities 2007). It is also part of the suggested guidelines for the practice of arthroscopic surgery as outlined by the Committee on Ethics and Standards and the Board of Directors of the Arthroscopy Association of North America (2008).

Simulation training is well suited to help develop metacognition, as it isolates critical aspects of professional practice and provides the trainee with objective and quantified feedback (Chaps. 6, 7, 9, and 11). This helps students to keep track of their progress towards learning and training goals and stimulates critical reflection (Paris and Winograd 1990). However, lifelong learning goes beyond training practical skills and needs to include knowledge goals to make sure practical skills are applied appropriately. This is a broad area, which ranges from the statistical knowledge necessary to identify best treatment options for a specific patient's pathology (evidence-based medicine) to refresher/advanced courses in anatomy, pathology, arthroscopy, etc. E-learning can be used to provide the lifelong learner with this extra knowledge on an as-needed, just-in-time basis and can be used for assessment as well.

4.3 E-Learning Design

The independence digital media allows from the classroom to makes it easy and attractive to implement problem-based learning and life-long lifelong learning strategies in the workplace (Obdeijn et al. 2014). The trainee is flexible in selecting time and place to engage in learning on an as-needed basis. Formative assessment (intended to provide feedback to the trainee) is easily implemented in such environments. Summative assessment (is the trainee well enough equipped to practise this or that procedure) is harder to implement, given the lack of control this flexibility brings along.

Afforded by the everyday use of networked computers, the flexibility, efficiency and effectiveness of e-learning have caused this to be a booming field since the late 1990s. However, developing e-learning is an involved process that includes developing learning goals, training course design, assessment, usability testing and creating appropriate multimedia illustrations. A full treatment of this field is outside the scope of this chapter, and the reader is referred to standard works on this subject, such as Clark and Mayer (2011) and Horton (2011). In the following section, nine instructional design principles are discussed to keep in mind when developing e-learning and training programmes in general.

4.3.1 Gagne's Instructional Design Principles

Gagne's work was very important for the development of instructions in the military. For example, during World War II, many technicians and pilots needed training of highly complex tasks. By implementing a systematic approach to training, *farm boys transformed into airplane mechanics in 30 days instead of 2 years*. Gagne identified

1. Gaining attention of the trainee. This is, for example, done by a demonstration of something that can go wrong in the actual worlds: This is a problem in the real operating room; therefore, training outside the operating room is necessary.
2. Inform the trainee about the objectives of the course/lesson. These objectives will help the trainee to organise their thoughts around what they are about to see, hear and/or do. Schaafsma and coworkers (2009) investigated what has been learned after a basic laparoscopic skill training and concluded that it is crucial that training objectives are clear prior to a course for both the expert and the trainee; otherwise, some important skill or knowledge might not be acquired.
3. Stimulating recalling of prior knowledge. This can make trainees build on their personal experience and previous knowledge and skills.
4. Present the material in an organised and meaningful way and divide it into familiar manageable units.
5. Provide guidance for learning. This can be giving by examples, non-examples, case studies, graphical representations, mnemonics and analogies.
6. Elicit performance. Allow the trainee to do something with the newly acquired behaviour, skills or knowledge. Repetition increases the likelihood of retention.
7. Provide specific and immediate feedback. Studies carried out in (simulated) operative settings suggested indeed that knowledge on their performance given in a systematic manner enhances training (Harewood et al. 2008; O'Connor et al. 2008).
8. Assess performance to determine if the lesson has been learned.
9. Enhance retention and transfer. Inform the trainee about similar problem situations, provide additional practice, put the trainee in a transfer situation and review the lesson (Gagne 1965).

nine events that activate processes needed for effective learning (Gagne 1965):

4.3.2 Examples of E-Learning Courses in Arthroscopy

Simulation training for surgical procedures is increasingly seen as an essential component of the curriculum. In the UK, compulsory simulation training is for the first time being introduced into the curriculum by the regulator, the General Medical Council. It is almost certain that this trend will continue.

Any practical procedure can be broken down into its component parts using the technique of hierarchical task analysis. Those components that cause difficulty for trainees can be identified. The arthroscopic skills involved can be divided into *cognitive* and *haptic*. The cognitive aspects could be trained with an online simulator, where the programme is held on a central server and where the simulator addresses those aspects of a surgical task that do not require a complex end user controller. The concept of a *cognitive trainer* for arthroscopy of the knee was explored by the Royal College of Surgeons of England in collaboration with Primal Pictures. This resulted in the pilot VATMAS simulator, which was built on earlier work on the VE-KATS simulator (Fig. 4.1) (Sherman et al. 2001). This tutorial-based simulator uses a simple and cheap interface to address the cognitive *non-haptic* components of arthroscopic knee surgery (Hurmusiadis et al. 2011).

An *overview* can be provided if the trainee became disorientated (Fig. 4.1). Additionally, the VATMAS simulator can take the trainee through a series of tutorials, whilst providing automated feedback based on time, accuracy and efficiency. From any point, images or videos from real arthroscopies can be called up. Finally, the arthroscope and probe can be independently manipulated with indication of contact with hard and soft surfaces.

Another example of development of an e-learning module was recently presented by Obeijn and coworkers who focused on wrist arthroscopy (Obdeijn et al. 2014). The need for such a module was assessed by questioning the members of the European Wrist Arthroscopy Society (EWAS). The e-learning module consisted of seven topics important for wrist arthroscopy: indications, patient positioning, traction, instruments, portals, entry procedure and radio-carpal anatomy. The e-learning module did not show learning enhancement in a randomised controlled trial with 28 medical students. However, the participants did find the module more pleasant to use, and its content is fully supported by a panel of experts. This module is a typical example of a flexible easy to engage and delivered as needed to support lifelong learning.

4.4 Team Skills

Besides psychomotor skills, up-to-date knowledge and knowledge acquisition skills, team skills are the third essential component for the arthroscopic surgeon. Since the ground-breaking report *To Err Is Human* (Kohn et al. 2000), we know that many medical errors are not errors of judgement or skill, but instead are caused by ineffective team cooperation and communication. Crew resource management (CRM) skills, which include communication skills, leadership skills and situation awareness, need to be trained to ensure safety in the operating room. How these skills after initial training can be further monitored in the operating room is covered in Chap. 14. We will continue with a discussion of CRM, communication, leadership and situation awareness.

4.4.1 Crew Resource Management

CRM is an approach borrowed from the airline industry but increasingly applied to the medical domain. Crew resource management entails a set of training procedures for use in environments where human error can have devastating effects. It encompasses a wide range of knowledge, skills and attitudes including interpersonal communications, situational awareness, problem-solving, decision-making, leadership and teamwork.

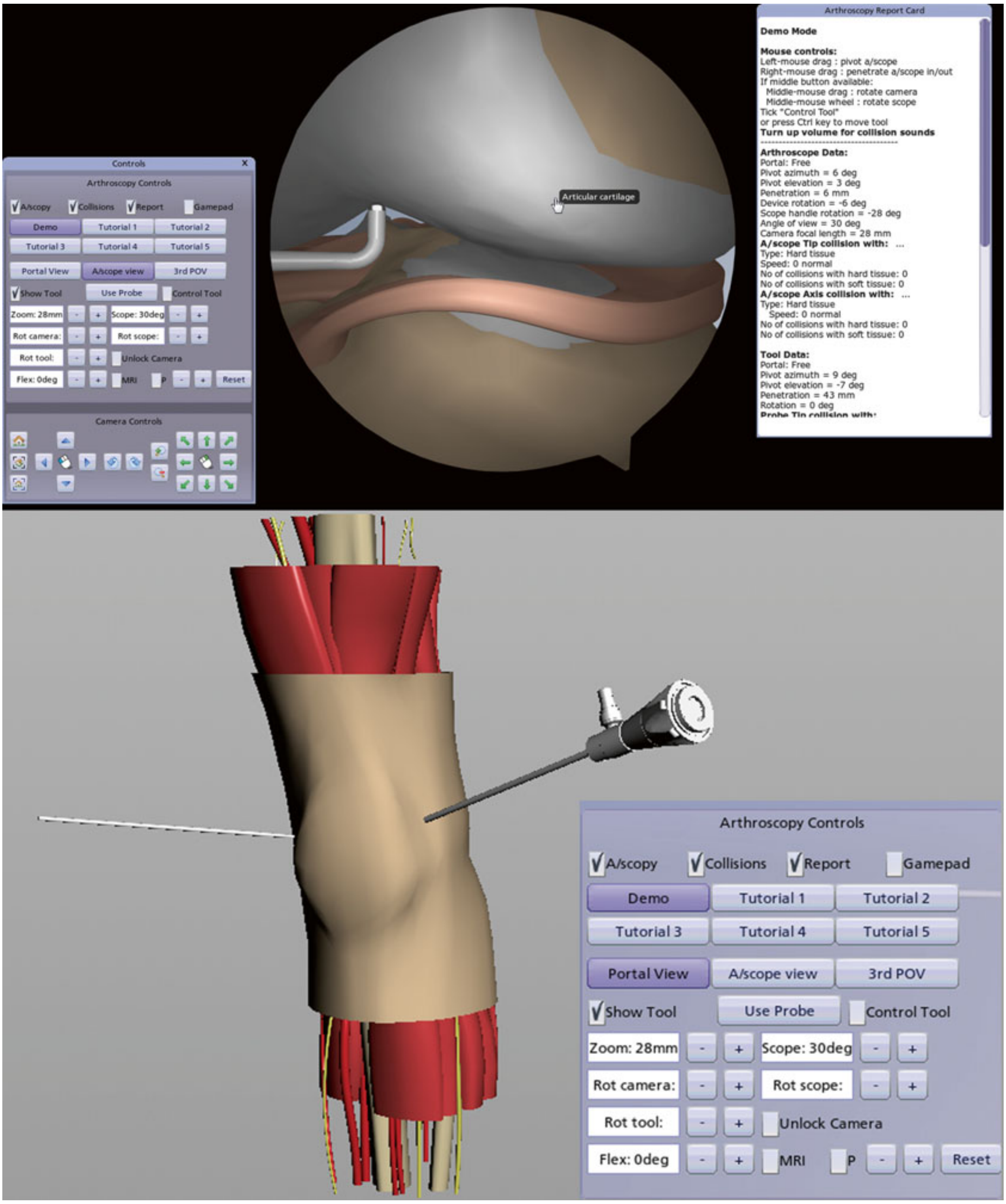

Fig. 4.1 Screenshot of VATMAS online simulator and screenshot of Epicardio simulator (© K Sherman, 2014. Reprinted with permission)

CRM is a management system using all available resources – equipment, procedures and people – in an optimal way to promote safety and enhance the efficiency of operations. Examples from the medical field are to indicate the importance and effectiveness of team training.

Grogan and coworkers (2004) implemented an 8 h CRM training course and the participants indicated that it improves attitudes towards fatigue management, team building, communication, recognising adverse events, team decision-making and performance feedback. Participants indicated that CRM training will reduce errors and improve patient safety. Neily and coworkers (2010) showed that team training reduces surgical mortality with 18 %.

France and coworkers (2008) performed direct observational analyses on 30 surgical teams and evaluated surgical team compliance with integrated safety and CRM practices after extensive CRM training. They found that the observed surgical teams were compliant with only 60 % of the CRM and perioperative safety practices emphasised in the training programme. The results highlight the challenge to adapt CRM from aviation to medicine. Although several organisations offer CRM training to health care professionals, CRM training is currently not yet part of standard education.

Operating room assistants and anaesthesiology personnel already have implemented such training; however, this is lagging behind somewhat in the surgical specialities. Disconnection in perception of teamwork in the operating room was reported previously by Sexton and coworkers (2000), who studied 1,033 operating room personnel (surgeons, anaesthesiologists, surgical residents, anaesthesia residents, surgical nurses and anaesthesia nurses). A majority of surgical residents (73 %) and surgeons (64 %) reported high levels of teamwork, but only 39 % of anaesthesiologists, 28 % of surgical nurses, 25 % of anaesthesia nurses and 10 % of anaesthesia residents reported high levels of teamwork. So in this area, there is much to gain.

4.4.2 Communication

Failure in communication has been identified as one of main contributing factors in adverse events (Kohn et al. 2000). Gawande and coworkers (2003) reported that after interviewing surgeons, 43 % of adverse events were a direct result of communication failures. Lingard and coworkers (2004) found 129 communication failures during 421 analysed relevant communication events (~30 %). They classified the communications into four different types: (1) occasion (45.7 %), in which timing of an exchange was requested or provided too late to be useful; (2) content (35.7 %), in which information was missing or inaccurate; (3) purpose (24.0 %), in which issues were not resolved; and (4) audience (20.9 %), in which key individuals were excluded. In 36 % of these communication failures, visible effects on system processes were found, such as inefficiency, team tension, resource waste, workaround, delay, patient inconvenience and procedural error. They indicated that these weaknesses in communication in the operating room may derive from a lack of standardisation and team integration.

Principles of crew resource management techniques can be applied to the operating room to improve communication. Awad and coworkers (2005) showed that medical team training using crew resource management along with the use of a change team can improve communication in the operating room through the use of preoperative briefings. Perceptions of communication between anaesthesia and surgery were improved significantly.

4.4.3 Leadership

Leadership in surgery entails professionalism, technical competence, motivation, innovation, teamwork, communication skills, decision-making, business acumen, emotional competence, resilience and effective teaching. Leadership skills can be developed through experience, observation and education using a framework including mentoring, coaching, networking, stretch assignments, action learning and feedback (Patel et al. 2010). Leadership is not formally taught at any level in surgical training; there are no mandatory leadership courses or qualifications for trainees or specialists, and leadership performance is rarely evaluated within surgical appraisal or assessment programmes. Therefore, it is imperative that leadership programmes are implemented in medical education curriculum and postgraduate surgical training (Patel et al. 2010).

4.4.4 Situation Awareness

Situation awareness (SA) is the perception of elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future. It involves being aware of what is happening in the vicinity, in order to understand how information, events and one's own actions will impact goals and objectives, both immediately and in the near future (Endsley 1995). Hogan and coworkers developed a novel assessment technique for practical trauma education and used the human patient simulator available in trauma education. Hogan used the Situation Awareness Global Assessment Technique (SAGAT) which has been widely used in other fields interested in performance in intense, dynamic situations and found it to be a valid, reliable measure of situation awareness (Hogan et al. 2006). They showed that information provided by SAGAT could provide specific feedback, direct individualised teaching and support curriculum change.

4.4.5 Simulation Training for Team Skills

Paige and coworkers (2009) measured the effect after all general surgical operating room team members at an academic affiliated medical centre underwent scenario-based training using a mobile mock operating room. They found that high-fidelity, simulation-based operating room team training at the point of care positively impacts 4 of the 16 items rated. They found that it improves self-efficacy for effective teamwork performance in everyday practice. Undre and coworkers found that multidisciplinary simulation-based team training is feasible (Undre et al. 2007). The differences in performance found indicate where there is a need for further training. The training was well received by surgical teams. They used human observers to assess non-technical skills. Issues that still need attention are the team performance measures for training: what to assess and how to assess. Furthermore, the development and evaluation of systematic training for technical and non-technical skills to enhance team performance are still in an early stage of development.

4.4.6 Integration of Skills and Knowledge

The independence digital media allows from the classroom to makes it easy and attractive to implement problem-based learning and lifelong learning strategies in the workplace (Obdeijn et al. 2014). Knowledge acquisition, procedural/technical skills training and team skills training have different requirements and are practised in different settings. For example, e-learning-based knowledge acquisition can be flexibly scheduled and private, whereas team skills training is bound to a specific setting and requires coordinating multiple participants. Before the resident is ready to continue training in the operating room, these different skills need to be integrated. Cognitive apprenticeship provides an approach to do just that.

4.4.7 Cognitive Apprenticeship

Cognitive apprenticeship takes into account that learned skills are performed in a specific professional context, and since many performance rules may be implicit in such an environment, training should be located in a similar context (Brown et al. 1989). Also, expert performance is often automated to a degree that an expert will find it

Modelling: This involves the expert performing the skill so that the trainee can observe and build a conceptual model of the processes required to accomplish it.

Coaching: Here, the expert observes the trainee perform the skill and offers hints, feedback, reminders and perhaps further modelling – aimed at bringing the trainee's performance closer to that of the expert.

Scaffolding: Learning is supported according to current skill level, and activities are organised to assist the trainee to progress to the next level. Support is gradually removed (fading) until the trainee is able to accomplish the skill alone.

Articulation: This involves any method of assisting the trainee to articulate their knowledge, reasoning, or problem-solving processes, e.g. questioning, explaining what they are doing and why they do it that way.

Reflection: Enabling the trainee to be critical of their own performance and problem-solving processes and to compare these with those of an expert, another trainee and, ultimately, an internal cognitive model of expertise.

Exploration: This involves pushing students into a mode of problem-solving on their own – critical if trainees are to adapt to new problems in the real world.

hard to formulate important performance principles. In contrast to traditional master-apprentice training, cognitive apprenticeship aims to structure learning in such a way that implicit rules and performance aspects are made explicit. To create a learning environment based on cognitive apprenticeship principles, the following six techniques need to be applied (Collins et al. as quoted in Woolley and Jarvis (2007)):

By explicitly aiming to simulate the whole professional context (including practical skills, knowledge and team skills), and by its structured, analytical approach to build towards competency by integrating these diverse subskills, cognitive apprenticeship is well suited to prepare the resident for the transition to continued training in the operating room.

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