Simulation in Surgical Education: Lessons Learned from a Multi-Site Randomised Cohort Study.

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ABSTRACT

Background

Surgical proficiency requires expertise in both technical and non-technical (interpersonal) skills. Simulation-based education (SBE) provides a useful adjunct to traditional training methods. Studies show SBE to be effective for the development of both technical and non-technical skills, however the best format for delivery of this training is not yet well understood.

The purpose of the primary research detailed in this thesis was to determine the best format for the delivery of simulated laparoscopic skills training by investigating the efficacy and feasibility of a self-scheduled, self-directed skills course. Secondary projects utilised simulated theatre scenarios to assess the non-technical skills of surgeons to determine if level of professional surgical experience has an impact on non-technical skills, and if surgeons respond to harassment of a colleague.

Methods

Surgical and gynaecology trainees, junior doctors and medical students were randomised to undertake either self-directed learning (SDL) only, or a combination of supervised training in a Mobile Simulation Unit (MSU) as well as SDL. Three laparoscopic skills tasks were taught and assessed. Skills data was compared to assess the efficacy of SDL, and whether supervised training in the MSU accelerated skill acquisition. Qualitative pre- and post-course questionnaires were also conducted.

In two separate studies, retrospective analyses of video-recorded simulated theatre scenarios were conducted. Firstly, the non-technical skills of surgical trainees and experienced surgeons were assessed and compared. Secondly, the participants' response to harassment of a colleague (which was part of the scenario) was recorded and analysed, again comparing the response of trainees with that of experienced surgeons.

Results

A total of 207 participants enrolled, with 156 (75.4%) completing assessment requirements. The majority of participants' skill improved, and some were able to reach expert proficiency standards in one or more tasks. In general, skills acquisition was dependent on the number of practice attempts performed, rather than where the training was undertaken. Overall efficacy of SDL was limited by poor practice session attendance. The greatest barrier to attending was lack of available time due to overriding clinical duties. Participants showed a preference for supervised training, scheduled fortnightly, after a shift.

The mean scores of surgeons' non-technical skills initially increased, peaking around the time of Fellowship, before decreasing roughly linearly over time. Harassment of a colleague was not always recognised, and the response from participants varied. The type of response depended on the nature of harassment being perpetrated and the seniority of the participant.

Conclusions

The efficacy of self-scheduled, self-directed laparoscopic skills training is limited by poor training attendance. To improve efficacy and feasibility of SBE, training should be conducted

with a combination of supervised scheduled sessions, and SDL. Greater effort is needed by training providers to implement strategies that enable practice session attendance.

Experienced surgeons are not immune to deficiencies in non-technical skills. Education and training in non-technical skills, including the recognition and management of bullying and harassment, needs to be better incorporated into the surgical training program as well as continuing professional development programs for qualified surgeons.

DECLARATION

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name in any university or tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name for any other degree or diploma in any university or other tertiary institution without prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint award of this degree.

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THESIS

CONTEXTUAL STATEMENT

Like many other high-risk professions, to become proficient in surgery requires expertise in both technical and on-technical (inter-personal) skills. No-longer is the “see one, do one, teach one” apprenticeship model for surgical training adequate on its own. There is a demand for more evidence-based training, and objective, standardised assessments. Although simulation-based education (SBE) is known to provide an effective adjunct to traditional training methods, the optimum format for delivery of this training is not well understood.

Furthermore, widespread implementation of surgical SBE activities has been hindered by a number of financial and logistical factors including establishing and maintaining facilities, employing dedicated educators and technicians, and time constraints when balancing trainees’ clinical duties and education time. Self-directed learning has been proposed as one method to improve training flexibility and limit the costs and staffing issues often associated with fixed-schedule surgical SBE.

The primary research project detailed in this thesis, the Laparoscopic Simulation Skills Program (LSSP), sought to produce a practical simulated laparoscopic skills course that improved the basic psychomotor skills required for laparoscopic surgery, and to determine the best format for delivery of this training to Australian surgical trainees, particularly those in rural and outer metropolitan training hospitals. Employing a comprehensive, mixed-methods study design, and utilising a Mobile Simulation Unit, the efficacy and feasibility of a self-scheduled, self-directed training format was investigated.

Analysis of adverse events within the healthcare system has shown that a large proportion of errors are a result of failures in non-technical skills such as communication, rather than a failure in technical expertise. During two secondary research projects, the non-technical skills of surgical trainees and experienced surgeons were assessed using simulated team theatre scenarios. These studies aimed to determine if level of professional experience impacts on a surgeons’ non-technical skills and reaction to harassment of a colleague, and to determine whether ongoing non-technical skills training should be mandated throughout a surgeons’ career.

CHAPTER 1: COMMENTARY

1.1 Surgical Education

The traditional paradigm of surgical education involves a “see one, do one, teach one” apprenticeship approach, whereby the trainee receives hands-on training with graduated responsibility in the operating theatre and other clinical environments under the guidance of a surgical consultant. Structured surgical training methods were introduced to America in the 1880s by Dr William Halstead, Chief of Surgery at Johns Hopkins Hospital.[1] This model of training, now known as the Halstedian model, placed an increased emphasis on knowledge in the sciences behind surgical practice, not just technical surgical skills acquisition, and it has continued as the basis for surgical education to this day.

However, surgical practice is ever-changing due to advancements in diagnostic and therapeutic technologies. In addition to the challenge of achieving the acquisition of precise technical and clinical skills, surgical trainees and consultants need to deal with growing demands within the healthcare system. There is pressure on surgical teams to improve operating theatre training efficiency due to longer waiting lists (placing additional pressure on the slower-performing trainees) and regulated shorter working hours, which are potentially reducing availability of in-hospital clinical training.[2,] Not to mention the potential legal and ethical debate surrounding novice surgeons practicing on live patients. It could be argued that the actual teaching and assessment of technical surgical skills is one of the least standardised components of surgical education. The need for quality assurance has meant a push towards objective, proficiency-based assessments and training standards.[2]

These challenges have required the development of improved educational strategies to continue the same level of trainee experience while at the same time reducing the burden of training on the patient-based environment. Simulation-based education (SBE) is now widely accepted as an important adjunct to clinical-based training. Simulation laboratories are becoming more common and, with ongoing developments in technology, are taking an ever increasing role within surgical education. Further consideration is needed to determine how best to integrate SBE curricula into the surgical training program.

Laparoscopic Surgery

A new era in surgical practice began in the 1980s with the introduction of laparoscopic or ‘key-hole’ surgery.[3] Laparoscopic surgery involves making small, 5mm to 15mm incisions into the skin and muscles of the abdominal wall, through which laparoscopic ports are inserted. A camera and laparoscopic instruments are placed through the ports and manipulated by the surgeon in order to complete the procedure. The surgeon views the procedure via a monitor that is located separate to the patient.[3]

Laparoscopy has now become the preferred method for performing a number of procedures, including cholecystectomy, appendicectomy, and many gynaecological procedures.[4] Laparoscopic surgery is associated with smaller incisions (and better aesthetics), less wound pain, and often a shorter recovery period.[4] However, laparoscopic technique is especially difficult to learn due lack of tactile feedback, an altered level of depth perception, the need to interpret a three-dimensional space projected onto a two-dimensional screen, and the specialised psychomotor skills required for handling of laparoscopic instruments.[5] These skills are not intuitive and the learning curve can be especially slow in the beginning.

1.2 Simulation Based Education

The Dreyfus model of skill acquisition is centred on the theory that the learner learns best while doing.[6] Simulation-based education (SBE) provides a perfect environment for this to occur. SBE refers to an artificial representation of a real world process to achieve educational goals through experiential learning.[7] In medical terms, the simulation activity replicates clinical scenarios for the purpose of teaching technical or interpersonal skills. Functional medical training models came into play in the eighteenth century in the form of simulated pelvis' and foetus' for Gynaecology and Midwifery training, although other medical demonstration aids are believed to have been used as early as 2500 years ago.[8] Medical simulation seemed to fall out of favour in the early twentieth century,[8] however simulation, especially for surgical training, has experienced a revival in recent decades due improvements in simulation technology coupled with the aforementioned healthcare demands and challenges of laparoscopic surgery.

There are now multiple forms of surgical simulator available ranging from basic synthetic task trainer models (for example latex skin suturing task trainers), to low fidelity laparoscopic box trainers, advanced virtual reality programs, live animal models and human cadavers.[2] All aim to mimic the real patient experience to varying degrees, and allow the trainee to repeat specific technical tasks for the development of co-ordination, equipment handling skills and dexterity.[9]

Simulation laboratories offer a controlled, less intimidating environment for the trainee, especially while at a basic level of skill.[10] During SBE, the focus is on the trainee, rather than the patient. SBE allows the trainee time to familiarise themselves with surgical equipment and to practice their skills at their own pace before being put in the situation of operating on a live patient. Pre-training on a simulator helps minimise risk to patients through operative error, prolonged procedure times and poorer operating room efficacy.[11,12]

Extensive evidence is now available in the literature documenting the validity and efficacy of individual simulators, and the benefits of surgical SBE for the acquisition of both technical and non-technical skills. Several comprehensive systematic reviews of randomised control trials and non-randomised studies have been published in recent years.[10-12] These reviews have shown that skills learned during SBE are transferable to the operating theatre. A number of studies have also shown that that laparoscopic simulator-trained participants made significantly fewer intraoperative errors than those not trained on simulators, an important factor when considering patient safety.[10]

Design of Simulation-Based Curricula

The design of surgical SBE curricula has been based on knowledge gained from the aviation industry and other areas of medical education.[13] There is consensus that successful learning and implementation of SBE relies on a number of key features. These include: distributed practice, deliberate practice, feedback, and proficiency-based practice.[14,15,16]

Distributed Practice

Typically medical and surgical education courses, including SBE activities, have been delivered as intensive, stand-alone weekend or week-long short courses. This is known as massed practice,[15] and while it can be effective, there is a risk that any skills developed during the course can be forgotten if they are not routinely practiced or revised. Distributed practice on the other hand, refers to the process whereby individual training sessions are undertaken for short durations but spread over a sustained period of time.[15] The theory behind distributed practice is that it allows time for consolidation of knowledge and skills between practice sessions.[14] Distributed practice has been shown to improve acquisition and transfer of technical skills learned on a simulator model.[17-19] Studies have also demonstrated distributed practice to assist in retention of skill[20] and the shorter training sessions can prevent mental and physical fatigue.[15]

Deliberate Practice

Conventionally it has been thought that expertise can be reached after sufficient time-based experience.[21] However, it is now known that reaching a level of expertise or skill mastery (that is, superior, reproducible performance) requires life-long dedication to active learning.[21] Deliberate practice builds on the theory of distributed practice for consolidation and refinement of skill. It involves engaging in individualised, intentional and focussed training drills, with well-defined assessment goals, aimed at improving a specific skill set, rather than merely performing endless random repetitions.[16,22]

Feedback

Feedback involves the provision of objective, performance-related information to the learner.[23] It promotes more efficient and effective training, and is an essential element of deliberate practice.[21,22] Corrective feedback from an experienced instructor educator can prevent the development of bad habits, as well as provide problem-solving advice. Feedback can be given concurrently (during the performance of the task) or in summary (immediately after). There is some evidence that summary feedback is superior as learners may begin to rely on prompting from the instructor, or become distracted from the task when feedback is given concurrently.[14,24] Summary feedback has been shown to be superior with regards to skills retention.[24]

Proficiency-Based Practice

It is difficult to assess whether or not sufficient learning has taken place without standardised benchmarks to assess that learning. Traditionally, surgical training programs and short courses have been conducted as "time-served" programs under guidance from experienced surgical supervisors but often with only subjective assessments. Proficiency-based practice involves training to pre-established, expert-derived standards, rather than simply time- or volume-based training.[16,25] This better takes into account the different learning curves for individual trainees, noting that some may take longer to master a task than others. During proficiency based practice, learners must master a skill before progressing or "graduating" to another level or task.

SBE provides a perfect environment for learners to train using the four principles above. Learners can repetitively practice whole or part-tasks, and even simulated procedures, until skills are mastered. Educators can be present to provide structured feedback and potentially create individual learning plans, and assessments can be performed in a risk-free environment.

1.3 Integrated Surgical Simulation. A review of the literature

Despite the evidence for effectiveness of SBE, surgical simulation has been slow to reach widespread use within surgical training programs.[16] Taking into consideration what is known about SBE and the theory of distributed practice, it could be implied that simulation activities that are fully integrated into the surgical curricula would be more successful for skill acquisition.

A literature review was conducted to examine the outcomes of simulated surgical skills curricula that have already been established and that are fully integrated into ongoing surgical training programs. In particular, this review aimed to examine and report on evidence relating to: 1) efficacy for skills acquisition; 2) user (trainee) satisfaction; and 3) effect on patient outcomes. By undertaking this literature review, it was hoped to identify the most appropriate method for delivery of training, the duration required, and the optimal stage of training at which the trainees would receive the maximal skills transfer benefit.

For the purpose of the review, the term *curriculum* refers to "the means and materials with which students will interact for the purpose of achieving identified educational outcomes".[26] Whereas the term training *program* refers to the surgical specialty training in which the trainee is enrolled (for example, General Surgery training program). The review focused on the use of SBE for laparoscopic skills, an essential surgical technique for present day General Surgeons.

Methods

The Cochrane Collaboration, PubMed, EMBASE and CINAHL online databases were searched during May and June 2015. Literature was limited to the following criteria: 1) Published in the English language; 2) Full text available; and 3) Published between 1 January 2005 and 30 June 2015.

The following search terms were used "(*Surg** AND *Simulat**) AND (*educat** OR *train**) AND *laparoscopy*". In order to concentrate the search on evidence surrounding integrated simulation-based skills curricula, rather than simply simulation technologies or simulators, the search was refined with the addition of a combination of the following terms "*curriculum"*, "*course*", or "*program"*. The search returned a total of 904 journal articles from the four databases: The Cochrane Collaboration (32), Pubmed (697), EMBASE (168) CINAHL (7).

All article titles and/or abstracts were reviewed for relevance. Articles were retrieved when the title and/or abstract indicated data relating to an integrated simulation-based surgical skills training curriculum (that is, the simulation must be part of ongoing surgical training program for surgical trainees, and not a stand-alone training course). The article needed to report on training outcomes (such as skills proficiency gained and patient outcomes), or qualitative data such as trainee perspectives regarding the curriculum. Reference lists of the retrieved articles were examined for relevant articles not identified by the electronic database search.

The primary focus of the review was SBE pertaining to General Surgical trainees. The search term *laparoscopy* was used as this is an essential technical skill for General Surgical trainees to master. However, articles were not excluded if the simulation-based skills curriculum was implemented in non-General Surgical programs (for example, Gynaecology or Urology). A total of ten articles reporting on nine different integrated simulated technical skills curricula were identified.[27-36] Only six articles reported on training outcomes[27-30,32] or trainee perspectives[27,31,32] from five curricula. It should be noted that training outcomes from the curriculum described by Stefanidis et al.[27] in their 2008 article were not reported until 2010.[28] Both articles are included in this review. Panait et al[29] report on an advanced laparoscopic skills curriculum that was based on a basic skills curriculum[33] delivered at the same institution. Although the basic curriculum is reported in a 2008 article by the same author, this article did not report on training outcomes, and has been excluded from this review. The included articles and an outline of the simulation curricula are listed in Appendix A.1.

Thee curricula were delivered to General Surgical trainees,[27-29,31] and two to 'Surgical Residents'.[30,32] Four curricula were fully integrated into the training program, with sessions dispersed over the course a training year (usually the first year of training),[29,30,32] or throughout all levels of training.[27,28] One article reported on a 1-month rotation delivering a comprehensive SBE curriculum to first year trainees.[31] Although technically this rotation was not fully integrated into the working week (trainee clinical hours during this rotation are minimal), it has been included in the review as all trainees at that hospital are rotated through the curriculum as part of their first year of training (that is, the curriculum is integrated into the training year, rather than the working week).

Critique

Overall, there was very limited quantitative or qualitative data recorded or reported when discussing the training curricula outcomes. There were also insufficiencies in reporting of the details of the training curricula themselves (for example, total time spent on training over the duration of the curricula,[27,28] or if trainees were formally assessed[31]). For proficiency-based curricula, it was often not reported how much training time was required in order for a trainee to reach proficiency.[27-29]

A degree of skills assessment was undertaken during all curricula, but only four articles reported on these training outcomes.[28-30,32] Although the curriculum reported by Gonzalez et al.[31] required trainees to undertake mock Fundamentals of Laparoscopic Surgery (FLS)[37] examinations, it was not clear if any additional formal skills assessment was performed, or if the mock scores formed part of the trainees' program assessments.

Where reported, the methods for assessment of technical skill were appropriate (pre and post-course testing using pre-determined proficiency levels). Assessments generally used validated assessment tools (for example, FLS assessment methods,[37] automated Virtual Reality Simulator assessments or recognised overall performance scores). Stefanidis et al.[27,28] provided a table of their defined proficiency levels. There was a lack of control groups (who did not undertake the SBE curriculum) to determine if there had been any additional benefit from SBE over and above the skills learned from participating in clinical and theatre-based training alone.

Statistical techniques were adequately documented for analyses undertaken. Statistical significance and p values were reported well. Graphs and tables, where present, were used appropriately to support text. Statistical data could not be pooled due to heterogeneity of training and assessment methods, and data reporting.

The most comprehensive report on training outcomes was published by Fernandez et al.[32] in regards to four years' experience with a training "Boot Camp" delivered to trainees at the beginning of their first year of surgical training. The remaining articles reported on only one academic year. This was generally the first year the curriculum was implemented. In total, 91 trainees took part in the five SBE curricula over a period of 8 years.

Training Outcomes

Technical Skill Acquisition

Only four articles reported on training outcomes in relation to the level of technical skill acquired.[28-30,32] Pre- and post-curriculum assessments were performed. Trainees were compared to pre-defined proficiency scores. All four curricula successfully resulted in significant improvements in skill according to the different assessment methods employed.

The Yale Advanced Laparoscopic Skills Curriculum detailed by Panait et al[29] was shown to be more effective for the senior trainees compared to junior trainees. Better skill improvement in junior trainees correlated with a greater exposure to laparoscopic procedures in the operating room (indicating theatre exposure played a larger role in skill acquisition), whereas technical skill improvement in senior residents was independent to theatre experience, indicating that the improvement in score was a true effect of the SBE curriculum. Trainees were required to complete the integrated Yale Basic Laparoscopic Skills Curriculum prior to beginning the advanced curriculum.[29,33]

Although the curriculum reported by Gonzalez et al.[31] involved subjecting trainees to mock FLS assessments for the purpose of focused feedback, it is not clear whether formal assessments were also undertaken. Performance metrics were not measured for virtual reality or open procedure tasks during this SBE rotation. Trainees undertaking a 9-week 'Boot Camp" undertook cognitive testing in addition to technical skill assessments.[32] Knowledge was found to improve. The cognitive assessment methods used were comparable to national standard assessment tools.

Edelman et al.[30] also performed delayed (skills retention) testing seven to eight months after the conclusion of the 16-week curriculum. They found significant deterioration in technical skill when compared to immediate post-course testing. This was most evident in the more difficult FLS tasks of intra- and extra-corporeal knot tying. The basic skills used for the peg transfer task were retained.[30] Reported training outcomes are outlined in Appendix A.2.

Trainee Perspectives

Trainee perceptions of the curricula were infrequently reported. However; the limited feedback that was described was generally positive. Gonzalez et al.[31] conducted a small qualitative survey at the end of the intensive one month curriculum using a 10-point Likert-scale questionnaire. Responses were strongly positive regarding the overall curriculum experience, resources and facilities available, and confidence developed.[31]

Stefanidis et al.[28] surveyed trainees regarding their motivations for attendance after the introduction of training incentives. Setting performance goals was ranked as having a greater impact on motivation than setting best goals or posting the name of the best performer. Fernandez et al.[32] simply reported feedback regarding the training had been "overwhelmingly positive".

Patient Outcomes

Not one article reported on the effect the SBE curricula had on clinical practice, operating room efficiency or patient outcomes.

Discussion

The use of simulators for the acquisition of laparoscopic skills is known to be effective, but delivery of simulation-based training is a complex undertaking. Learning theory indicates that trainees should have ongoing, repeated access to the simulation training in order to be able to practice their skills in a deliberate and distributed manner. Integrated courses that are incorporated into the regular working week are, in principle, the ideal format for delivery of SBE.

A search of the literature over a 10-year period to 2015 recovered objective outcomes data from only five integrated simulated laparoscopic skills curricula. The majority of curricula identified in this literature search comply with the theory of distributed practice.[28-30] Perhaps the best example of a distributed practice curriculum is reported by Stefanidis et al (2008 & 2010).[27,28] Trainees were required to undertake weekly training sessions until a level proficiency was achieved, after which the sessions were spread out to a monthly schedule. Trainee performance was monitored closely and training session frequency was increased back to weekly if there was any evidence of deterioration in skill.[27,28] The majority of trainees who undertook the included curricula were found to improve in technical skill level. However, the need for skill maintenance should not be neglected. Edelman et al.'s[30] findings of skill deterioration after training cessation have been recorded in a number of other trials investigating efficacy of both low fidelity and virtual reality trainers. Skill decline has been observed at testing undertaken as early as one to six months after training cessation.[20,38,39] These findings demonstrate the need for continuing with maintenance training sessions.

The most appropriate training session duration and frequency required for adequate skills maintenance it still to be determined, however it is likely to depend on the skill set being developed, the type of simulator used, and other training opportunities available in the clinical setting. Research has shown that motor skills begin to fatigue after one to two hours of continual practice.[15] This is likely to be an ideal session length and would be more easily fit within the confines of clinical duties.

An important feature of deliberate practice is being able to receive performance feedback in order for a trainee to develop an individual learning plan. Many virtual reality simulators have in-built metrics analysis programs that can provide feedback to the trainee. This may suffice in the case of basic skills, however, when it comes to more complex tasks and procedural skills, feedback from an experienced educator has been found to be more beneficial than simulator feedback alone.[40-42] The educator can prevent the development of bad habits. Educator feedback was either very limited or not provided in three of the curricula included in this review.[28-30] Multi-modal feedback was given to trainees undertaking the curricula described by Fernandez et al.[32] and Gonzalez et al.,[31] including staggered assessments, video-recordings and debriefing sessions. However, Gonzalez et al.[31] did not report on subsequent skills outcomes. Trainee perspectives regarding the usefulness of any feedback, and their preferences for feedback format in general were not explored in the included studies.

Limitations of the current literature

There are a number of limitations to the literature available regarding integrated simulated laparoscopic skills curricula. Firstly, although numerous laparoscopic SBE curricula have been reported in the peer-reviewed and grey literature, very few have been formally evaluated. There is little published quantitative or qualitative data regarding the efficacy of already established integrated laparoscopic SBE curricula. Most articles identified for inclusion in this review reported on outcomes from only one academic year, and the overall sample size of trainees was small – only 91 trainees in 5 SBE curricula. Results may not be generalisable to other surgical training programs. Indeed, none of the studies are specific to the Australian training environment.

When designing any training curricula, it is important to take into account the needs and preferences of those who will ultimately be undertaking the training. However, trainee perspectives were infrequently and inadequately reported. Furthermore, there was a distinct paucity of data regarding any changes to patient outcomes as a result of implementing the integrated SBE curriculum.

The lack of overall data and the heterogeneity of the curricula described in the above articles restrict the ability to conclusively state their efficacy or feasibility as a means to teach laparoscopic skills on an ongoing basis.

Many questions regarding the delivery SBE still remain unanswered. What is the optimal training duration in order to reach maximal skills acquisition? How frequently should training sessions be undertaken in order acquire skills and prevent skill deterioration? How much supervised or didactic teaching and instructor feedback is required? And most importantly, is an integrated SBE curriculum effective in improving patient safety, surgical outcomes or operating room efficiency?

1.4 Surgical Simulation Training in Australia

Surgical training in Australia and New Zealand is provided by the Royal Australasian College of Surgeons (RACS). The surgical training program, known as Surgical Education and Training (SET), is a four- to seven-year program, depending on the surgical specialty.[43] In Australia, SET trainees are allocated to one of five training regions and rotate at 6-monthly intervals between training hospitals within that region for the duration of their training.[43]

The vast geography and relatively small population of Australia places Australian SET trainees in a unique situation. A trainee may find themselves positioned as the sole trainee within a rural hospital, hundreds of kilometres away from a large metropolitan city.[44] Any existing barriers to accessing SBE are amplified by distance.[45,46] It is not financially or logistically feasible for each individual hospital to establish a simulation laboratory on site, regardless of the benefits that SBE may yield. It is also not feasible for a rural trainee to be expected to return to a central, metropolitan simulation centre at regular intervals in order to undertake simulation training. Consequently, formal access to SBE during SET is limited.

In 2012, the Australian Safety and Efficacy Register of New Interventional Procedures – Surgical (ASERNIP-S), a department of RACS, conducted a national survey of SET Trainees and Supervisors from all surgical specialties investigating the availability of and demand for technical skills simulation resources around the country.[47] Surprisingly, 63% of SET trainees and 43% of Supervisors reported they did not have any access to simulation activities at their site of employment.[47] The greatest unmet demand (i.e. the difference between the proportion of respondents who would use an activity if it was available and the proportion who already had access to the activity) for simulation activities was by junior SET trainees for simulation in basic laparoscopic skills,[47] this is despite junior trainees being the most likely group to benefit from such training.

There are a number of SBE short courses available to trainees and already qualified surgeons within Australia. General Surgical SET trainees are required to complete the Australia and New Zealand Surgical Skills Education and Training (ASSET) course in order to progress to their second year of training (SET 2).[48] ASSET is a comprehensive week-long, stand-alone training course teaching in both surgical theory and practical basic surgical skills, including laparoscopic instrument handling. A variety of other SBE technical skills short courses can be accessed through providers other than RACS, however there is currently no national standardised, integrated SBE curriculum available to General Surgical SET trainees.

In 2009, RACS endeavoured to overcome the obstacles of distance and costs associated with training (i.e. building and maintenance of skills centres, employment of trainers etc.) with the purchase a Mercedes Benz Sprinter courier van that was internally remodelled to form a “dry lab” classroom complete with four training stations, each with an LCD television monitor.[47,49] This van, known as the Mobile Simulation Unit (MSU), was based on a successful truck-sized MSU developed in Ireland to provide simulation training to rural Irish surgical trainees.[50] The RACS MSU has now been deployed on several successful simulation training research projects, and has been found to be an effective environment for learning, with no significant difference in training outcomes when compared to a fixed-site simulation centre.[47,49] The vast majority (77%) of SET trainees responding to the 2012 national survey reported that they would be likely to use an MSU if it was available at their site of employment.[47] This resource holds great potential to be able to deliver standardised simulation skills training facilities to all surgical trainees across Australia, regardless of their training location.

1.5 Project Aims and Objectives

While it is now established that SBE can provide an effective adjunct to traditional clinical-based surgical training, it is still to be determined the most beneficial way to integrate SBE into the surgical training program in order to achieve the greatest effect on technical and non-technical skills acquisition, and ultimately lead to improved patient outcomes.

The ideal core components of a good SBE curriculum have been established. Focus must now shift to determining how these components best fit together. It is clear that more definitive research is required regarding the efficacy, feasibility, and outcomes of simulation-based surgical skills curricula that have been integrated into the regular working week.

The primary research project described in this thesis, the Laparoscopic Simulation Skills Program (LSSP), sought to determine the optimum format for delivery of a practical simulated laparoscopic skills course, and to improve access, particularly in rural and outer metropolitan training hospitals. A new format for the delivery of laparoscopic skills training was investigated.

The following aims were achieved by answering the research questions below:

1) **Accelerated skills acquisition**

   To produce a practical simulated laparoscopic skills course for junior doctors and SET trainees that improve the basic psychomotor skills required for laparoscopic surgery.

   - Questions:
     - Is self-directed learning, on its own, an effective method of delivering laparoscopic skills training?
     - To what extent does a period of more formal, supervised training affect skills acquisition?

2) **Optimising training delivery**

   To determine the best format for delivering the simulated laparoscopic skills course at metropolitan, outer metropolitan and rural training hospitals.

   - Questions:
     - Does Mobile Simulation Unit access impact on laparoscopic skills acquisition?
     - Does the course provided meet the needs of trainees (i.e. is it feasible)?
     - What do trainees want in a training course?
     - What are the barriers and motivators for attending training, and how can attendance be facilitated?

1.6 Methods

Study Design and Visitation Schedule

The Laparoscopic Simulation Skills Program (LSSP) was conducted as a multi-site, randomised cohort study. The LSSP was implemented at ten different training hospitals across metropolitan Adelaide (3), rural South Australia (2) and rural western Victoria (5) between June 2015 and November 2016. A total of 17 site visits were conducted, including three visits each to 2 of the metropolitan Adelaide hospitals, two visits each to 1 metropolitan Adelaide and 2 rural Victorian hospitals, and five visits to 5 individual rural hospitals in South Australia (2) and Victoria (3). An outline of the visitation schedule and enrolled participants is shown in Appendix B.1.

Sites were chosen based on Australian Standard Geographical Classification - Remoteness Area (ASGC-RA 2006)[51] and accreditation for the training of SET trainees.[52] Hospital bed numbers[44] were used as an indicator of surgical unit size and therefore an approximate indication of number of eligible participants per site.

Each site visit was conducted over a 4-week period. This duration took into account interstate travel allowances, as well as the dates for trainees' hospital rotations – for example avoiding dates of rotation change-over, while still enabling concurrent site visitations.

Participants

The primary target participants were SET trainees and junior doctors (interns and Resident Medical Officers, also known as RMOs) as advancing their skills early is thought to address the greatest workforce need and provide the greatest benefit. Medical students, International Medical Graduates and trainees from the Royal Australian College of Obstetricians and Gynaecologists (RANZGOC) were also invited to participate.

Individuals were eligible to enrol if they were available for the duration of the MSU visitation week and SDL periods at each hospital site, and if they had not previously undertaken formal training in the skills tasks taught during the project.

Intervention

Randomisation

Participants were randomised, using sealed enveloped methodology, into to two cohorts. To ensure total enrolments between cohorts were similar, an equal number of Cohort 1 and Cohort 2 randomisation envelopes were available at each site.

Cohort 1 was allocated to undertake self-directed learning (SDL) only. Cohort 2 was allocated to a combination of supervised training within the MSU and SDL.

Mobile Simulation Unit

The RACS MSU was deployed to each hospital site for a period of one working week (Monday to Friday), and was open from 9am until 7pm each day. The open times were determined by the most popular training times during previous MSU-based research.[47] Participants were required to present to the MSU for enrolment and randomisation. Upon enrolment, they were given an introduction to the simulators and laparoscopic instruments. The trainers then demonstrated the proper performance of the three laparoscopic skills tasks (described in more detail below).

Participants were given the opportunity to ask questions and clarify technique, before undertaking their baseline assessment, also described below.

Cohort 1 participants had no further access to the MSU or trainers after baseline assessment. Cohort 2 participants, on the other hand, were invited to return to the MSU as much as they liked during the MSU week for further supervised training, and to receive guidance and feedback regarding their technique.

Self-Directed Learning (SDL)

The main training format utilised during the LSSP was self-scheduled SDL. SDL has been proposed as one method to improve training flexibility, as well as limit the costs associated with employing trainers and staffing simulation laboratories.

Simulators were set up within each hospital site and remained on-site for a period of three weeks ("SDL period"). All participants were able to use the simulators for SDL at a time convenient to them. At the conclusion of the 3-week SDL period, the MSU returned to the site for the trainers to undertake final participant assessments.

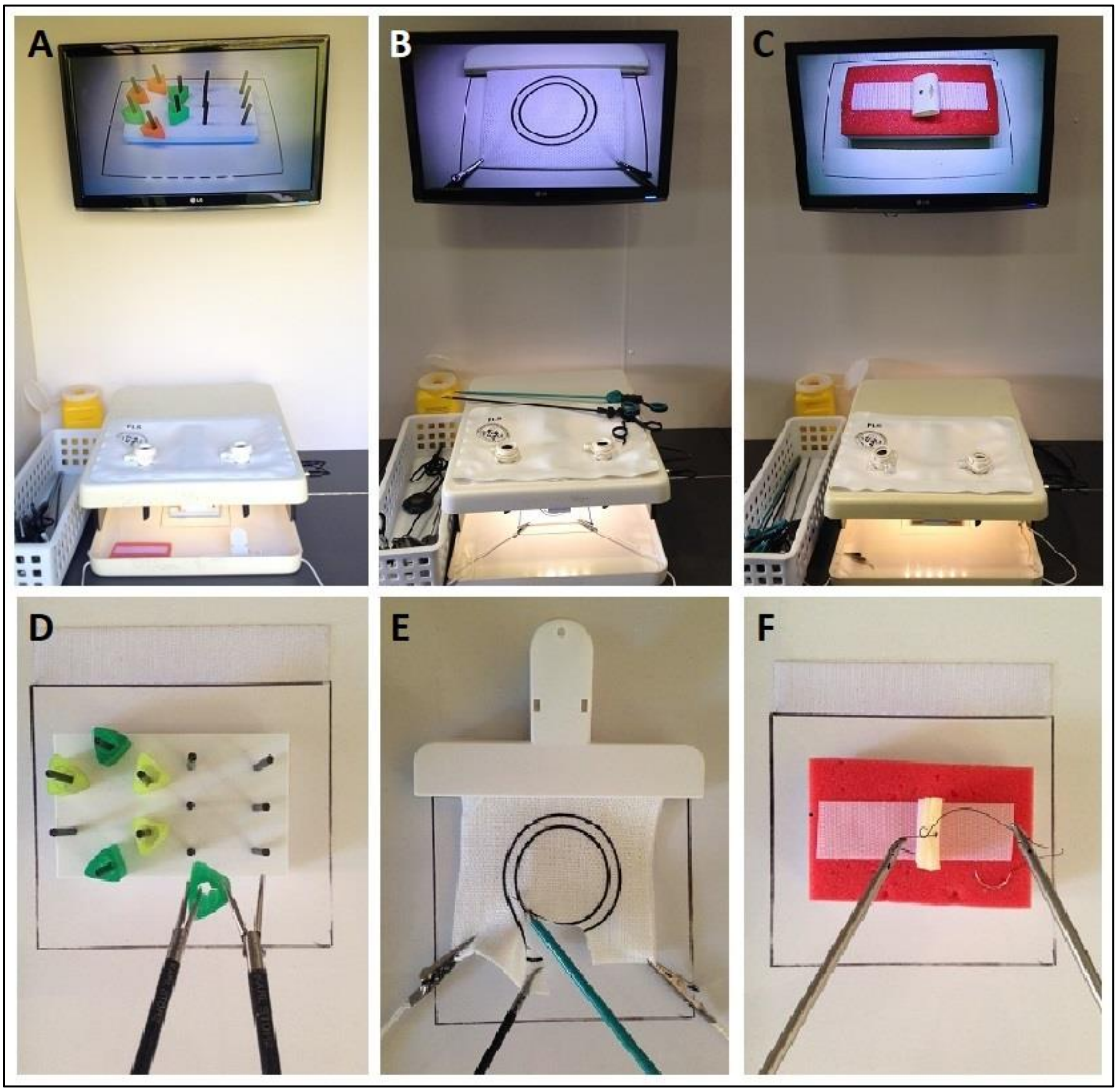
Participants were issued with a training log-book to record training undertaken in the MSU and SDL training periods. They were required to document both the date and duration of any training sessions undertaken, as well as the number of practice attempts they made at each task. These records were used analyse the impact of training in the MSU and SDL periods on participant scores.

Skill Training Tasks

The course utilised simple box-trainer style laparoscopic simulators. These simulators are compact, portable and intuitive. Three tasks from the Fundamentals of Laparoscopic Surgery (FLS) course[37] were taught – Peg Transfer, Pattern Cutting and Intra-Corporeal Knot Tying. The FLS program and tasks are recognised internationally, and are often used in studies investigating laparoscopic skills training. Previous RACS research[47] found these tasks to be the most popular with trainees attending the MSU. The tasks have been developed to teach skills in depth perception, co-ordination, and gross and fine motor control. The three skills tasks are shown in Figure 1, and descriptions of the tasks are outlined below:

1) Peg Transfer
   Using laparoscopic Marylands grapsers, participants were required to lift one of six objects off of a peg-board using their non-dominant hand, transfer it mid-air to a grapser in their dominant hand, and place the object onto a peg on the other side of the board. Once all six items had been transferred, the process was reversed and all objects were returned to their starting side.
2) Pattern Cutting
   Using a grasper and laparoscopic scissors, participants were required to cut on a circular line printed on a piece of gauze that was suspended between clips.
3) Intra-corporeal Knot-Tying
   Participants were required to place a suture precisely through two dots marked on a Penrose (rubber) drain that had been slit. They were then required to tie an intra-corporeal knot, consisting of one double-throw, followed by two single throws. The knot must close the slit in the drain, and each throw must sit square to ensure the knot does not slip.

Figure 1 Simulated Laparoscopic Skills Tasks



The box-trainer laparoscopic simulators within the Mobile Simulation Unit showing the set-up (above) and performance (below) for the three simulated skills task: Peg transfer (A and D); Pattern Cutting (B and E); and Intra-Corporeal Knot-Tying (C and F).

Technical Skills Assessment

Participants' technical skills were assessed at baseline (on enrolment) and at the end of the SDL period. Cohort 2 participants undertook an additional assessment on the Friday of the MSU training week. Assessments were conducted within the MSU and were performed according to the validated FLS task methodology.[37] All assessments were conducted in the same format: the participants were given two practice attempts at the task, before being assessed on their third attempt. Assessments were recorded on hard-copy score sheets and were transcribed into an Excel Spreadsheet on return to the office. The assessment requirements are described in Appendix B.2 and B.3.

Qualitative Data

The project also sought to assess participant and local educator opinions on what they believe makes a successful simulation training program. Participants were required to complete two questionnaires: one at the time of enrolment ("pre-course") and the second after completing their final assessment ("post-course"). The questionnaires were completed within the MSU. The post-course questionnaire was also emailed to any participant who was not able to attend the final assessment.

The pre-course questionnaire asked for basic demographic details, level of surgical experience, current access to SBE activities, and perceived ideas regarding SBE. The post-course questionnaire focussed on perceptions of the LSSP course undertaken, barriers to accessing SBE, and their preferred format for delivery of SBE activities. The majority of questions were in Likert-scale or multiple-choice format. Participants were also given the opportunity to provide free-text feedback.

A questionnaire was also distributed to surgical supervisors and educators involved in the training of junior doctors and SET trainees ("Educator Questionnaire"). This questionnaire was distributed via email by local Surgical Administration and Medical Education staff. See Appendices B.4 – B.6 for copies of the participant and educator questionnaires.

1.7 Hypotheses

- Simulation-based laparoscopic skills training accelerates skills acquisition, and this improvement is greatest in those who undertake supervised training.

- Self-scheduled, self-directed learning improves access to simulation-based education activities.

CHAPTER 2: SIMULATION FOR TECHNICAL SKILLS TRAINING

2.1 Overview

The following subchapters relate to technical skills simulation training and detail the outcomes from the primary research project, the Laparoscopic Simulation Skills Program (LSSP).

Two manuscripts – a systematic review detailing voluntary participation in simulation-based laparoscopic skills training, and an editorial, or ”In Practice Report”, discussing the difficulties faced when recruiting junior doctors for the LSSP – have been published. Outcomes from the LSSP are presented in the remaining subchapters. These subchapters are presented in publication format and are divided according to the theme of the results.

2.2 Systematic Review of Voluntary Participation in Simulation-Based Laparoscopic Skills Training: Motivators and Barriers for Surgical Trainee Attendance.

STATEMENT OF AUTHORSHIP

Title of Paper	Systematic review of voluntary participation in simulation-based laparoscopic skills training: motivators and barriers for surgical trainee attendance.
Publication Status	☒ Published ◯ Accepted for publication ◯ Submitted for publication ◯ Unpublished and unsubmitted work in manuscript style
Publication Details	Gostlow H, Marlow N, Babidge W, Maddern G. Systematic review of voluntary participation in simulation-based laparoscopic skills training: motivators and barriers for surgical trainee attendance. Journal of Surgical Education. 2017;74(2):306-318. doi: 10.1016/j.jsurg.2016.10.007. Accepted 6 October 2016. Published online 8 November 2016. Available at: http://www.jsurged.org/article/S1931-7204(16)30211-2/fulltext

PRINCIPAL AUTHOR

Name of Principal Author	Hannah Gostlow		
Contribution to the Paper	Conception of the work, data acquisition, analysis and interpretation, manuscript writing and critical revision, and acted as corresponding author.		
Overall Percentage (%)	80%		
Certification	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the principal author of this paper.		
Signature		Date	7/1/2018

CO-AUTHOR CONTRIBUTIONS

By signing the Statement of Authorship, each author certifies that:

- the candidate's stated contribution to the publication is accurate (as detailed above);
- permission is granted for the candidate to include the publication in the thesis; and
- the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Nicholas Marlow		
Contribution to the Paper	Supervised conception of the work, data acquisition and interpretation, and manuscript evaluation and critical revision.		
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Contribution to the Paper	Supervised conception of the work, and manuscript evaluation and critical revision.		
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Contribution to the Paper	Supervised conception of the work, and manuscript evaluation and critical revision.		
Signature		Date	8/1/2018

ABSTRACT

Objective

To examine and report on evidence relating to surgical trainees' voluntary participation in simulation-based laparoscopic skills training. Specifically, the underlying motivators, enablers and barriers faced by surgical trainees with regards to attending training sessions on a regular basis.

Design

A systematic search of the literature (PubMed; CINAHL; EMBASE; Cochrane Collaboration) was conducted between May and July 2015. Studies were included on whether they reported on surgical trainee attendance at voluntary, simulation-based laparoscopic skills training sessions, in addition to qualitative data regarding participant's perceived barriers and motivators influencing their decision to attend such training. Factors affecting a trainee's motivation were categorised as either intrinsic (internal) or extrinsic (external).

Results

Two randomised control trials and seven case series' met our inclusion criteria. Included studies were small and generally poor quality. Overall, voluntary simulation-based laparoscopic skills training was not well attended. Intrinsic motivators included clearly defined personal performance goals, and relevance to clinical practice. Extrinsic motivators included clinical responsibilities and available free time, simulator location close to clinical training, and setting obligatory assessments or mandated training sessions. The effect of each of these factors was variable, and largely dependent on the individual trainee. The greatest reported barrier to attending voluntary training was the lack of available free time.

Conclusion

Although data quality is limited, it can be seen that providing unrestricted access to simulator equipment is not effective in motivating surgical trainees to voluntarily participate in simulation-based laparoscopic skills training. To successfully encourage participation, consideration needs to be given to the factors influencing motivation to attend training. Further research, including better designed randomised control trials and large-scale surveys, is required to provide more definitive answers to the degree in which various incentives influence trainees' motivations and actual attendance rates.

ACGME COMPETENCIES

Practice based learning and improvement; Medical knowledge

KEY WORDS

Laparoscopy; Motivation; Self-Directed Learning; Simulation-Based Education; Surgical Education; Voluntary Training.

INTRODUCTION

Altered depth perception, lack of tactile feedback and the need for unique psychomotor skills mean the performance of laparoscopic surgery is not immediately intuitive. During training, operative time is increased, especially in the early stages of a trainee's learning curve. Work-hour restrictions, pressures to increase theatre throughput, and the ethical debate regarding inexperienced surgeons operating on live patients meant that the traditional apprenticeship model of surgical training needed to be revised.

There is now a demand to increase training efficiency, accelerate trainee skill acquisition and ensure competency-based training. Simulation-based education (SBE) can achieve these goals. SBE allows trainees to practice task-specific exercises without risk to patients or themselves. It has been established that SBE improves technical surgical skills, and that skills learned in the simulation laboratory are transferrable to the operating theatre.[11,12] Despite much investigation, the most appropriate way to effectively incorporate SBE into the surgical training curriculum is still yet to be established.

Delivery of SBE can be a labour- and resource-intensive exercise. Costs include hiring of laboratory technicians and educators, and purchase of expensive simulator equipment. The implementation of self-directed simulation training programs, where the individual has responsibility for their own learning activities, has been proposed as one means to limit the staffing costs associated with SBE while still promoting continuing education. When attended on a voluntary basis (i.e., un-rostered training sessions whenever the trainee has free time), self-directed learning has the additional benefit in which trainees can have potentially unlimited access to training outside the confines of scheduled sessions or the availability of training staff.

AIM

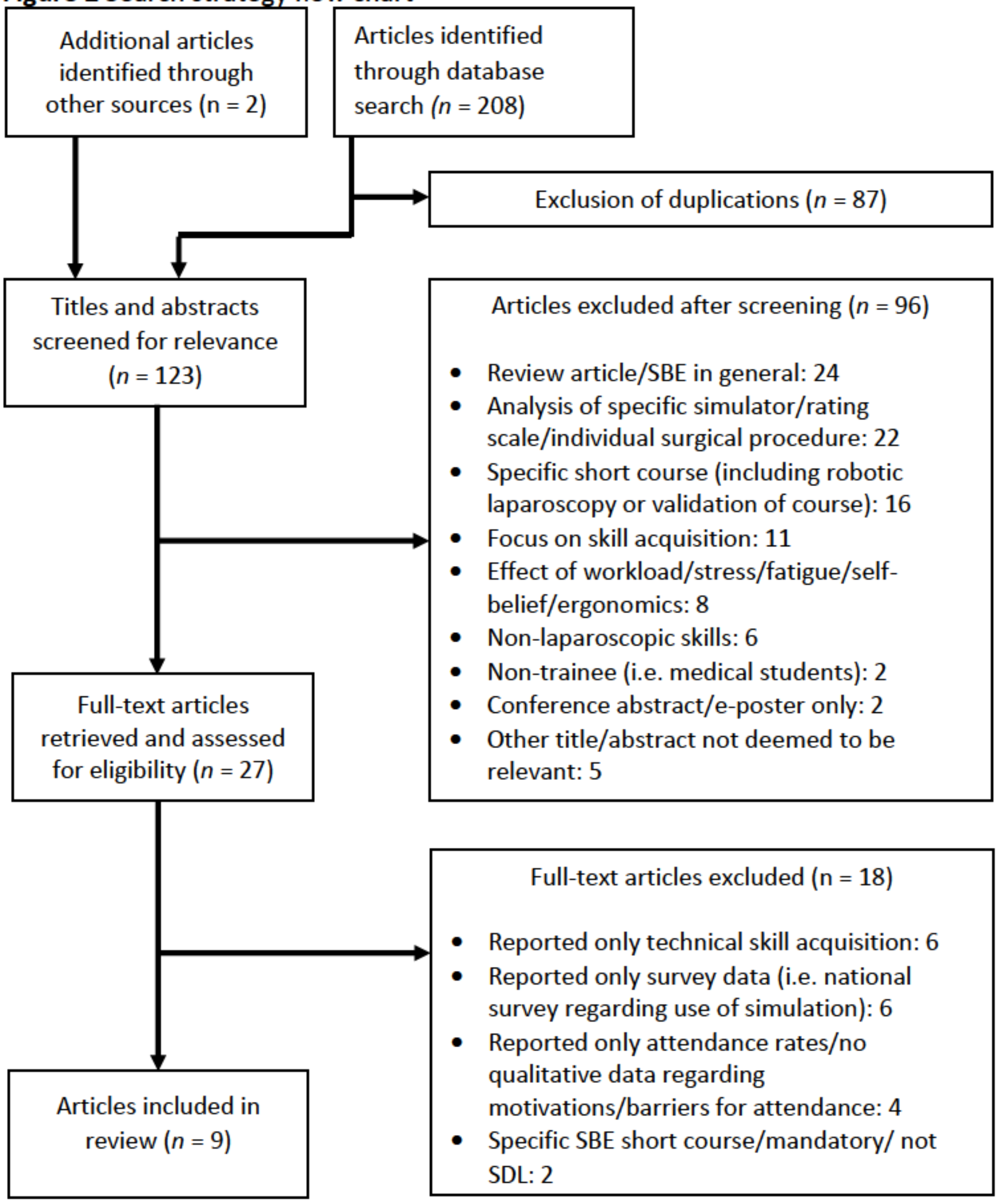
The purpose of this review is to examine and report on evidence relating to surgical trainees' voluntary participation in simulation-based laparoscopic skills training. This review specifically examines the underlying motivators, enablers and barriers faced by surgical trainees with regards to practicing SBE on a regular basis. The results from this review can be used to inform training providers about planning and implementing ongoing SBE activities within the surgical training curriculum.

MATERIALS AND METHODS

Search Strategy

A literature search was conducted (by author H.G.) using PubMed, Cochrane Collaboration, EMBASE and CINAHL online databases during May 2015 to July 2015. Searches were conducted without a language restriction. The core search strategy used the terms "(*educat** OR *train**) AND *simulat** AND *laparosc** AND" with the addition of "*mandatory", "obligatory", "voluntary", "participation", "self-directed"*, or "*motivation"*. Article titles and abstracts were reviewed for relevance. Articles were retrieved when they were judged to possibly meet the inclusion criteria. Reference lists of retrieved articles were also searched to locate any articles that were not identified by the electronic database searches. Two reviewers (authors H.G. and N.M.) then independently applied the inclusion criteria to the retrieved articles. Any differences were resolved by discussion between the two reviewers. See Figure 2 for search strategy flowchart.

Figure 2 Search strategy flow chart



SDL, Self-directed learning; SBE, Simulation-based education

Inclusion Criteria

Articles were included if they investigated the voluntary participation in simulated laparoscopic skills training by surgical trainees. The training simulator needed to be available for use during the regular working week (rather than a stand-alone training course). Included studies had to report on the following: measures of training session attendance (sessions attended, time spent on training, or number of attempts made at training tasks); qualitative data regarding participant's perceived barriers and motivators influencing their decision to attend voluntary training; and suggestions on how to increase attendance.

Articles were excluded if the SBE did not relate to laparoscopic technical skills, if non-surgical participants were enrolled (e.g., medical students only, or Nursing/Allied Health Practitioners), or if attendance rates or qualitative data were not reported.

For the purpose of this review, we defined voluntary training as the provision of SBE at times convenient to the trainee. That is, without formal scheduling or free from penalties for non-attendance.

Data Extraction and Analysis

One reviewer (H.G.) extracted data into data extraction sheets designed for this review and a second reviewer (N.M.) checked the data extraction. Study design and outcome reporting was highly variable. Owing to the heterogeneity of the results, statistical pooling was not possible; however, like outcomes have been grouped narratively in the results. Factors influencing participation were grouped according to whether or not they are intrinsic (internal to the participant, for example personal enjoyment and sense of achievement or purpose) or extrinsic (external influences, for example simulator location, compulsory assessments, or mandated participation). Data extraction and analysis was undertaken in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement.[53]

Details of Included Studies

Nine studies investigating the uptake of voluntary participation in simulated laparoscopic skills training are included in this review.[28,45,46,54-59] Only two randomised control trials (RCT) were identified.[45,54] The remaining studies were case series'.[28,46,55-59]

One RCT compared attendance rates between participants given access to a website promoting trainee collaboration and participants that did not have access to the website.[45] The second RCT investigated the uptake of training between participants using a take-home box trainer compared to participants attending a simulation centre.[54]

Two studies examined participation rates before and after the introduction of training incentives.[28,55] Four studies assessed attendance at training sessions only (no incentives),[46,56-58] and the remaining study was conducted as an inter-hospital competition to assess if "competitive gaming" improved participation.[59] Details of the included studies are outlined in Table 1.

Stefanidis et al.[28] and Seymour[56] scheduled participants to attend regular training sessions with an instructor. Seymour[56] also encouraged participants to attend additional self-directed learning sessions. Although the training sessions in both studies were considered mandatory, no consequences were given for non-attendance. Actual attendance rates were key outcome measures. These two studies are therefore still included in this review. In all other studies, the participants were invited to undertake self-directed training on an individual and voluntary basis.

A total of 241 participants were recruited over the nine studies. Participants included trainees from General Surgery,[28,46,57] Urology,[57] and Gynaecology.[57,58] In addition to surgical trainees, one study also included a number of surgical interns and consultant surgeons.[59]

Study durations ranged from 4 weeks[45] to 12 months.[28] Training curricula differed between studies, however, most of them used either all[28,45,55,57] or part[54,56,58,59] of a pre-existing validated simulation curriculum, implemented according to the requirements of the study. In several instances, modules were allocated to participants according to module difficulty and participant training level (also known as post-graduate year level, or PGY),[46,56] or by adapting the curriculum so that modules had to be performed in a sequence before progressing to the next level.[58,59]

Table 1 Overview of Included Studies

Author & L.O.E[a]	Participants	Training Duration	Simulator & Curriculum	Intervention/ Comparison	Attendance Outcomes	Survey/ Interview
Petrucci et al[45] 2015 Québec, Canada II: RCT	14 'Surgical' Residents 7 Control, 7 Intervention PGY 1-2	4 weeks	Simulator not stated 5 FLS tasks	SDL Comparison between intervention (access to collaborative website with discussion board, emails, reminders, FLS articles, peers' training results) and control groups (no website access)	Self-reported Log book: - Number who attended training - Number of sessions attended - Total training time	Pre-course (10-point scale): - Interest in MIS Post-course (10-point scale): - Motivation to practice/ influences - Barriers to practice (short answer) Perceptions of intervention
Korndorffer et al[54] 2012 New Orleans, USA II: RCT	20 'Surgical' Residents 10 Control 10 Intervention PGY 1-5	60 days Retention testing 60 days later	Control: Stryker laparoscopic video tower on Park Trainer Laparoscopic cart Intervention: Joystick Simscope 2 FLS tasks Assessments: FLS Box Trainer	SDL Comparison of attendance and training outcomes between intervention group (training at home) and control group (simulation centre-trained)	Self-reported Log Book: - Total training time - Number of sessions attended - Number of practice attempts made	Two focus-group interviews (4 weeks post retention testing): - Preconceived ideas regarding training - Strengths/weaknesses of training - Reasons for selecting training times/pattern of training
van Dongen et al[55] 2008 Utrecht, The Netherlands IV: Case Series	22 'Surgical' Residents 7 PGY 1-2 7 PGY 3-4 8 PGY 5-6	8 months 4 months pre- and 4 months post- intervention	Virtual Reality Simulator 9 VR software tasks	SDL Comparison of attendance pre- and post- introduction of training incentives Bi-weekly measure of sessions attended/scores Naming of participant who achieved highest score. Prize awarded	VR recorded attendance and scores: - Number who attended training - Total training time - Preferred training time	Post-course (5-point scale): - Perceptions of: simulation training course, personal skill level, availability of training in theatre, application of VR as a means to teach skills - Reasons for non-attendance - Suggestions to increase attendance

Table 1 continued

Author & L.O.E[a]	**Participants**	**Training Duration**	**Simulator & Curriculum**	**Intervention/ Comparison**	**Attendance Outcomes**	**Survey/ Interview**
Stefanidis et al[28] 2010 North Carolina, USA IV: Case Series	15 General Surgery Residents PGY 1-4	12 months 6 months pre- and 6 months post- intervention	Virtual Reality Simulator (LapMentor) 5 FLS tasks 9 VR software tasks	Weekly 'mandatory' scheduled sessions with additional SDL Comparison of attendance rates pre- and post- introduction of training incentive Public naming of participant who achieved 'best goals' highest score	VR recorded attendance and scores: - Number of sessions attended - Attendance rates at each session - Number of practice attempts made	Survey 5 months post introduction of incentives (20-point scale): - Impact on motivation of: setting performance goals; setting best goals; and naming best performer - Whether or not attendance was due to mandatory nature of course or internal motivations
Seymour[56] 2005 Massachusetts, USA IV: Case Series	21 'Surgical' Residents 10 PGY1-2 11 PGY 3-5	7 months	Virtual Reality Simulator (MIST-VR) PGY 1-2: 3 MIST basic skills tasks PGY 3-5: MIST-VR Core Skills 3 (suturing skills)	Mentored scheduled sessions with additional SDL Measure of attendance at SDL	VR recorded attendance and scores: - Number of sessions attended	Minimal information regarding survey questions
Chang et al[46] 2006 Massachusetts, USA IV: Case Series	29 General Surgery Residents 5 each of PGY 1-5 3 research residents	3 months	Hybrid VR and Physical models (ProMIS) 5 VR software modules Tasks assigned based on PGY	SDL Measure of attendance at SDL	Sign-in sheet: - Number of sessions attended - Preferred training time	Post-Course (4-point scale): - Perceptions of the simulator, and training course - Perceptions on what would increase participation - Reasons for non-attendance

Table 1 continued

van Empel et al[57] 2012 The Netherlands and Belgium IV: Case Series	80 General Surgery, Gynae, Urology residents 'All PGY eligible'	6 weeks	Low fidelity box trainer (LapStar) 'Advanced Suturing Course'	SDL Measure of training attendance for an at-home laparoscopic suturing simulator	30 participants completed a formal logbook: - Total training time - Desired training time - Remainder of participants estimated their practice time	Survey 1 (5-point scale): (80 respondents) - Questions regarding the course, voluntary home practice, availability of training in theatre Survey 2 (3 Open-ended questions): (18 respondents) - Problems when training (own & perceived problems faced by others) - Suggestions to increase participation
Burden et al[58] 2013 Gloucestershire, England IV: Case Series	9 Gynae Residents Junior specialist trainees (ST 1-2)	6 months	Virtual Reality Simulator (LapSim) 9x VR software basic skills tasks 1x VR salpingectomy Tasks performed in order	SDL Measure of attendance at SDL	VR recorded attendance and scores: - Total training time - Preferred training time - Number of practice attempts - Number of training modules completed	Two Focus-group interviews: - Perceptions of the simulator training course - Barriers to access - Suggestions to increase participation
Verdaasdonk et al[59] 2009 The Netherlands IV: Case Series	31 'Surgical' 6 Interns 22 Trainees 3 Surgeons	3 months	Virtual Reality Simulator (Simendo) 3 skills tasks Tasks performed in order	SDL Measure of attendance for SDL using 'competitive gaming' as an incentive Inter-hospital competition with laptop prize	VR recorded attendance and scores: - Total training time - Number of practice attempts	Post-course (10 point scale): - Motivation to learn skills - Reason for participation (for fun, to win, to learn skills, felt obligated)

L.O.E, Level of evidence; RCT, Randomised Controlled Trial; PGY, Post-Graduate Year level; FLS, Fundamentals of Laparoscopic Surgery; SDL, Self-Directed Learning; MIS, Minimally Invasive Surgery; VR, Virtual Reality simulator; ST, Surgical Trainee year level.

[a]Level of evidence based on National Health and Medical Research Council (NHMRC) evidence hierarchy.[60]

Training sessions (attendance or practice attempts) were recorded objectively (if using a virtual reality simulator)[55,58,59] or via self-reporting (e.g. using a logbook or sign-in sheet).[45,46,54,57] Training times were reported as either total time spent training (per individual or group),[45,54,55,57-59] number of training sessions undertaken (per individual or group),[28,45,46,54,56] attendance rates at training sessions,[28] number of attempts made at the tasks (per individual or group),[28,54,58,59] or the number of participants who trained as a proportion of the total number enrolled in the study.[28,45,46,55]

Qualitative survey questions included but were not limited to availability of time to train; relevance of the simulator to their clinical practice; motivations for training; reasons non-attendance; and suggestions on how to improve attendance. Surveys generally involved ranking level of agreement with certain statements on a Lickert or visual analogue scale.[28,45,46,55,59] Semi-structured focus-group interviews were undertaken in two studies.[54,58]

Quality of Included Studies

Overall, the included studies were of poor quality.[60] It was not possible to blind participants for any of the interventions included in the RCTs, and blinding of outcome assessors was not described.[45,54] All studies were small, and the majority were undertaken at a single-institution. Sample sizes varied from 9[58] to 80[57] participants. The largest study suffered loss to follow-up, with less than a quarter of the original participants completing the final survey.[57] Power calculations and statistical significance were often not reported.[45] Details of survey questions were not consistently reported, there was inadequate description of the intervention (e.g., the contents of the survey questions or timing of assessments[56]), and there was inadequate description of some the data being reported.[45,56]

RESULTS

Overall Participation and Attendance

Overall participation in voluntary laparoscopic SBE was poor. Individual participant attendance rates and the number of attempts made at training tasks within each study were also highly variable.[28,45,54,56,58,59] On average, participants only spent between 2 minutes[58] and 65 minutes[45] on training per week. In one study, participants' reported that their average time spent on training (49 minutes per week) was much lower than what they had desired (60 minutes per day).[57] An overview of participation and attendance rates is provided in Table 2.

Attendance was generally better amongst junior compared to senior participants. Seymour[56] reported that junior participants undertook more training sessions each, with one senior participant failing to train at all despite the training being considered "mandatory". Likewise, Change et al.[46] found no senior participants (PGY 4-5) took park in voluntary training after the compulsory simulation introduction session. Contrary to these results, another study reported that attendance was evenly dispersed across all training levels, both before and after the introduction of training incentives, noting that overall attendance in this study was poor (15/22 participants failed to train at all).[55] (See Appendix C.1 for complete table of result for attendance in relation to participant training level).

Table 2 Overall Participation and Attendance

Author	Duration of intervention	Outcome measures	Results	Estimated training time per participant[a]	Interpretation
Petrucci et al[45]	4 weeks C = Control group, W = Website intervention group	Effect of training incentives (collaborative website) on training undertaken Training sessions undertaken Total time spent training	Attended ≥1 training session: - C = 2/7 vs. W = 4/7 participants Number of individual training sessions attended: - C = 4 sessions, mean 2, range 1-3 each - W = 15 sessions, mean 3.75, range 2-6 each Combined total time spent on training: - C = 480min vs. W = 1035min	Estimated average training time per participant over 4 weeks: - C = 240min - W = 258.75min Estimated average training time per participant per week: - C = 60min - W = 64.69min	Limited session attendance and time spent on training High variability between participants Collaborative website had small effect
Korndorffer et al[56]	60 days H = Home-trained, C = Simulation centre-trained	Effect of simulator location on training undertaken Training sessions undertaken Total time spent training Total number task repetitions/attempts made	Combined total time spent on training: - H = 458+/-290min vs. C = 356+/-133min ** Total number practice attempts made: - H = 86+/-35 vs. C = 85+/-34 ** Number of individual training sessions attended: - H = 13+/-7.8 vs. C = 7.2+/-2.7, p<0.05	Estimated average training time per participant per week: - H = 53.44min - C = 41.354min	Limited session attendance and time spent on training Location of SBE (home vs. centre) had minimal effect on total training time Home-trained with shorter but more frequent sessions High variability between participants
Van Dongen et al[55]	8 months 4 months pre and post incentive	Effect training incentives (performance goals) on training undertaken Training sessions undertaken Total time spent training	Participants who attended ≥1 training session: - Pre-Incentive = 2/22 - Post-Incentive = 7/22 Combined total time spent on training: - Pre-incentive = 163min - Post-Incentive = 738min	Estimated average training time per participant over 4 months: - Pre-incentives = 81.5min - Post-incentives = 105.43min Estimated average training time per participant per week: - Pre-incentives = 5.09min - Post-incentives = 6.59min	Negligible time spent on training Training incentive (competition) had minimal effect

Table 2 continued

Author	Duration of intervention	Outcome measures	Results	Estimated training time per participant[a]	Interpretation
Stefanidis et al[28]	12 months 6 months pre- and post-training incentives 'Mandatory' weekly sessions	Effect of training incentives (performance goals) on training undertaken Training sessions undertaken Attendance rates at sessions Total number task repetitions performed	Median weekly scheduled training session attendance rates: - Pre-Incentives = 21% (range 0-54% per session) vs. - Post-incentive = 51% (range 8-96% per session) p<0.001 Participants attended 10.7 +/-6.7 training sessions over the study period An average of 153 repetitions (range 21-412) during study period	N/A	Poor attendance (even though mandatory) High variability between participants Training incentive (competition) had minimal effect
Seymour[56]	7 months 'Mandatory' sessions + SDL	Training sessions undertaken	Training attendance outside of mandatory blocked sessions: - Junior trainees = 10-38 sessions attended - Senior trainees = 3-23 sessions attended Junior residents undertook more training sessions than seniors (18+/-3 vs. 9 +/-2, p<0.01)	N/A	High variability between participants
Chang et al[46]	3 months	Training sessions undertaken	29/51 undertook introductory training session Attended at least 1 training session: 9/29 (31%) = 4 (80%) PGY1, 2 (40%) PGY2, 3 (60%) PGY3, and 0 PGY4-5 participants Completed training curriculum (attended ≥3 sessions in 3 months): 4/29 (14%) = 3x PGY1, 1x PGY2	N/A	Poor attendance

Table 2 continued

Van Empel et al[57]	6 weeks	Total time spent training	97 trainees undertook the Advanced Suturing Course 80 completed the first study survey Total time spent training: - Self-reported (72 responses): average 360min - Formal logbooks (30 participants): average 298.5min (SD=383.1) Actual average total training time (=49.75min/wk) was significantly shorter than the desired average total practice time 1687.6min (SD=1225.9, p<0.05) (=281.3min per week) Total average time practiced between those keeping a log and those who didn't: 405.5min vs. 415.0 min, p = 0.96	Estimated average training time per participant over 6 weeks: - Survey reported = 360min - Logbook recorded = 298.5min Estimated average training time per participant per week: - Survey reported = 60min - Logbook recorded = 49.75min Reported desired training time per participant per <u>*working*</u> week = 4.69hrs Reported desired training time per participant per <u>*day*</u> = 56.25min	Limited time spent on training Trainees did not train as much as they had desired
Burden et al[58]	6 months	Total time spent training Training sessions undertaken Total task repetitions/ attempts made	Total training time per participant: - Median 66min (range 20-140min, mean 53.5min, 95%CI 23-83) Number of failed attempts made on the last module attempted: - Median 18 (range 4-57, mean 17.9, 85%CI 5.3-30.5) 6/9 participants (66.7%, 95%CI 29.9-92.5) completed 6/10 modules No-one completed all modules	Estimated average training time per participant over 6 months: 53.5min Estimated average training time per participant per week: 2.23min	Negligible time spent on training High variability between participants

Table 2 continued

Author	Duration of intervention	Outcome measures	Results	Estimated training time per participant[a]	Interpretation
Verdaasdonk et al[59]	3 months 2 hospitals enrolled late	Total time spent training Total task repetitions/ attempts made	Combined total training time: 79hrs and 20min Total training time per participant: - Median 53min (range 4.4min – 19hr 4.5min) Combined total number of attempts with a final score registered: 777 Total number of task attempts per participant: - Median 6 (range 1-212) - 16/31 (52%) made >1 and <50 attempts - Only 5 made >22 attempts	[b]Estimated average training time per participant over 3 months: 153.55min [b]Estimated average training time per participant per week: 12.79min	Limited (median) time spent on training High variability between participants Training incentive (competition) had variable effect

SDL, Self-Directed Learning; N/A, Not Available; PGY, Post-Graduate Year Level; SD, Standard Deviation; SBE, Simulation-Based Education

** Not statistically significant

[a]Calculation based on reported results, and assumed 4 weeks per month.

[b]Estimation based on all 31 participants having equal access to the simulators for 3 months.

Intrinsic Factors

Preferred hours of training

The simulator equipment was available at all times in five studies,[45,46,54,55,58] out-of-hours (at home) in two studies,[54,57] and only within regular working/office hours in one study.[28]

Between 60% and 70% of participants with unlimited access to simulator equipment preferred to train during regular working hours.[46,58] Van Dongen et al.[55] reported that 58% of training was performed during night shift, however, no details were given for training during day shifts or while off-duty. Participants were not motivated to practice in their free-time.[45] In an RCT comparing home-training with simulation centre-training, the home-trained participants preferred shorter but more frequent training sessions (home group 13 +/- 7.8 sessions vs. centre group 7.2 +/- 2.7, P <0.05) without a significant difference in total training time (home group 458 +/- 290min vs. centre group 356 +/- 133min).[54] Overall, 80% of home-trained participants would avoid training while fatigued, whereas all of the simulation centre-trained participants would still continue to train while fatigued[54] (See Appendix C.2 for complete table of results for preferred hours of training).

Performance goals

Three studies reported the impact of setting performance goals (benchmark standards or proficiency scores to work toward).[28,45,57] Participants in the two studies that set performance goals felt that these goals did motivate them to practice.[28,45] Furthermore, Stefanidis et al.[28] found motivation ratings of setting goals correlated positively with attendance rates (r = 0.75, P <0.01).

In another study, where performance goals were not defined, approximately a quarter of respondents felt that their motivation for training would improve if they were provided with goals (27.7% or 5/18) or if obligatory assessments were implemented (22.2% or 4/18)[57] (See Appendix C.3 for complete table of results for impact of setting performance goals).

Competition and 'competitive gaming'

Three studies deliberately introduced competition with rewards elements to entice trainees to practice.[28,55,59] This was associated with only modest increase in participation rates.

Van Dongen et al.[55] publically named and awarded a prize to the best performing participant and observed a slight increase in the number of participants who attended at least one practice session (increase from 2/22 (9.1%) up to 7/22 (31.8%) participants). Stefanidis et al.[28] found median session attendance rates to increase to 51% (range 8-96%) with the introduction of similar incentives compared to 21% before incentives (range 0-54%) (P <0.001).

More than 50% of participants taking part in the inter-hospital competition created by Verdaasdonk et al.[59] stated that they joined up "in order to win" rather than "for fun", "to learn laparoscopic skills" or because they "felt obliged". The time spent on the simulator and the number of attempts each participant made at the intervention task was still highly variable (range of 1 – 212 attempts made over 4.4min – 19hrs 4.5min of practice time).[59]

Although Petrucci et al.[45] designed their intervention website to promote collaboration, rather than competition, it also notified intervention group participants of their peer's training sessions and best scores. Participants in this study were asked to indicate their level of agreement with several statements on a 10-point Lickert scale (10 = strongly agree). The control group (C) members (without access to peers' training results) were more inclined to feel motivated than intervention group (W) when it came to knowing if their peers were practicing (C = 8.9 +/- 1.2 vs. W = 6.4 +/- 3, P = 0.07), if their peers were achieving higher scores (C = 7.8 +/- 1.7 vs. W = 5.7 +/- 2.9, P = 0.12), or if they would be compared to senior colleagues (C = 7.7 +/- 2.5 vs. W = 5.6 +/- 3.5, P = 0.12). While the intervention group, who did have access to this information, tended to disagree with the statement that they pushed themselves more after seeing the progress of others (4.5 +/- 3)[45] (See Appendix C.4 for complete table of results for impact of competition and competitive gaming).

Personal enjoyment and relevance to training

Overall, participants felt the simulators were easy (71.8 - 96%)[46,56] and enjoyable (95%)[46] to use, and that SBE improved their skills (87% agreed, 13% strongly agreed)[46] and confidence in theatre.[58] In one study, 60% of participants stated it was internal factors that motivated them to practice, rather than the mandatory nature of the course (40%).[28] When asked to rate their level of motivation on a 10-point scale (0 = no motivation, 10 = enormous), trainees participating in the inter-hospital competition conducted by Verdaasdonk et al.[59] stated they were highly motivated to learn laparoscopic skills (median score of 9). Furthermore, Van Empel et al.[57] reported the vast majority (83.3%) of participants felt they did not get enough minimally invasive (laparoscopic) surgery practice without the simulation program.

Motivational barriers to continued practice included fatigue and boredom,[54] as well as frustration due to the inability to complete training modules (and therefore progress through the curriculum).[58] Lack of realism, lack of tactile feedback, and absence of laparoscopic port placement training were problems noted by members of one focus group.[58] Others felt that they were not being given the opportunity in the operating theatre to use the skills they had learned on the simulator[58] (See Appendix C.5 for complete table of results for impact of personal enjoyment and relevance to training).

Extrinsic Factors

Work hour restrictions

Clinical responsibilities and time restrictions were the greatest reported barriers to accessing SBE.[45,54,55,57,58] Participants preferentially spent their time on clinical duties, even when training sessions were considered mandatory.[28,56] Training on a simulator at home, out-of-hours, did not eliminate the impact of lack of available free time.[57] When surveyed, the majority of participants agreed (65% agreed and 31% strongly agreed) with the statement that they would use the simulator more if the working week was shorter.[46] Participants also believed that providing protected training time and incorporating SBE into the working week would increase participation[57,58] (See Appendix C.6 for complete table of results for impact of work hour restrictions).

Simulator location

Locating the simulator within an off-site simulation centre was seen as a barrier to attending training.[45] Similarly, being rostered for an off-site rotation was the main reason for non-attendance (44%) at training when the simulator was located on the main hospital campus.[46] The use of a make-shift simulation laboratory (for example, placing the simulator within an office room in the surgical department) did not impact negatively on motivation to training.[55,58]

Participants appreciated being able to train where it was quiet and away from clinical interruptions.[58]

Participants using a take-home box trainer were neutral when asked if they would prefer practicing in-hours in a skills laboratory rather than out-of-hours at home (31.6% agreed, 38.2% neutral, 30.2% disagree).[57] This is supported by the findings of the RCT by Korndorffer et al.[54] There was no statistically significant difference in total time spent on training between groups using a take-home box trainer after-hours versus simulator centre training in working hours.[54] The author, however, found that the home training participants tended to train more frequently but for a shorter duration[54] (See Appendix C.7 for complete table of results for impact of simulator location).

Educator instruction or feedback

Four studies provided participants with access to experienced Educators during training.[28,46,56,58] In two of these studies, the Educator was available for individual mentoring at any time on request.[46,58] Not one participant requested individual mentoring. Further, 75% of participants in one study felt that educators were not needed,[46] whereas there was divided opinion regarding the importance of educators in another.[58] Only a small proportion (2/22) of participants (who did not have access to an educator) suggested providing coaching along with competitive gaming would increase participation[55] (See Appendix C.8 for complete table of results for effect of educator instruction or feedback).

Mandatory Training and Assessments

Scheduled mentored sessions were "mandatory" in the studies by Stefanidis et al.[28] and Seymour[56]; however, no consequences were given for non-attendance. Median session attendance rates were low (51% (range 8 - 96%)) despite the introduction of training incentives.[28] "Mandatory" training was not effective at increasing participation when there were no penalties applied to those who were non-compliant.[28,46,56]

Results were conflicting when participants were asked whether or not they would train more if the sessions were compulsory. Chang et al.[46] found 64% of participants agreed with this statement, whereas 50.1% of participants in the study by Van Empel et al.[57] disagreed. Although participants in the study by Van Dongen et al.[55] generally disagreed with the statement that they won't train unless it is obligatory (2.26 (standard deviation = 1.10) on a 5-point Lickert scale where 5 = strongly disagree), more than half (15/22) did not train at all when it was voluntary. When asked for suggestions on how to increase participation, 9 of 22 (40.1%) of participants in this study recommended making simulation training mandatory.[55] Mandatory training was also welcomed by many participants in the focus groups held by Burden et al.[58] Other suggestions to increase participation included introducing obligatory assessments or deadlines to complete modules.[46,55,58]

van Empel et al.[57] found the vast majority (76.6%) of participants agreed with the statement that training on a simulator should be obligatory before being allowed to perform in theatre,[57] whereas in another study[55] the participants' opinions were neutral (See Appendix C.9 for complete table of results for impact of mandatory training).

DISCUSSION

Motivation to learn is dependent on both intrinsic (internal) and extrinsic (external) factors.[61,62] Although intrinsic motivating factors are often individual and generally fixed, extrinsic factors can more easily be modified by program directors in order to achieve improved participation in voluntary training.

Personal enjoyment in the educational activity and its perceived relevance to training are strong intrinsic motivators to continue practicing. It is not surprising that the more senior trainees spent less time on training considering the training interventions commonly offered only basic skills tasks. Senior trainees may feel that they are already proficient in these areas and that the training was not relevant to their practice. A skills training curriculum should be tailored to the individual skill level. Chang et al.[46] and Seymour[56] attempted to accommodate senior trainees by dividing the training modules according to difficulty and PGY level, but with little success in improving senior trainees' participation rates. Increasing or varying the level of task difficulty while training has been shown to contribute to motivating residents to continue to practice.[63] Furthermore, Burden at al.[58] found participants became frustrated and de-motivated by being limited to completing the modules in a prescribed order. Self-regulated practice and training in a more distributed pattern has been shown to improve skills retention in the longer term compared to directed, blocked learning.[54,64]

The employment of a simulation educator is another important step in addressing a trainee's perceived lack of relevance of the simulation tasks to their training. The educator can link the simulation tasks back to procedures during the real operating room experience, promoting their relevance, and boosting a trainee's motivation to undertake them. Educators can provide encouragement, which may in turn increase enjoyment and mitigate trainee frustrations. In a previous review of their curriculum, Stefanidis et al.[27] found that participation rates increased from 6% up to 71% with the introduction of a specific simulation educator. Whilst performance feedback can be provided by most virtual reality simulators, individual feedback from an educator is more beneficial than self-feedback or simulator feedback alone.[40,41] Educators can identify areas of weakness, provide structured feedback, and advise techniques on how to improve so that the trainees can practice a task and progressively refine their skills. This is known as Deliberate Practice, and is essential for the achievement of expertise.[21] Mentor-guided self-directed learning was successfully employed in a recent study by Aho et al.[65] Using the principles of Deliberate Practice, participants attended three sessions with a mentor during a 6-week self-directed learning period. All participants reported they had practiced more frequently, and all were able to successfully reach their personal training goals. Educator feedback can also prevent the development of incorrect procedural skills and bad habits (corrective feedback), resulting in a more efficient use of training time and potentially stimulating enthusiasm.[42]

Interestingly, the addition of educator feedback was not highly valued by participants in these studies. Not one participant in the included studies sought individual advice from the educators, despite some participants clearly struggling with the tasks.[58] Burden et al.[58] discussed supervision during the participant focus groups. Participants in one focus group were reluctant to seek help. The reason behind this is not explored in their report. It may be related to fear of embarrassment or pressure to perform in front of their clinical training supervisor. Employing a simulation skills educator separate to the clinical training supervisor may eliminate this problem.

Overall, "competitive gaming" seems to have limited effect. Publically acknowledging the best performing participant was ranked as having a lesser impact on motivation to train than simply setting performance goals.[28] Pre-defined "expert" performance goals are vital in providing trainees with purpose and mastery – important intrinsic motivators for training.[62] Creating competition may have the adverse effect of demotivating poorly performing trainees, and may not take into account differences in trainees' opportunities for practice in the clinical setting. Most virtual reality simulators can measure performance metrics (motion analysis, error scores and time to complete tasks) which can be used to report on individual trainee's progress. Although curriculum proficiency standards should take priority, it is perhaps more beneficial to set performance goals relative to an individual's current skill set.

By far the greatest extrinsic factor influencing voluntary training was the lack of available time. Trainees are ultimately employed in order to provide a clinical service for the hospital. Ward duties, outpatient clinics, theatre lists, and departmental meetings leave limited free time for optional activities such as voluntary SBE. While clinical duties can be educational, the priority remains the patient. Stefanidis et al.[28] and Seymour[56] rostered trainees to receive weekly mandatory training sessions. No penalty was given for non-attendance and attendance rates were still poor. It is not reported as to whether these sessions were conducted in "protected time"; that is, free from clinical interruptions, and ideally with the provision of another colleague to cover clinical duties. Simply stating that a training session is "mandatory" is not enough of an extrinsic motivator to ensure participation. Systems (such as rostered sessions, protected time, and engaging surgical supervisors for their support) need to be put in place to assist trainees to actually be able to attend. Consequences for non-attendance can then be introduced. One such example is the Yale University Basic Laparoscopic Skills Curriculum delivered at the Yale School of Medicine.[33] Program Directors at this institution have now mandated that all first year trainees must complete this curriculum before being allowed to perform in theatre. Preclusion from operating theatre privileges or withholding accreditation are both strong motivators to attend simulation training and were interventions supported by a number of participants in the included studies.

In order for trainees to feel motivated for SBE, the simulator must be intuitive (to avoid frustration) and be readily accessible. With limited free time available, trainees are unlikely to be able to make time to travel to simulation centres away from their site of training. A formal simulation centre is not necessary. Locating a simulator in a quiet room, away from immediate clinical interruptions provided a satisfactory alternative training location.[55,58] This may become an important factor when considering the costs of implementing SBE, especially at smaller hospitals. In addition, if the simulator is located in an area frequented by the trainees, its presence will serve as a visual reminder to train.

Limitations

The literature search was restricted to studies investigating the voluntary utilisation of laparoscopic skills simulators by surgical trainees. Therefore, it may fail to capture findings from studies investigating other forms of voluntary simulated surgical skills training (i.e., non-laparoscopic technical skills, interpersonal/non-technical skills), or SBE involving non-surgeons (i.e., Medical doctors, Nursing, Allied Health). The simulation training curriculums varied greatly in content and duration. Study outcomes and survey questions were not standardised, precluding our ability to statistically pool results.

Study sample sizes were incredibly small, and generally single-institutional. Furthermore, the largest study[57] suffered high participant drop-out rates, with less than one-quarter of the initial participants responding to the end-of-course questionnaire. As the remaining participants may be more motivated to attend simulation in general, their survey answers may not be representative of all trainees. There is overall a lack of information regarding the individuals who were invited to participate in the studies but chose not enrol. Their motivations for non-enrolment could provide further insight into development of more successful voluntary simulation training programs.

This review focused on participation in voluntary training sessions. Although it was reported in a number of the included studies, the quality of the training and proficiency level obtained by the participants lies outside the purpose of this review.

CONCLUSIONS AND RECOMMENDATIONS

Current literature examining the factors influencing voluntary participation in simulation-based laparoscopic skills training is weak. Nevertheless, the results from this review indicate that merely providing unlimited, voluntary access to laparoscopic simulator equipment is not effective in achieving surgical trainee attendance.

Setting clearly defined personal performance goals and ensuring relevance to clinical practice were identified as important intrinsic motivators. These may be facilitated through the distributed scheduling of sessions with an Educator to provide encouragement and feedback during self-directed learning.

Obligatory assessments and mandated SBE sessions (including consequences for non-attendance) are more likely to motivate trainees. In addition to locating the simulator equipment close to clinical training areas, it is recommended that attendance at SBE be supported through the provision of protected time during working hours.

Motivation to attend training was influenced by a number of factors. Although the effect of each of these factors was variable, and highly dependent on the individual trainee, they play a crucial part in driving trainees forward; the authors recommend their incorporation should be considered alongside course content and structure.

Further large-scale, well-designed studies are needed to more adequately assess the effect of introducing training incentives or consequences for non-attendance. Investigation is also required into the training outcomes from self-directed SBE, and to what extent more formal supervised training is required for skill development. More comprehensive surveys of trainees' motivations should be conducted by training providers to better assess and cater to the needs of their trainees before implementing voluntary, self-directed laparoscopic SBE programs.

2.3 The Efficacy of Self-Scheduled, Self-Directed Training for the Acquisition of Basic Laparoscopic Skills

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Certification	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the principal author of this paper.		
Signature		Date	7/1/2018

CO-AUTHOR CONTRIBUTIONS

By signing the Statement of Authorship, each author certifies that:

- the candidate's stated contribution to the publication is accurate (as detailed above);
- permission is granted for the candidate to include the publication in the thesis; and
- the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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ABSTRACT

Background

Simulation-based training can be expensive and is often inhibited by inflexible trainee schedules. Self-directed learning (SDL) has been proposed as one method to improve access and limit associated training costs. The aim of this multi-site, randomised cohort study was to assess the efficacy and feasibility of SDL as a means to develop basic laparoscopic skills.

Methods

Medical students, junior doctors and trainees in surgery and gynaecology (*n*=207) were randomised to undertake either a period of SDL (Cohort 1), or a combination of supervised training in a Mobile Simulation Unit (MSU) and SDL (Cohort 2). Three skills tasks were practiced then assessed at baseline, at the end of MSU training week (Cohort 2 only), and at the end of the 3-week SDL period. Logbooks were used to record session attendance and number skills task attempts.

Results

A total of 150 participants completed final assessment requirements. Both cohorts achieved similar overall task scores at baseline and final assessment, with high variability in skill level and session attendance. The majority of participants improved, and many reached proficiency targets in one or more tasks. In general, improvement in score was affected by the number of attempts per task rather than training format, noting there was little additional benefit of SDL after MSU training.

Conclusions

While self-scheduled, SDL can be effective for the development of basic laparoscopic skills, outcomes are reliant on actual practice attempts. It is logistically more feasible to provide rostered, supervised practice sessions to ensure attendance and provide feedback during training.

INTRODUCTION

Laparoscopic skills are difficult to master. It is now established that simulation-based laparoscopic training leads to skill development, and that the skills learned in the simulation laboratory are transferrable to the operating theatre.[11] Research is now focussing on how best to deliver simulation training and incorporate it into the surgical training curriculum. Access to simulation training can be limited by a number of factors including costs associated with purchasing simulator equipment and establishing training facilities, the availability of training staff, and busy, inflexible trainee work schedules.[66] These factors are often further compounded by rural training locations – where surgical departments are smaller, funds and space are more limited, and trainees often have to travel to metropolitan locations to attend simulation training courses.

Traditionally, simulation-based laparoscopic skills training has been delivered via stand-alone training courses and massed training sessions.[67] However, evidence has shown that training in a distributed pattern, that is shorter but more frequent training sessions, can lead to better skills development and retention than massed sessions.[68,69]

Self-directed learning (SDL) has been proposed as one means to improve access to simulation-based training. By allowing flexible, self-determined training schedules, training is theoretically more easily incorporated into the regular working week. Trainees can achieve a more distributed training regimen, with the additional benefit of minimising cost associated with employing training staff.

The primary objective of this study was to develop and assess the efficacy and feasibility of a self-scheduled, self-directed simulation-based training program, and the secondary objective was to determine if a period of more formal (supervised) training improves skill outcome and motivation to train.

METHODS

Participants

Medical students, junior doctors (interns and pre-training residents), as well as surgical and gynaecology trainees were invited to participate. Advertising material was distributed to all eligible individuals via email by local hospital Administration and Medical Education Officers. Advertisements were also posted on bulletin boards within hospitals and medical schools. Interested individuals were advised to contact the researchers for more information regarding participation.

Randomisation

Upon enrolment, participants were randomised to one of two cohorts using sealed envelope methodology. Cohort 1 (SDL) participants were allocated to undertake self-directed learning (SDL) only. Cohort 2 (MSU+SDL) were allocated to undertake a combination of both supervised and self-directed training. All participants received an introduction to the simulators and instrument handling technique, with trainers demonstrating the correct performance of each task prior to participant performance. Participants were given the opportunity to ask questions and clarify technique.

Intervention

Mobile Simulation Unit

A large Mercedes Sprinter van, internally converted to resemble a dry skills centre, was used as the Mobile Simulation Unit (MSU). The MSU has a bench along one wall, with four simulator stations. Hydraulic legs are deployed to ensure the van remains stable while participants are training and air-conditioning ensures comfort. The MSU has previously been evaluated by surgical trainees and was found to be a suitable substitute training environment.[49] The MSU was deployed to each hospital site for a period of one working week ("MSU week"). Participants were required to present to the MSU in order to enrol in the study.

Cohort 1 participants did not have further access to the MSU or trainers after completing enrolment and baseline assessment. Whereas Cohort 2 participants were invited to return to the MSU as much as they liked during MSU week for supervised training, during which they received individual feedback on their task performance, and advice on how to improve.

Laparoscopic skills tasks

Participants trained on three basic skills tasks – peg transfer, pattern cutting and intra-corporeal knot-tying. The tasks were based on tasks from the Fundamentals of Laparoscopic Surgery (FLS) program.[37]

Self-Directed Learning

At the conclusion of MSU week, a FLS box-trainer simulator was set up at the hospital for participants from both cohorts to use at a time convenient to them for a period of three weeks ("SDL period").

All participants received verbal and written information regarding task performance and proficiency scoring, and YouTube video links to refer to during the SDL period. Participants were required to complete a logbook detailing practice session times and the number of attempts made at each task. They were also provided with a supply of training consumables. All training sessions within the MSU and SDL periods were entirely self-scheduled and attendance was up to the discretion of the individual participant. Participants were however encouraged to practice as often as possible.

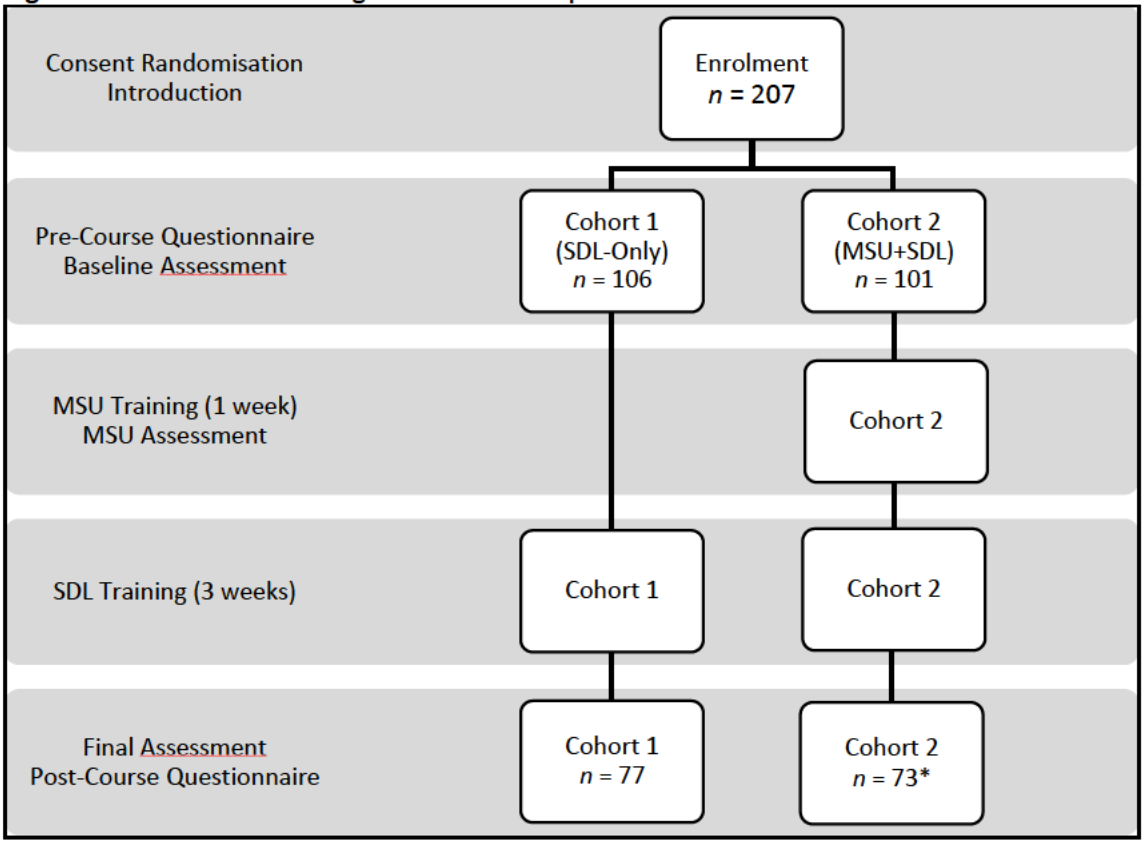
Assessments

Participants were assessed in the MSU at baseline (on enrolment), at the end of MSU week (Cohort 2 only), and at the end of the SDL period. To ensure standardised assessments, all assessments were performed in the MSU using scripted instructions. Participants were given two practice attempts per task before being assessed on their third attempt. Scoring was based on the proficiency standards of the validated FLS program[37] which take into account both accuracy and time to complete the task. If the task completion time or penalties for inaccuracy exceeded the minimum pass mark, then a score of zero was given (rather than a negative value). The two practice attempts at each task during the assessment were not counted towards MSU or SDL practice sessions. Figure 3 outlines the training and assessment timeline.

Ethics

Written informed consent was obtained from all participants at enrolment. Ethics approval was granted by the Human Research Ethics Committee (HREC) of The Queen Elizabeth Hospital, South Australia, for National Mutual Acceptance (NMA) (approval reference number HREC/15/TQEH/76). HREC approval was granted by individual hospitals if they were not bound by NMA approval.

Figure 3 Flow-chart of training and assessment protocol



MSU, Mobile Simulation Unit; SDL, self-directed learning. *Includes seven participants who completed the final assessment but did not complete the MSU assessment.

RESULTS

Participant demographics, enrolments and completions

Seventeen visits to seven rural and three metropolitan hospitals within South Australia (SA) and Victoria were conducted (including three visits each to 2 metropolitan hospitals in SA, two visits each to 1 metropolitan SA and 2 rural Victorian hospitals, and the remaining five visits to 5 individual rural hospitals in SA and Victoria). Of the 207 individuals who enrolled in the study, 143 completed all assessment requirements (Cohort 1: 77; Cohort 2: 66). A further seven Cohort 2 participants did not attend MSU training or the MSU week assessment but completed all other requirements. Unless otherwise specified, results are presented on an 'intention to treat' basis, that is, these seven individuals are treated as part of Cohort 2 (except where this is not possible, in which case they are excluded). See Table 3 for participant demographics for enrolments and completions.

Baseline assessment

It can be seen in Table 4 and Figure 4 that there was no significant difference between the two cohorts at baseline assessment (peg transfer: P=0.260; pattern cutting: P=0.600; and knot tying: P=0.640; and Total Score: P=0.350). Only one participant (a surgical trainee) scored higher than the proficiency standard for pattern cutting and intra-corporeal knot tying. A number of participants failed one or more tasks as indicated by a score of 0. There was high variability in scores between participants.

Table 3 Participant Demographics

	Cohort 1		Cohort 2		
	Enrolled (M:F)	**Completed (M:F)**	**Enrolled (M:F)**	**Completed (M:F)**	**No MSU assessment* (M:F)**
Students	66 (33:33)	55 (30:25)	54 (28:26)	46 (26:20)	2 (0:2)
Interns	17 (9:8)	9 (5:4)	24 (11:13)	9 (4:5)	3 (1:2)
RMOs	19 (13:6)	10 (9:1)	18 (7:11)	7 (3:4)	2 (1:1)
SET	3 (3:0)	2 (2:0)	-	-	-
RANZCOG	1 (0:1)	1 (0:1)	5 (1:4)	4 (0:4)	-
Total	106 (58:48)	77 (46:31)	101 (47:54)	66 (33:33)	7 (2:5)

M:F, male to female ratio; MSU, Mobile Simulation Unit; RANZCOG, Royal Australian and New Zealand College of Obstetricians and Gynaecologist trainees; RMO, Resident Medical Officer (pre-training doctor); SET, Surgical Education and Training trainees. *Participants who did not attend any MSU training or the MSU assessment, but completed all other requirements.

Table 4 Mean and standard deviation of baseline and change in task scores

	Peg transfer		Pattern cutting		Knot tying		Total	
	Avg.	SD	Avg.	SD	Avg.	SD	Avg.	SD
Baseline Task Scores								
SDL	79.49	15.68	32.91	19.18	53.05	25.57	165.15	44.00
MSU+SDL	81.64	11.59	34.22	17.24	54.89	22.86	170.75	35.56
Change in Task Scores								
SDL	19.2	14.9	28.3	21.2	25.6	30.7	73.1	52.0
MSU+SDL	16.9	9.3	28.6	19.9	31.6	23.6	77.1	36.0

Numerical summary of mean (Avg.) and standard deviation (SD) of baseline task scores and change in task scores (following training) for both cohorts. Cohort 1 (SDL); Cohort 2 (MSU+SDL).

Final score and overall change in score

A number of participants from each cohort achieved proficiency standards in one or more tasks at final assessment. In Cohort 1 and Cohort 2, 19.5% (15/77) and 23.3% (17/73) of participants achieved proficiency for peg transfer, 39.0% (30/77) and 28.8% (21/73) for pattern cutting, 18.2% (14/77) and 31.5% (23/73) for knot tying, and 16.9% (13/77) and 17.8% (13/73) for total score, respectively.

Four participants, all from Cohort 1, failed a task at final assessment (pattern cutting: 1, knot tying: 3). Furthermore, the majority of participants who deteriorated in an individual task, or in overall score, were also from Cohort 1 (peg transfer: 7 versus 2 participants, pattern cutting: 8 versus 4, knot tying: 11 versus 2, total score: 5 versus 1, for Cohort 1 versus Cohort 2, respectively).

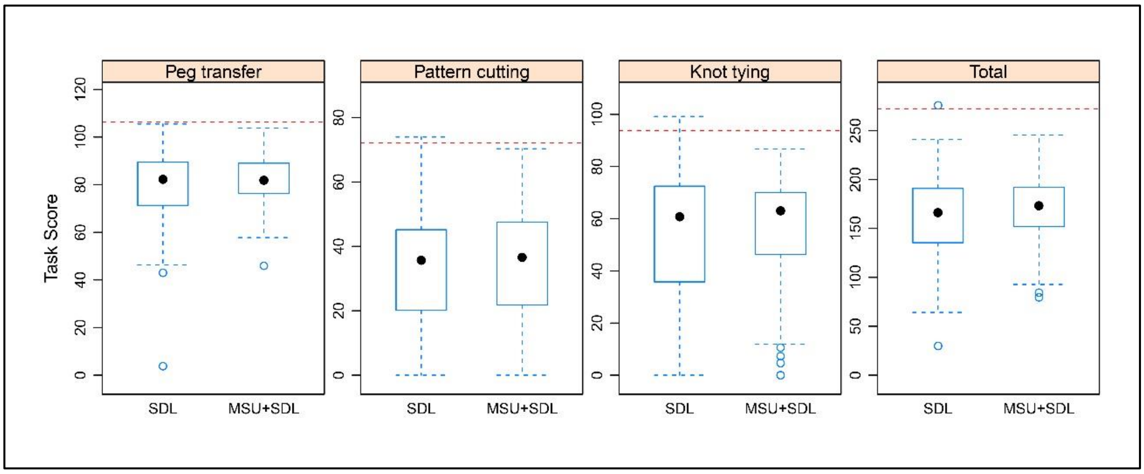
Change in score was calculated for each participant to assess the effect of training. Participant's baseline score was deducted from their final score to identify any increase; using this method, each participant becomes their own control. Box plots of the change in score are shown in Figure 5, and a numerical summary is provided in Table 4. Overall there was a general increase in score; however, some participants performed worse in their final assessment compared to baseline assessment (indicated by negative change in scores). On average both cohorts achieved similar improvements for all tasks, noting there was a large variability between participant scores.

Table 5 Summary of change in score for each training period

Comparison	Peg transfer		Pattern cutting		Knot tying	
	Avg.	Rate*	Avg.	Rate*	Avg.	Rate*
MSU period (Cohort 2 only)	12.92	Not significant (P = 0.120)	10.69	5.13 (P = 0.0048)	14.26	6.89 (P = 0.009)
SDL period (Cohort 1)	14.88	1.47 (P = 0.00045)	28.48	Not significant (P = 0.10)	19.21	3.04 (P = 0.011)
SDL period (Cohort 2 after MSU training)	0.77	1.47 (P = 0.00045)	11.87	Not significant (P = 0.100)	3.97	3.04 (P = 0.011)
Overall (Final – Baseline)	13.30	1.64 (P = 0.0001)	24.11	1.83 (P = 0.051)	20.65	3.40 (P = 0.0059)

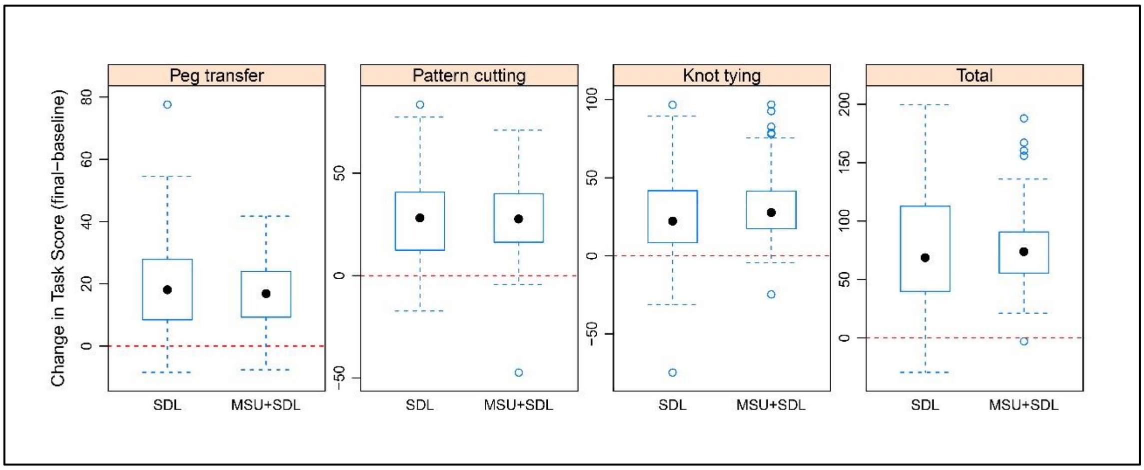
Avg., average improvement. *The number of additional units of improvement in score for every 1 unit increase in the square root of the number of practice attempts made (i.e. number of attempts increases 0, 1, 4, 9, 25 etc.).

Figure 4 Baseline task scores



Box plots of baseline task scores for both cohorts. Dashed red lines indicate proficiency level. Blue circles indicate potential outliers. Cohort 1 (SDL); Cohort 2 (MSU+SDL); MSU, Mobile Simulation Unit; SDL, self-directed learning.

Figure 5 Overall change in task scores



Box plots of overall change in task scores for both cohorts. Dashed red lines indicate 'no change', while positive values indicate an improvement in score. Blue circles indicate potential outliers. Cohort 1 (SDL); Cohort 2 (MSU+SDL); MSU, Mobile Simulation Unit; SDL, self-directed learning.

Effect of number of practice attempts

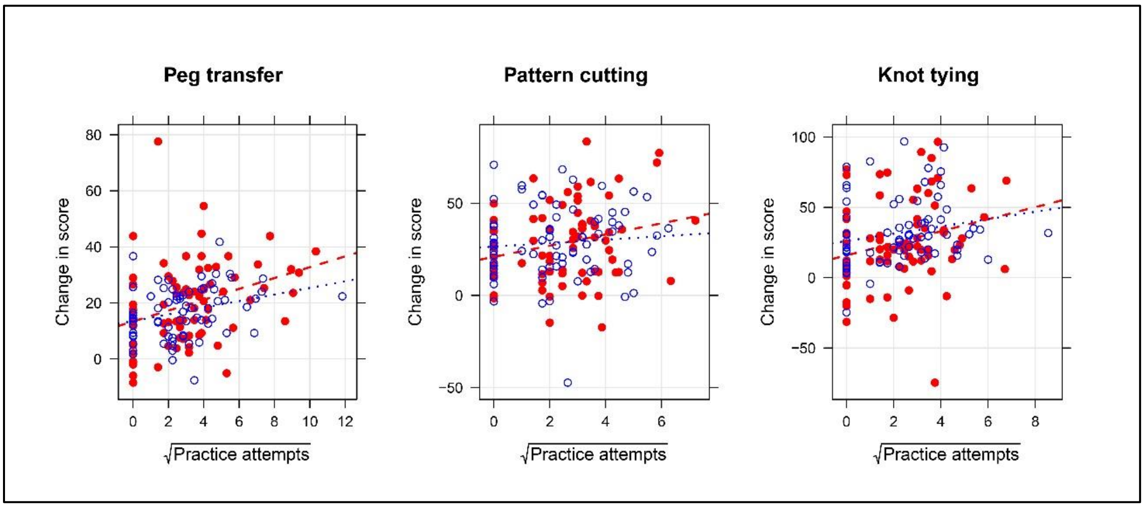
SDL log books were available for 147 of the 150 participants who completed the final assessment. The follow analysis reports results on the: overall effect of practice; the effect of MSU practice; and, the effect of SDL practice. This analysis excludes the 3 participants without logbooks (2 SET trainees from Cohort 1, and 1 RMO from Cohort 2). There was high variability in the number of training sessions undertaken by individual participants during both the MSU and SDL periods.

Scatter plots of the change in score versus the square root of the total number of practice attempts are shown in Figures 6, 7, and 8, together with separate best fit linear regression lines for each cohort. The square root of the number of practice attempts was used to overcome potential skewness issues in the number of practice attempts, that is, most participants practiced only a few times, whereas a few participants practiced a lot. The greater the slope of the liner regression lines, the more significant the improvement in score with practice attempts.

Overall effect of practice

For all three tasks, improvement in overall score was affected by the number of practice attempts made (peg transfer, P<0.0001; pattern cutting, P=0.051; and knot tying, P=0.0059), with greater increases in score observed in those who practiced more (see Figure 6). There were no statistically significant differences in slope (peg transfer, P=0.360; pattern cutting, P=0.920; and knot tying P=0.520) or the intercept between training groups (peg transfer, P=0.290; pattern cutting, P=0.350; and knot tying 0.190), indicating that both cohorts benefitted equally from practice sessions. Even without attending any practice sessions, participants were still found to improve between baseline and final assessment. For peg transfer, the average improvement was 13.3 units, for pattern cutting 24.11 units, and for knot tying 20.65 units.

Figure 6 Change in task scores versus square root of the total number of practice attempts

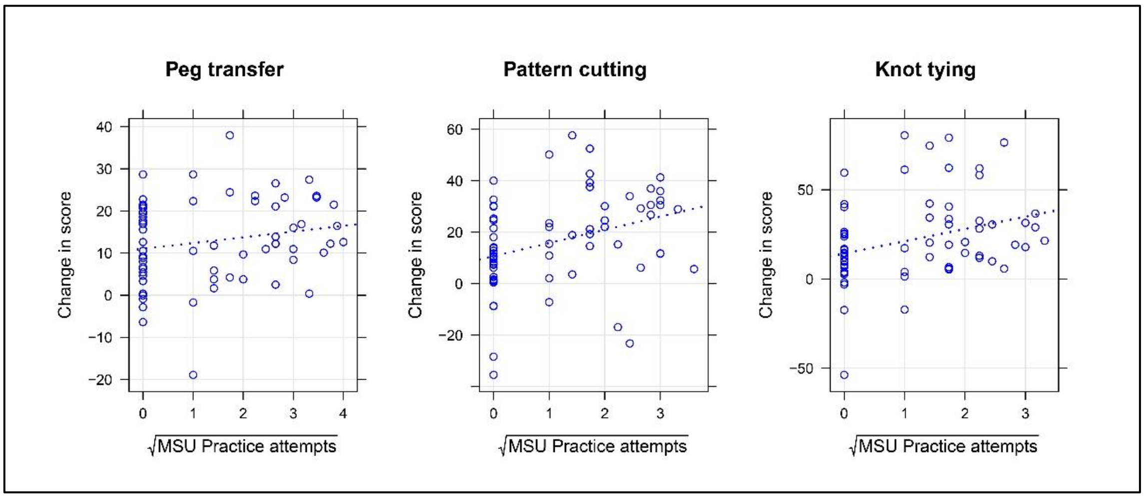


Change in task scores versus square root of the total number of practice attempts. Red dots and dashed lines represent Cohort 1 (SDL); blue circles and dotted lines represent Cohort 2 (MSU+SDL).

Effect of MSU practice

Change in score was also calculated to assess skill development in the MSU practice week (see Figure 7). Although participants improved by 12.92 units on average for peg transfer, there was no evidence that change in score increased with increased practice attempts (P=0.120). Improvement in score was, however, affected by the number of practice attempts for both pattern cutting (P=0.0048, average improvement 10.69 units) and knot tying (P=0.009, average improvement 14.26 units).

Figure 7 Change in task scores following MSU training versus square root of the number of practice attempts

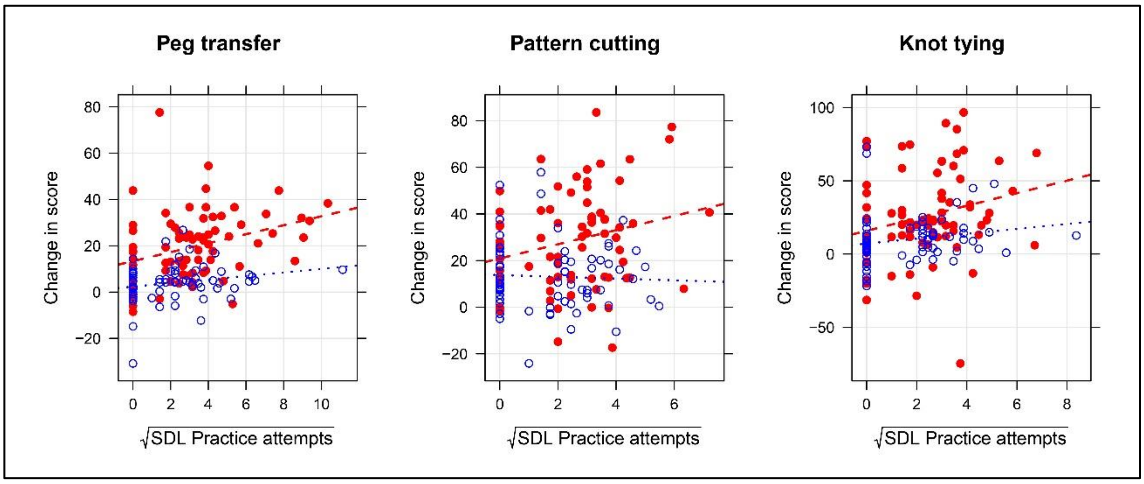


Change in task scores following MSU training versus the square root of the number of MSU practice attempts (Cohort 2 only). Analysis excludes the seven Cohort 2 participants who did not attend any MSU training or the MSU assessment.

Effect of SDL practice

As a result of the SDL practice period (see Figure 8), the change in score for peg transfer was positively affected by the number of practice attempts (P=0.00045). Cohort 1 improved by 14.88 units on average, whereas Cohort 2 had close to zero improvement (0.77 units). However, both cohorts did improve at the same rate, with 1.47 units, on average, for every 1 unit increase in the square root of the number of practice attempts.

Figure 8 Change in task scores following SDL training versus square root of the number of practice attempts



Change in task scores following SDL training versus the square root of the number of SDL practice attempts for both cohorts. Red dots and dashed lines represent Cohort 1 (SDL only); blue circles and dotted lines represent Cohort 2 (MSU+SDL).

For pattern cutting, on the other hand, improvement in score was not significantly affected by the number of practice attempts (P=0.10) but there were differences in the improvement between the cohorts (P<0.0001). The average increase in score was 28.48 units for Cohort 1, and 11.87 units for Cohort 2.

Knot tying scores were affected by the number of SDL practice attempts (P=0.011), which was the same for both cohorts (P=0.30). Again, Cohort 1 improved more than Cohort 2 (P=0.0003) during the SDL period, with an average of 19.21 units versus 3.97 units respectively. The rate of improvement was the same (3.04 units of improvement, on average, for every 1 unit increase in square root of the number of practice attempts). A numerical summary of average improvement in score, and the rate of improvement for each training period is provided in Table 5.

DISCUSSION

This study assessed the efficacy and feasibility of self-scheduled, self-directed learning as a means to develop basic laparoscopic skills in three simulated tasks, and whether or not a period of supervised training and feedback in a Mobile Simulation Unit had an additional benefit. Results showed that, on average, both cohorts achieved improved scores for all three tasks, with a number of participants, including medical students, reaching proficiency standards in one or more of the tasks. There was no statistically significant difference between cohorts at final assessment.

Evidence from research into surgical and psychomotor education recommend training is undertaken in a distributed manner, with trainees attending shorter, more frequent training sessions as opposed to massed practice. The philosophy behind distributed practice is that repetitive exposure to tasks, and the rest period between training, allows for consolidation of learning.[68,69] This in turn can lead to better skills acquisition and retention. In principle, self-directed learning with self-determined practice schedules seems ideal. The trainee has control over training content, and improved flexibility of training sessions can potentially result in attending several shorter sessions a week whenever they have free time. In practice however, outcomes are not so fortuitous. While there were a number of highly motivated participants enrolled in this study, the majority trained very few times, if at all, and this almost certainly impacted on the limited difference demonstrated between the two cohorts.

In general, overall improvement in score was affected by the total number of practice attempts, rather than by where the practice took place. In keeping with other studies,[63,70,71] those who practiced more were more likely, on average, to achieve a greater improvement in score and reach pre-defined proficiency targets.

When analysing individual training periods, skills improvement during the SDL period was found to be greater for Cohort 1 than it was for Cohort 2. This is most likely due to the fact that Cohort 2 had achieved their improvement during the MSU practice week. In other words, there was little additional benefit of SDL after the MSU period. Supervised training, such as provided in the MSU, gives trainees the opportunity to clarify technique and to relate the simulator tasks back to clinical practice. Supervised training also allows for the trainee to receive structured personalised feedback regarding their performance. The trainer can prescribe specific tasks targeting skills that may need to be refined. This process is known as deliberate practice and is an essential component of skill mastery.[21] Under supervision, Cohort 2 participants were able to target their training and receive mentoring on the tasks they struggled with most. This feedback could account for the higher proportion of Cohort 2 participants reaching proficiency in knot-tying, the most complex of the three tasks. The majority of participants who deteriorated in skill level for one or more tasks were from Cohort 1 who received no feedback.

This study enrolled a large proportion of medical students and very inexperienced junior doctors. For some, this study was their first opportunity to handle laparoscopic instruments.

Simulation provides the perfect setting for doctors to develop their skills before being exposed to the live operating theatre environment. The skills tasks implemented during this study were deliberately basic and were designed to familiarise novice surgeons with laparoscopic instruments and fundamental instrument handling techniques. Given the simplicity of the tasks, it may be that the initial introduction and written information given at the time of enrolment is all that is necessary for learning these tasks. A greater difference may have been shown between cohorts if more advanced tasks or even simulated surgical procedures were used. On the other hand, despite receiving a thorough introduction to the correct use of the instruments, it was noted by the trainers that a number of participants were still handling the instruments incorrectly. Although this is unlikely to be a problem for the more experienced trainees, correct instrument handling is vital. Without corrective supervisor feedback, there is a risk of developing bad habits that are harder to correct as time progresses.[40] This is an example of an inherent drawback of self-directed learning.

The results of this study indicate that, although voluntary SDL can be effective for skills acquisition, it is unlikely to be a feasible training format in the long-term because trainees do not reliably attend practice. In order to be effective and facilitate actual attendance, SDL needs to be supplemented by the addition of more formal training strategies. One potential solution is the addition of intermittent mandatory sessions with an educator. Mentored sessions have been found to improve trainees' motivation to practice and their ability to achieve personal learning goals during an otherwise self-directed training program.[65,66] Periodical assessments can also be introduced to assess training progress and ensure adequate skills acquisition, and correction of bad habits.

Two limitations of this study were identified. First, even without attending any practice sessions, some participants from both cohorts were found to improve, on average, during each training period. This may be attributed, in addition to task simplicity, to the assessment protocol used whereby participants undertook two practice attempts at each task prior to the assessed attempt. Although not formally recorded, it was noted by the trainers that some participants improved greatly during these attempts. In addition, there was a number of participants who performed well during the practice attempts, but ultimately failed the assessment (for example, completing the knot tying task proficiently, but ultimately failing the task due to pulling the drain off of the foam block while reaching for the scissors to cut the suture string). Results might have been different if all three attempts were scored and averaged, or if assessment was performed on the first attempt only.

Second, the absence of any significant difference between the cohorts may also be affected by the overall lack of training attendance during both the MSU week and SDL period. If mandatory minimum training requirements were implemented for Cohort 2 during the MSU week, there may have been a greater difference between cohorts. Furthermore, it was not possible to prevent participants from different cohorts training together and sharing their knowledge and tips. Although trainers were not blinded to the participants' cohort, the use of objective assessment tools mitigates any bias this may have had.

CONCLUSION

Self-directed learning can be effective for the acquisition of basic laparoscopic skills if training sessions are attended. However, given the difficulties maintaining voluntary attendance, and the benefits that can be attained with structured feedback, it is perhaps more feasible to provide mandatory, rostered, supervised training within a simulation centre, or Mobile Simulation Unit on a regular but distributed basis. This would not only ensure attendance was achieved, but also provide a means to deliver corrective feedback regarding technique, and assessments to monitor training progress. Additional self-scheduled, self-directed training sessions could continue during the intervals between rostered sessions.

2.4 Attendance at a Self-Directed Simulated Laparoscopic Skills Training Course. A Multi-Site Prospective Randomised Cohort Study

STATEMENT OF AUTHORSHIP

Title of Paper	Attendance at a self-directed simulated laparoscopic skills training course. A prospective multi-site randomised cohort study.
Publication Status	◯ Published ◯ Accepted for publication ☒ Submitted for publication ◯ Unpublished and unsubmitted work in manuscript style
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PRINCIPAL AUTHOR

Name of Principal Author	Hannah Gostlow		
Contribution to the Paper	Conception of the work, data acquisition, analysis and interpretation, manuscript writing and critical revision, and acted as corresponding author.		
Overall Percentage (%)	80%		
Certification	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the principal author of this paper.		
Signature		Date	7/1/2018

CO-AUTHOR CONTRIBUTIONS

By signing the Statement of Authorship, each author certifies that:

- the candidate's stated contribution to the publication is accurate (as detailed above);
- permission is granted for the candidate to include the publication in the thesis; and
- the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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Contribution to the Paper	Conception of the work, data acquisition, analysis and interpretation, and critical revision of manuscript		
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Contribution to the Paper	Supervised conception of the work, and manuscript evaluation and critical revision.		
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Contribution to the Paper	Supervised conception of the work, and manuscript evaluation and critical revision.		
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ABSTRACT

Background

Despite literature confirming its effectiveness, access to surgical simulation in Australia remains limited. Self-directed learning (SDL) has been proposed as one approach to improve access to simulation training by reducing program running costs, and facilitating attendance through more flexible training options. The aim of this prospective, multi-site randomised cohort study was to assess the feasibility of integrating SDL within a simulated laparoscopic skills training program.

Methods

Medical students, junior doctors and trainees in surgery and gynaecology (n=207) were randomised to undertake either SDL only, or a period of supervised training within a Mobile Simulation Unit followed by SDL. Participants completed logbooks detailing their training sessions. Attendance patterns and preferred training times were compared. Pre- and post-course surveys were conducted examining motivations for participation, as well as barriers and enablers for training attendance.

Results

Attendance at self-directed simulation training was highly variable but generally poor. The most popular training times were around lunchtime and in the afternoon. Attendance peaked in the days prior to final assessments. The greatest reported barrier to attending training was lack of available free time. Participant post-course survey responses noted a preference for mandating training, and scheduled training sessions within protected time.

Conclusions

SDL on its own is not a feasible modality for integrating simulated laparoscopic skills training into the surgical curriculum. If SDL is to be introduced, it needs to be implemented in conjunction with other more formal training requirements, such as intermittent scheduled mandatory sessions with an educator or periodic skills assessments.

INTRODUCTION

Simulation-based surgical skills training has been established as a safe and effective method for development of surgical skills[11] and a number of surgical training providers internationally now have mandated simulation activities within their training programs. However, there are currently no simulation-based laparoscopic skills training programs integrated within the national Australian Surgical Education and Training (SET) curriculum, and no minimum standard for simulation training exist. Furthermore, a national survey found that 63% of surgical trainees in Australia do not have access to surgical simulation equipment at their site of employment.[47]

Training providers need to overcome numerous barriers when developing and implementing simulation-based education programs. Costs involved with the development of training infrastructure and employment of educators, as well as the logistics of scheduling group training sessions within a busy working week can prohibit the execution of successful simulation training programs.[67]

Self-directed learning has been one method proposed to limit these noted barriers. Under this approach, participants introduced to the requirements and rules governing each task, are able have control over the scheduling of their practice sessions and the content practiced therein.

The Royal Australasian College of Surgeons (RACS) implemented the Laparoscopic Simulation Skills Program (LSSP) to investigate the efficacy and feasibility of self-directed learning as a means to develop basic laparoscopic skills. While some research into attendance at self-directed simulation training has been performed, previous studies have tended to be small and within a single institution.[66] The LSSP was a large, prospective, multi-centre study enrolling medical students and trainee doctors from all levels of experience. The aim of the LSSP was to assess the feasibility of integrating SDL within a simulated laparoscopic skills training program.

METHODS

Participants

Medical students, junior doctors (interns and resident medical officers), as well as trainees from the RACS Surgical Education and Training (SET) program and the Royal Australian and New Zealand College of Obstetricians and Gynaecologists (RANZCOG) were invited to attend. Advertising material was distributed to eligible individuals via mass email from Medical Administration and Medical Education Unit staff. Advertisements were also posted in hospital offices, on medical school and special interest group (i.e. medical student surgical society) electronic bulletin boards and social media pages. Prior to each visit, the Heads of each Surgical Department were contacted to inform them of the project purpose, seek permission to include the hospital in the visit schedule, and to encourage staff and students to enrol. Interested individuals were asked to contact research staff for more information regarding enrolment

Intervention

A Mobile Simulation Unit (MSU)[49] van was deployed to each hospital site for a period of one working week ("MSU week") to enrol participants and provide introduction to the three basic skills training tasks (peg transfer, pattern cutting and intra-corporeal knot tying[37]). The MSU was open from 9am until 7pm, Monday to Friday that week.

Upon enrolment, participants received in introduction to the laparoscopic simulators, instrument handling techniques, and received a guided demonstration on the correct performance of each task. Participants were given an opportunity to ask questions and clarify technique. They then undertook two practice attempts at each task before being assessed on their third attempt. This attempt formed their baseline score.

Participants were randomised to one of two cohorts using the sealed envelope method. Cohort 1 was assigned to undertake self-directed (SDL) learning only, and received no further coaching. They did not have further access to the MSU or trainers. Cohort 2 (MSU+SDL) participants on the other hand were able to return to the MSU as much as they liked during MSU week for further supervised training and individualised feedback on how to improve their technique. Cohort 2 participants' skills were re-assessed at the end of the MSU week to measure the impact of this training.

At the end of MSU week, a simple laparoscopic box-trainer was set up at the hospital for participants from both cohorts to continue use in a self-directed learning manner for the following three weeks ("SDL period"). All participants had equal access to the SDL room and simulators during this time. The MSU returned to the hospital at the conclusion of the SDL period for all participants to undertake a final skills assessment. To ensure standardised assessments across sites, all assessments were conducted within the MSU using scripted instructions and criteria based on the validated Fundamentals of Laparoscopic Surgery[37] assessment protocol.

Participants were given verbal and written information regarding the proficiency standards and error scoring for each task, as well as YouTube video links to refer to during the SDL period. They were sent a practice reminder email at the start of each week (weeks 2 & 3), as well as an assessment reminder email and text message towards the end of week three.

Participants were required to complete a logbook detailing their SDL practice sessions (date, session times, and number of attempts made at each task). MSU practice session details were recorded by the trainers. A training session was defined as at least one attempt on at least one task.

Pre- and post-course surveys were conducted to examine motivations for participation, as well as barriers and enablers for attendance at simulation training. The majority of questions were in multiple choice or Likert-scale format (ranking level of agreement on a 5-point scale where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree). A short online follow-up survey was also emailed to any participant who did not attend the final assessment, asking their reason for non-attendance.

There were no minimum training requirements for the MSU week or SDL period and all training was entirely self-scheduled. No specific incentives were offered for attendance apart from the opportunity to improve skill. However, participants were encouraged to train as much as possible.

Ethics

Written informed consent was obtained from all participants at enrolment. Ethics approval was granted by the Human Research Ethics Committee (HREC) of The Queen Elizabeth Hospital, South Australia, for National Mutual Acceptance (NMA) (approval reference number HREC/15/TQEH/76). HREC approval was granted by individual hospitals if they were not bound by NMA approval.

RESULTS

Enrolments

Participants were enrolled between June 2015 and November 2016, inclusive. Seventeen visits to seven rural and three metropolitan hospitals within South Australia (SA) and Victoria were undertaken (including three visits each to 2 metropolitan hospitals in SA, two visits each to 1 metropolitan SA and 2 rural Victorian hospitals, and the remaining five visits to 5 individual rural hospitals in SA and Victoria). A total of 207 participants were enrolled (Cohort 1: 106; Cohort 2: 101). See Table 6 for participant demographics.

Table 6 Participant Demographics

Participant Type	Total Number Enrolled		Logbook Data Available		Survey Data Available	
	Cohort 1 SDL only	Cohort 2 MSU+SDL	Cohort 1 SDL only	Cohort 2 MSU+SDL	Cohort 1 SDL only	Cohort 2 MSU+SDL
Medical Students	66	54	55	48	58	47
Interns	17	24	9	12	9	14
RMOs	19	18	10	8	12	9
SET & RANZCOG Trainees	4	5	1	4	3	4
Subtotal	106	101	75	72	82	74
Total	**207**		**147**		**156**	

MSU, mobile simulation unit; RANZCOG, Royal Australian and New Zealand College of Obstetricians and Gynaecologists; RMO, Resident Medical Officer; SDL, self-directed learning; SET, Surgical Education and Training.

MSU Usage

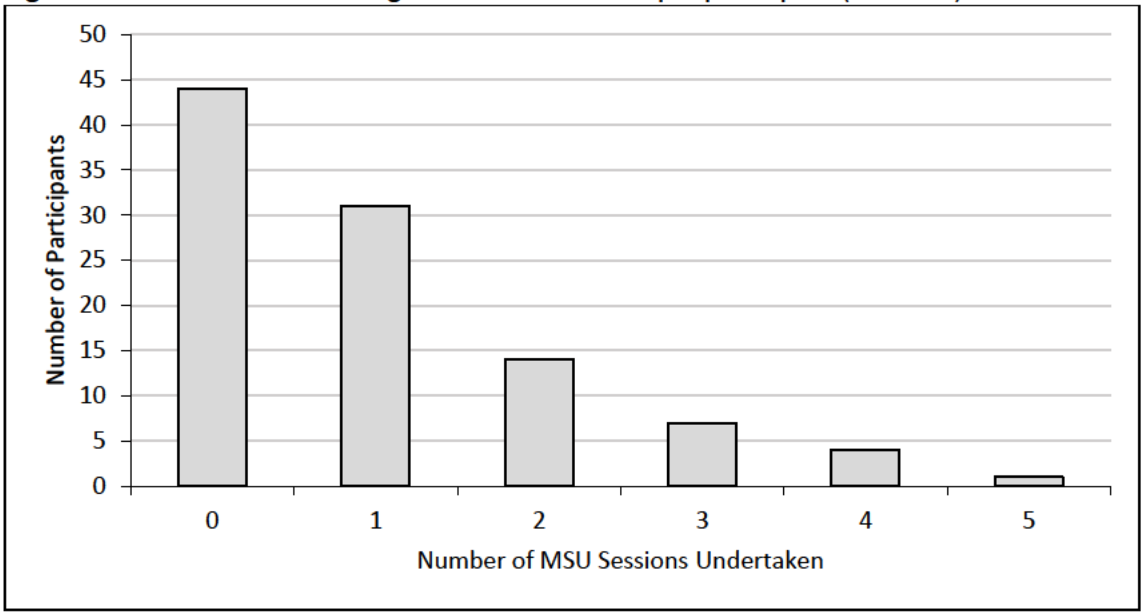
Of the 101 participants randomised to Cohort 2, 57 (56.4%) returned to the MSU for at least one training session. A total of 101 MSU training sessions were undertaken. Attendance was highly variable. Of the participants who practiced, between one and five sessions were undertaken (Figure 9), and between 0 and 16 attempts were made at each task (Table 7). Training in the MSU was distributed throughout the day, with a slight preference for late afternoon and early evening sessions (Figure 10).

Table 7 MSU and SDL training sessions and tasks practice attempts undertaken

	MSU Training			SDL Training					
	Cohort 2			Cohort 1			Cohort 2		
% who trained	56.4% (57/101)			80.0% (60/75)			65.3% (47/72)		
	Total*	**Avg.†**	**Range†**	**Total***	**Avg.†**	**Range†**	**Total***	**Avg.†**	**Range†**
Training Sessions	101	1.77	1-5	215	3.58	1-10	155	3.30	1-11
Practice Attempts									
Peg Transfer	271	4.76	0-16	1250	20.83	0-107	687	14.61	1-124
Pattern Cutting	196	3.44	0-13	667	11.12	0-52	424	9.02	0-30
Knot Tying	194	3.40	0-11	631	10.52	0-46	463	9.85	0-70

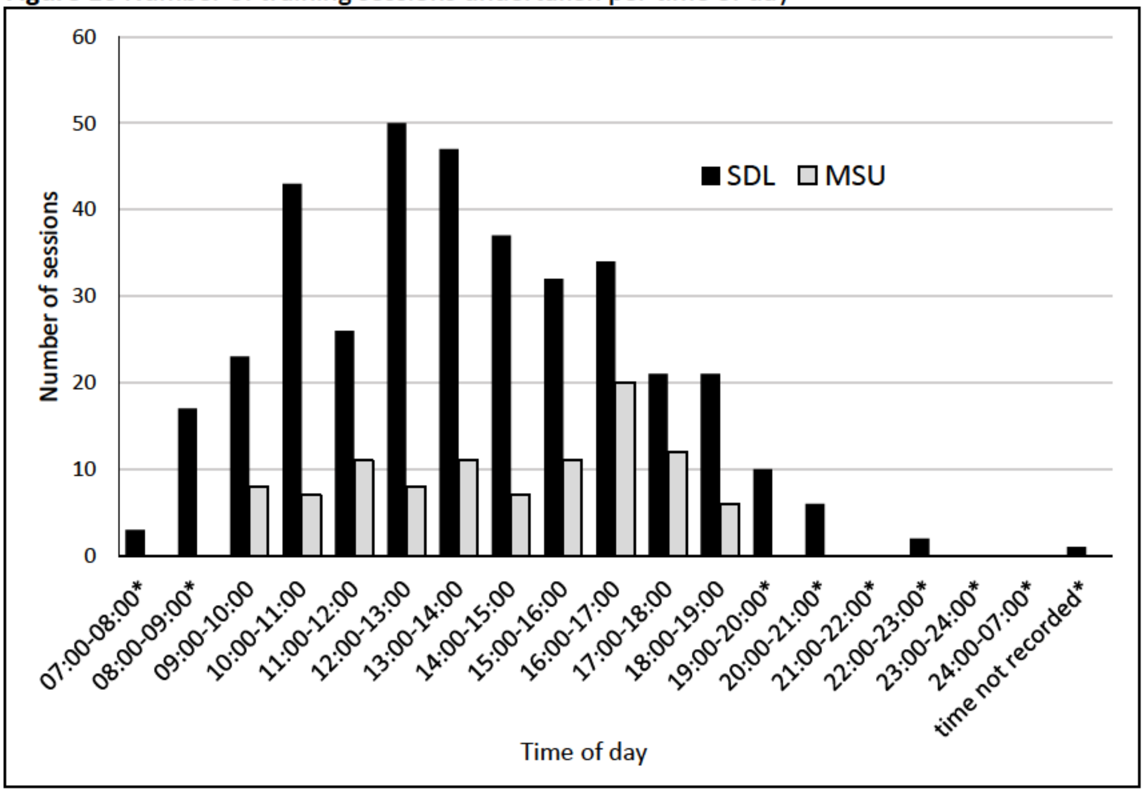
Data presented is for the participants who undertook at least one training session during the respective training periods, and who submitted a SDL logbook. *per cohort. †per participant. Avg., average; MSU, Mobile Simulation Unit; SDL, self-directed learning.

Figure 9 Number of MSU training sessions undertaken per participant (Cohort 2)



Number of MSU training sessions undertaken per participant (Cohort 2 only). MSU, Mobile Simulation Unit.

Figure 10 Number of training sessions undertaken per time of day



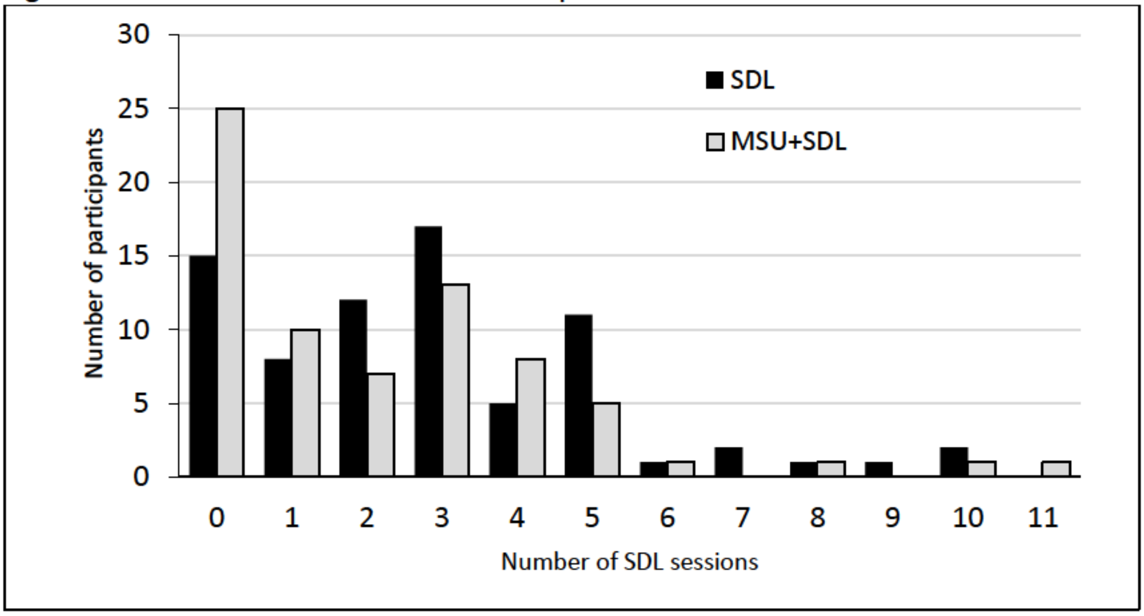
Number of training sessions undertaken per time of day for the MSU and SDL training periods. *Data relates to SDL training period only as the MSU was not available for training at these times. MSU, Mobile Simulation Unit; SDL, self-directed learning.

SDL Usage

Logbooks were available for 147 of the 150 participants who completed all assessment requirements. Of those, 80.0% (60/75) of Cohort 1 and 65.3% (47/72) of Cohort 2 participants undertook at least one SDL training session. Of those who practiced, between 1 and 11 SDL sessions were undertaken each (Figure 11). Total number of attempts at each task was highly variable (Table 7). On average, a larger proportion of Cohort 1 participants trained, and those who trained undertook a greater number of sessions and practice attempts at each task compared to Cohort 2. Higher attendance at MSU training sessions did not correlate with increased attendance at SDL.

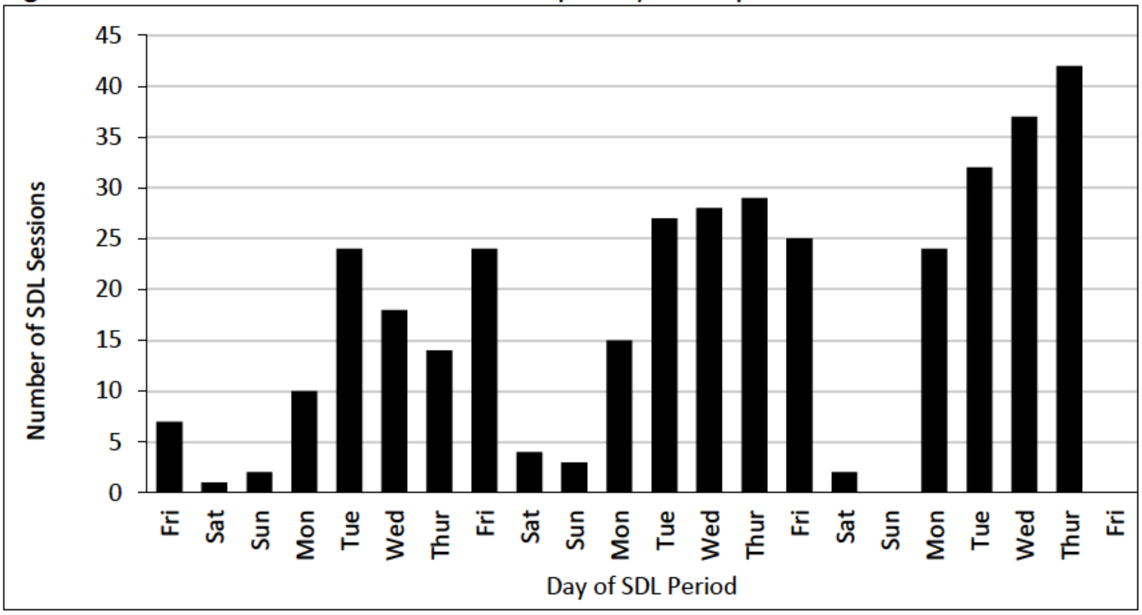
The most popular times for practicing SDL were around lunch time and in the late afternoon (Figure 10). There was a spike in SDL session attendance in the two to three days prior to the final assessment date (Figure 12).

Figure 11 Number of SDL sessions undertaken per cohort*



*Data presented for the 147 participants (Cohort 1, SDL: *n* = 75; Cohort 2, MSU+SDL: *n* = 72) who competed all assessment requirements and logbook. MSU, Mobile Simulation Unit; SDL, self-directed learning.

Figure 12 Number of SDL sessions undertaken per day of SDL period



Number of SDL sessions undertaken per day of SDL period (for Cohort 1 and 2 combined), commencing on the Friday of MSU week. MSU, Mobile Simulation Unit; SDL, self-directed learning.

Survey Data

All participants were surveyed at enrolment regarding their motivation to participate in the study. The strongest influence on their decision to participate was the desire to learn new skills (average response = 4.69 on a 5-point scale where 1 = strongly disagree, 3 = neutral, and 5 = strongly agree) followed by an interest in surgical simulation (average response = 4.32) (See Table 8).

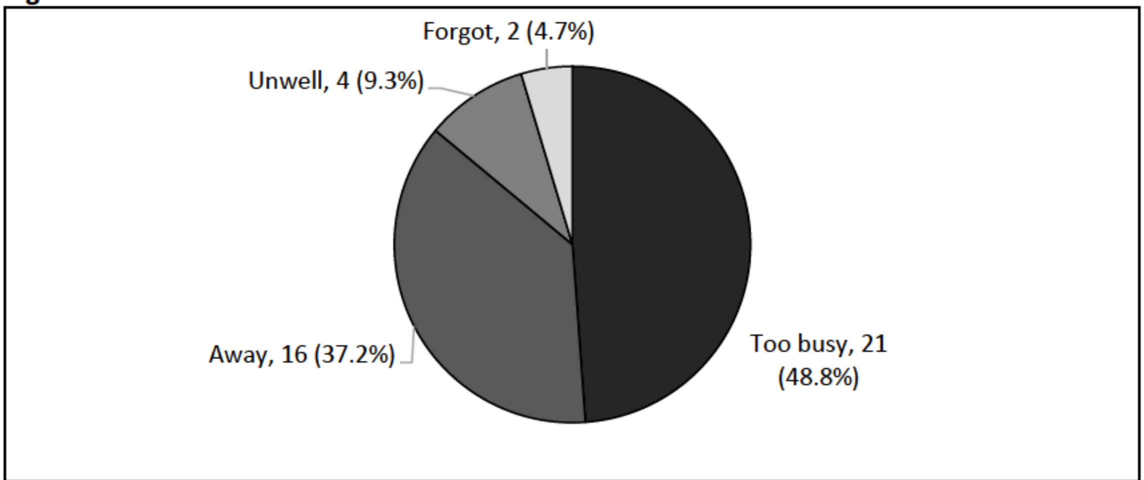
The post-course questionnaire was conducted in the MSU at final assessment, and distributed via email to all participants who did not attend. A total of 156 post-course questionnaires were returned. Participants agreed (average response = 3.92) that simulation training should become a mandatory part of the surgical curriculum, but that sessions should be rostered and provided in protected time (average response = 3.85). When given the choice of session times, the majority of participants would prefer sessions to be scheduled after work (52.6%: 81/154 respondents) or in a lunch break (33.8%: 52/154), and to be conducted at least once a fortnight (51.6%: 79/153) or once a week (35.3%: 54/153).

Table 8 Qualitative questionnaire responses

Pre-Course Questionnaire (total *n* = 207)						
Motivation for participation in the study	**SD**	**D**	**N**	**A**	**SA**	**Avg.**
Want to learn new skills (202)	0	0	1	60	141	4.69
Interested in surgical simulation (202)	0	0	16	105	81	4.32
Want to practice/refine skills (202)	2	2	45	73	80	4.23
Interested in a surgical career (201)	2	8	40	66	85	4.11
Don't have access to SBE equipment elsewhere (201)	2	14	55	88	42	3.77
Influenced by peers (202)	17	39	68	59	19	3.12
Influenced by supervisor (202)	37	50	62	35	18	2.74
Post-Course Questionnaire (total *n* = 156)						
Regarding the LSSP course	**SD**	**D**	**N**	**A**	**SA**	**Avg.**
I found it hard to dedicate time to attend SDL (154)	4	24	28	59	39	3.68
Regarding simulation training in general						
Simulated laparoscopic training should be a mandatory component of the surgical curriculum (153)	0	5	35	81	32	3.92
Simulated laparoscopic training should be rostered and in protected time rather than ad hoc (152)	1	12	26	83	30	3.85

Numbers in brackets represent the number of responses to the individual question. Avg., average response (where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree); D, disagree; LSSP, Laparoscopic Simulation Skills Program; N, neutral; SA, strongly agree; SBE, simulation-based education; SD, strongly disagree.

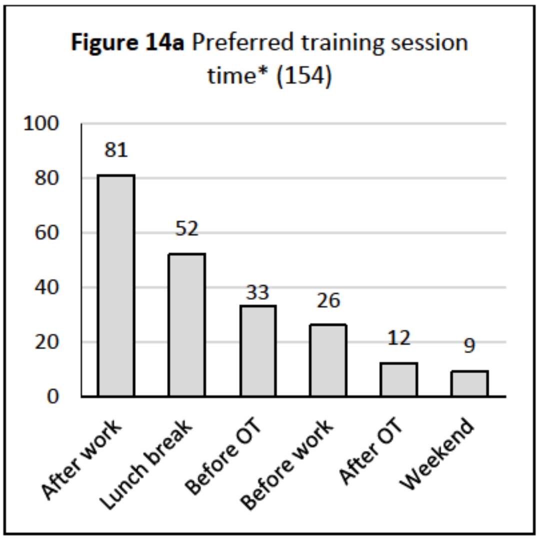
Figure 13 Reason for non-attendance at final assessment*

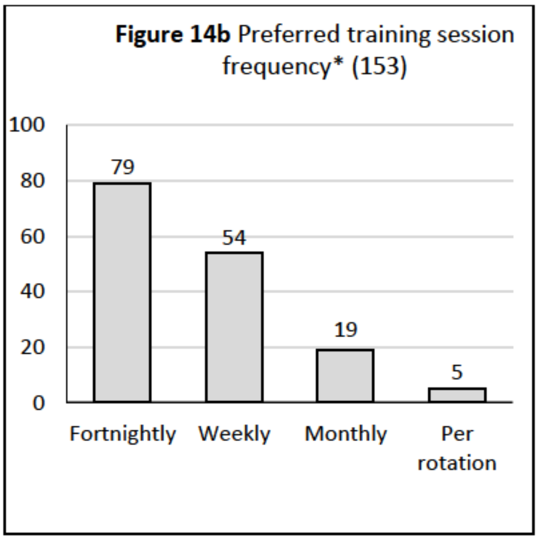


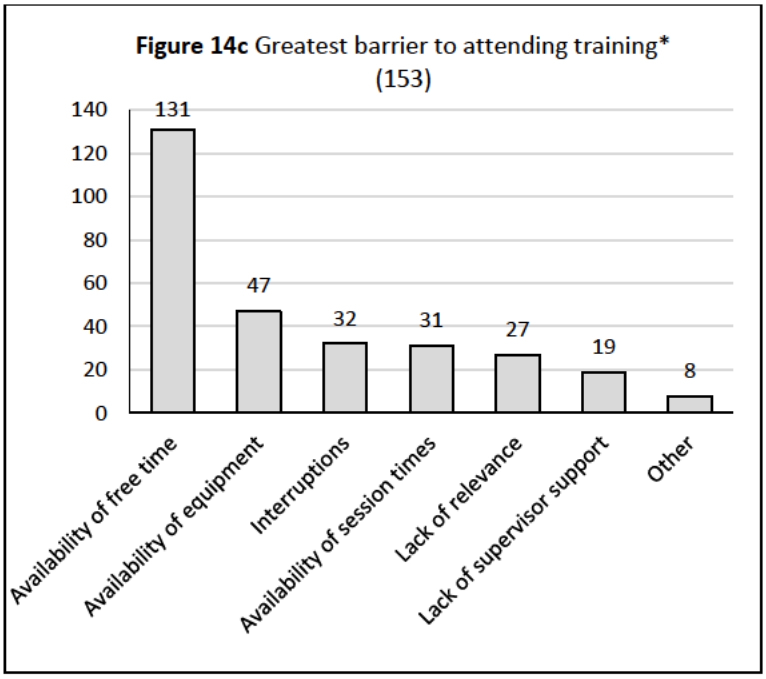
Pie chart showing the reason for non-attendance at the final assessment. *Survey response received from 43 of the 56 participants who did not attend final assessment.

In regards to attendance, many participants (average response = 3.68) found it hard to dedicate time to attend SDL, and the lack of available free time (due to clinical duties) was the greatest reported barrier to attendance at simulation training in general (85.6%: 131/153 respondents). It was also the main reason for non-attendance at the final assessment (48.8%: 21/43 respondents) (See Figure 13). Furthermore, when asked to rank eight different factors' influence on their decision to participate in simulation in general, session times and location of the simulator were more often ranked as the most important factors. See Figure 14 for participant preferences for training session scheduling and perceived barriers to attendance.

Figure 14 Participant preferences for simulation training sessions and perceived barriers to attendance







Numbers in brackets represent the number of respondents to the individual question. *Participants were able to select more than one response. OT, operating theatre.

DISCUSSION

Access to surgical simulation activities in Australia is limited. The LSSP presented a unique opportunity for participants to have access to simulation equipment that is not normally available, and to take part in free simulation training provided by an internationally recognised training body. The LSSP is one of the largest studies of its kind, which achieved relatively high participant retention rates for the final assessment and questionnaire. Participants enrolled because they were interested in surgical simulation and motivated to learn new skills. Nevertheless, on-going attendance at training sessions in both the MSU and SDL periods was highly variable, and often poor.

The study findings are consistent with other reported literature regarding voluntary attendance at self-directed simulation training.[66] The LSSP was an entirely voluntary project, with no incentives or rewards offered for those who trained. By nature of the recruitment process, those who enrolled were more likely to be motivated about learning new skills. However, a large proportion of participants failed to attend any training after their enrolment. Attendance at voluntary training is reliant on both an individual's intrinsic motivation as well as external factors.[66] Interestingly, a higher proportion of Cohort 1 participants returned for self-directed practice sessions compared to Cohort 2 participants. On average, these Cohort 1 participants also undertook a greater number of SDL practice sessions and greater number of task attempts compared to Cohort 2. These participants may have felt the need to make up for their inability to train during the MSU week. Overall, there was no significant difference found between cohorts at final assessment, with improvement in skill reliant on number of sessions attended rather than where the training took place.

The attendance results may have been influenced by the high proportion of participating medical students. At their current level of training, students are not required to have laparoscopic skills. Furthermore, a couple of site visits coincided with university holiday or examination periods, with many students understandably prioritising their time for exam study instead. Some students may have enrolled out of curiosity, with subsequent loss of interest, leading to completion of only the minimum assessment requirements. It should be noted, however, that the four participants who practiced the most (10 or 11 SDL sessions each) were actually medical students. Individual intrinsic motivation clearly plays an important role.

Although not formally recorded, it was noted by the trainers that many participants, particularly medical students, would enrol in pairs or encourage their friends to enrol later in the week. Participants who had enrolled in pairs often practiced together, regardless of their cohort allocation. A number of participants were motivated by friendly competition between their peers. These participants often trained more frequently and kept a record of their task completion times in addition to the required logbook data. The effect of competition on motivation to train has previously been investigated but was not was not found to have a great influence.[55,59]

Provision of personal training goals and proficiency standards, on the other hand, have been shown to motivate attendance,[28] and improve skills acquisition and retention.[72-74] Self-rating of performance can have a motivational effect and enables trainees to self-regulate their practice.[75] All participants in the LSSP were provided with written and verbal information regarding the proficiency standards for each task. The LSSP logbook did not require participants to record task completion scores, however if scores were recorded, it may have provided stimulus for participants to train more frequently.

Interestingly, although participants did not rank assessments as an important influence on their decision to participate in simulation in general, there was a recorded spike in SDL session attendance in the days immediately prior to the final study assessment. Assessments, even if formative, can be an effective incentive for training.[27,75,76] Periodical progress assessments could be introduced into a self-directed training program. This could help promote a more distributed practice routine, rather than 'cramming' prior to a final assessment. Trainees who fail to show skill improvement, or who fail to reach proficiency targets, could then be rostered to attend mandatory supervised remedial training sessions.[67] Participants in this study believed that simulation training should become a mandatory component of the surgical training curriculum regardless.

The majority of participants who did not attend the final assessment were doctors. In keeping with previously published literature,[66,77] participants reported the greatest barrier to attending the final assessment, as well as attending simulation training in general, was lack of available free time due to clinical responsibilities. Final assessment dates for each site visit were fixed, and a number of participants (mainly doctors) had enquired about arranging alternative assessment dates. These external factors confirm the importance of flexible training hours provided at a time convenient to the trainee. Training providers should consider trainee schedules when providing access to simulation or employing educators.[27] Any scheduled sessions should be targeted at times in the day when clinical duties tend to subside. Attendance and survey data support scheduling of sessions at lunch time, late afternoon or after a shift. Providing protected training time, where the trainee is relieved of clinical duties and interruptions during these times, is another important enabler for training attendance.[27]

There are many factors that impair trainees' ability to attend voluntary, self-scheduled, and self-directed learning on a regular basis. Instead of focussing on how trainees can fit simulation training on top of their current working week, more effort needs to be spent by training program providers to better integrate it into the core components of the training curricula. Mandating simulation training attendance is one of the only factors that have been found to improve attendance rates in the long term.[46,76,77] Whether the mandatory sessions are supervised or self-directed, rostered or self-scheduled, as well as defining what the minimum training requirements are, needs to be determined by the individual surgical units in consultation with their trainees. This would ensure the simulation program not only meets the requirements of those undertaking it, but also ensure that trainees actually have the motivation and the ability to attend.

Due to the heterogeneity of hospitals visited, and sometimes limited facilities available, it was not possible to standardise the room used for SDL training. While the majority of sites had 24-hour access to the simulators, a few sites were limited to access within office hours only, or required the participant to obtain a key from security in order to access the rooms after-hours. A number of participants reported that this hindered their ability to train when they wanted.

A potential limitation of the study is that unsupervised study may lead to the repetition and adoption of errors into practice. In an attempt to avoid mastering an error, all participants were given an introduction into each task and were able to practice it twice before their baseline assessment. They were also given the opportunity to ask questions and clarify technique during the introduction session. However, it was noted by the trainers at final assessment that some participants were still holding instruments incorrectly or making technical errors during their assessment.

Attendance at SDL training was self-reported, leading to occasional inconsistencies in recording session details (for example, SDL session duration disproportionally long compared to the number of task attempts made, and the loss of three logbooks belonging to participants who did actually train). If unsupervised self-directed training is to become a mandatory component of the surgical curriculum, training logs would need to be formalised to ensure accuracy, the achievement of which may be facilitated or impeded depending on the type of simulator used for training.

Despite achieving respectable overall enrolment numbers, enrolments from junior doctors was lower than anticipated. Advertising material was distributed by third parties to maintain the confidentiality of eligible individuals and prevent unfair influence from the LSSP researchers. It is consequently difficult to quantify the exact numbers of eligible individuals at each site visited, however it is likely that only a proportion of eligible junior doctors and SET and RANZCOG trainees enrolled. It is possible that the recruitment advertising material, in particular emails, were not read by eligible individuals due to the vast number of work-related emails an individual will receive each day. The researchers attempted to overcome this by using multiple advertising mediums, including social media and special interest groups. A number of doctors contacted the researchers to express interest in enrolling but were ultimately unable to do so due to work commitments or annual leave during the visitation dates.

CONCLUSIONS

Despite the best intentions of motivated participants, attendance at voluntary self-directed simulation training was highly variable, with a large proportion not practicing at all. Lack of available free time due to clinical responsibilities is still the greatest barrier to attending simulation training, meaning SDL on its own, is not a feasible option for laparoscopic skills training.

Ultimately, if self-directed training is to be integrated into the surgical curriculum, it needs to be implemented in conjunction with more formal training strategies such as additional rostered sessions, or periodical progress assessments to motivate self-scheduled practice. Providing mandatory sessions within protected time, taking into consideration trainee work schedules, would ensure availability, and were participants' preferred method for delivery of simulation training.

2.5 Participant Perceptions of the Laparoscopic Simulation Skills Program

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Overall Percentage (%)	70%		
Certification	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the principal author of this paper.		
Signature		Date	7/1/2018

CO-AUTHOR CONTRIBUTIONS

By signing the Statement of Authorship, each author certifies that:

- the candidate's stated contribution to the publication is accurate (as detailed above);
- permission is granted for the candidate to include the publication in the thesis; and
- the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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ABSTRACT

Introduction

Simulation based-education (SBE) has proven to be effective for skills development however current access to SBE within the Australian surgical training curriculum is poor. The Laparoscopic Simulation Skills Program (LSSP) was designed determine the best format for delivery of SBE to Australian surgical trainees, particularly in non-metropolitan areas. This article assesses participants' perceptions of the LSSP.

Methods

Medical students, junior doctors, and surgical and gynaecology trainees (n = 207) were randomised to undertake either a period of supervised training in a Mobile Simulation Unit followed by self-directed learning (SDL), or to a period of SDL only. Three basic laparoscopic skills tasks were practiced and assessed. A post-course qualitative survey was conducted to assess participants' perceptions of the course provided, and whether it met their needs.

Results

Positive feedback was received from the majority of the 156 survey respondents, with 96% reporting improved confidence in their basic laparoscopic skills. Training facilities met the participants' needs. While the SDL format was considered effective for skills development, participants found it difficult to allocate time to attend SDL, and there was a preference for more formal instruction. Participants believed that the course would most benefit pre-training doctors.

Conclusions

The LSSP provided a practical and convenient method to deliver simulation training to both rural and metropolitan training locations, and could be deployed on a rotational basis to each hospital. The LSSP course could be improved by formal scheduling of supervised training sessions in addition to SDL.

INTRODUCTION

Simulation based-education (SBE) is playing an increasingly important role in both medical and surgical education; it provides trainees with a safe environment to acquire, practice and maintain their skills. SBE is especially effective for technical surgical skills, with the training having been shown to be transferable to the operating theatre.[11,63] Indeed, SBE has now been incorporated as a compulsory requirement in numerous surgical training programs internationally. One example is the introduction of the Fundamentals of Laparoscopic Surgery program by the American College of Surgeons.[78]

In Australia and New Zealand, surgical training is known as the Surgical Education and Training (SET) program, and it is provided by the Royal Australasian College of Surgeons (RACS).[43] Trainees accepted into SET within Australia are allocated to one of five national training regions, and rotate every six months between different metropolitan, outer metropolitan and rural hospitals within that region. There is currently no national standard for access to surgical SBE in Australia, and no fully-integrated surgical SBE programs for SET trainees exist. Access to SBE activities typically depend on local resources. In a previous survey conducted by RACS, 63% of SET trainees and 43% of surgical supervisors reported no access to SBE activities at their site of employment.[79,80] As a consequence, trainees, especially those outside of metropolitan areas, often have to leave work to attend SBE that is usually only provided at larger metropolitan locations.

The Laparoscopic Simulation Skills Program (LSSP) was designed to determine the best format for delivery of a simulated laparoscopic skills training course, particularly in rural and outer metropolitan locations. An important part of the project was to understand the needs and perceptions of those who would ultimately be undertaking the course. This article examines participants' perceptions of the quality and feasibility of the course delivered.

METHODS

Participants

Medical students, junior doctors (interns and resident medical officers (RMOs)), as well as surgical and gynaecology trainees were invited to participate.

Training intervention

The LSSP was implemented in ten hospitals across metropolitan Adelaide, and rural South Australia and Victoria between June 2015 and November 2016. A total of 17 site visits were completed, including repeat visits to several individual hospitals.

In 2009 RACS purchased a large commercial Mercedes-Benz Sprinter van and converted it internally to resemble a dry skills centre.[49] This van, known as the Mobile Simulation Unit (MSU) has previously been utilised in several studies and has been found to be as effective as a fixed-site simulation centre.[81] The MSU (Figure 15) was set up at each hospital for one working week to enrol participants, and for trainers to demonstrate the correct performance of three basic laparoscopic skills tasks: peg transfer, pattern cutting and intra-corporeal knot tying using basic, box-trainer style laparoscopic simulators.[37]

Participants were randomised into one of two cohorts using sealed envelope methodology. Cohort 1 participants undertook self-directed learning (SDL) only and did not have any further access to the trainers in the MSU. Cohort 2 participants were invited to return to the MSU for supervised training and feedback for one week, as well as participate in the SDL period. At the conclusion of MSU week, the simulation equipment was set up at each site for a period of three weeks for all participants to undertake SDL. Participants were provided with verbal and written information on the proficiency standards and performance of each task, as well as a supply of training consumables.

Skills assessments were performed in the MSU at baseline (on enrolment), at the end of MSU week (Cohort 2 only), as well as at the end of the three-week SDL period.

Figure 15 The Mobile Simulation Unit

Qualitative evaluation

A post-course questionnaire was conducted to record participant's perceptions on the quality of the course delivered. Questions included but were not limited to: perceptions of the training facilities and level of supervision, on-going feasibility of the LSSP, and who the course would be most appropriate for. The majority of questions were in Likert-scale format (ranking level of agreement on a 5-point scale, where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree), as well as multiple choice answers. The questionnaire was conducted in the MSU at the time of the final assessment, and was also emailed to participants who did not attend the final assessment. Results are presented as proportions or percentages and, where applicable, average scores are also provided.

Ethical considerations

Written informed consent was obtained from all participants. Ethics approval was granted by the Human Research Ethic Committee at the Queen Elizabeth Hospital (HREC/15/TQEH/76) under National Mutual Acceptance (NMA). Individual ethics approval was granted by individual hospitals where NMA was not recognised.

RESULTS

A total of 156 questionnaires were completed by the 207 participants who enrolled in the LSSP (Cohort 1: *n* = 81; Cohort 2: *n* = 75). It is important to note that not all participants answered every question adequately (for example, some participants missed all or part of a question). Only data from the questions that were answered sufficiently have been included. The number of sufficient responses has been identified per question.

Level of support provided

As shown in Table 9, nearly all (98.6%: 71/72) of the participants who undertook supervised training agreed or strongly agreed that they received good support (average response = 4.65 on a 5-point scale, where 5 = strongly agree), and this additional support aided in their skill development (average 4.58). A large proportion of the overall participants (72.0%: 108/150) believed that the SDL training was sufficient for their needs. However, many would have liked more formal coaching (average 3.63). Of the participants who would have liked more formal coaching, the majority (63.2%: 55/87) were from Cohort 1 and had access to SDL only.

Table 9 Perceptions regarding the LSSP and level of support provided

Question/Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Avg.
I was provided with sufficient support during MSU training (72†)	0	0	1	23	48	4.65
The addition of MSU training aided in my skill development (71†)	0	0	3	24	44	4.58
Direct coaching improves my skill acquisition (153)	0	2	12	55	84	4.44
SDL training was sufficient for my training needs (150)	2	16	24	68	40	3.85
I would have liked more formal coaching (153)	0	22	44	55	32	3.63

Numbers in brackets represent the number of responses to the individual question. †Question applied to Cohort 2 participants only. Avg., average response, where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree; MSU, Mobile Simulation Unit; SDL, self-directed learning.

Equipment and facilities

Overall, the training location and facilities provided during both the MSU and SDL training periods met the participants needs (average 4.43 and 4.34 for MSU and SDL facilities, respectively) (see Table 10). Over 95% (146/153) agreed or strongly agreed that the simulators were both easy to use (average 4.45), and that the tasks were appropriate for their level of training (average 4.42). However, many participants (64.1%: 98/153) found it difficult to dedicate time to attend SDL training sessions (average 3.68).

Training outcomes and ongoing feasibility

Overwhelmingly 96.1% (148/154) of participants agreed or strongly agreed that the LSSP course improved their confidence in regards to basic laparoscopic skills (average 4.34). Participants were motivated (average 3.93) and would continue to use the simulators regularly if available at their workplace (average 4.08) (see Table 11). The majority (79.2%: 122/154) of participants believed SDL is an effective way to develop basic laparoscopic skills (average 3.97), and that on-going participation would be useful (88.9%: 137/154 agreed or strongly agreed, average 4.20).

However, participants were slightly less likely to think on-going participation would be feasible (average 3.88).

Table 10 Perceptions regarding the equipment and facilities

Question/Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Avg.
I thought the simulators were easy to use (153)	0	0	7	70	76	4.45
The consumables supply was sufficient for my training needs (153)	0	3	10	58	82	4.43
MSU met my needs (e.g. noise levels, comfort, location) (145)	0	0	7	68	70	4.43
The simulator tasks were appropriate for my level of training (153)	0	0	7	75	71	4.42
I was able to book session times which suited my schedule (153)	1	4	15	53	80	4.35
The SDL location met my needs (e.g. noise levels, comfort) (152)	0	3	14	64	71	4.34
During SDL, the location of simulation equipment was easily accessible (151)	1	12	15	57	66	4.16
I found it difficult to dedicate time to attend SDL (e.g. due to work/social commitments, supervisor unwilling to allow time) (154)	4	24	28	59	39	3.68

Numbers in brackets represent the number of responses to that question. Avg., average response, where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree; MSU, Mobile Simulation Unit; SDL, self-directed learning.

Table 11 Perceptions regarding training outcomes and on-going feasibility

Question/Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Avg.
Participation in this course has given me more confidence when it comes to my ability to perform basic laparoscopic skills (154)	0	1	5	89	59	4.34
Participation in this program would be useful on an ongoing basis (154)	0	3	14	86	51	4.20
I would continue to use the simulators regularly if made available at my workplace (154)	1	8	20	74	51	4.08
Self-directed learning is an effective way to develop surgical skills (154)	1	9	22	84	38	3.97
I felt motivated to want to continue SDL (154)	0	9	29	80	36	3.93
Participation in this program would be feasible on an ongoing basis (154)	1	6	33	85	29	3.88

Numbers in brackets represent the number of responses to that question. Avg., average response, where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree; SDL, self-directed learning.

Cost of enrolment

Participants were asked whether or not they would enrol in the LSSP course if they had to pay. As shown in Table 12, participants would not be willing to pay more than $50 (AUD) to enrol in this course.

Table 12 Perceptions regarding cost of enrolment

Question/Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Avg.
I would have enrolled in this course if it had cost me $50	6	33	20	67	28	3.51
I would have enrolled in this course if it had cost me $100	25	55	31	34	9	2.66
I would have enrolled in this course if it had cost me $150	45	66	27	15	1	2.10
I would have enrolled in this course if it had cost me $200	69	58	15	11	1	1.81

Avg., average response, where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree.

Target trainee population

Participants felt that pre-SET RMOs (i.e. doctors intending on entering surgical training, but not yet in the SET program) would be the group most likely to benefit from the LSSP course, followed by surgical interns. The LSSP course was not deemed to be useful for more senior SET trainees (see Table 13).

Table 13 Perceptions regarding target trainee population

Question/Statement (141) †	Yes	No
This course is most appropriate for surgical interns	84	57
This course is most appropriate for Pre-SET RMO	106	35
This course is most appropriate for SET 1-2	72	69
This course is most appropriate for SET 3-4	16	125
This course is most appropriate for SET 5	9	132

†Participants were able to select more than one answer. RMO, Resident Medical Officer (pre-training doctor); SET, Surgical Education and Training (year levels 1-5)

DISCUSSION

The aim of the LSSP was to determine how best to deliver simulation-based training within the Australian SET curriculum, particularly to trainees in non-metropolitan training locations. The LSSP course was designed as a self-scheduled, self-directed, simulated basic laparoscopic skills course intended to fit around a participants' regular working week. This format was chosen to provide greater participant flexibility as previous research identified that clinical duties and other interruptions form one of the greatest barriers to regular SBE attendance.[66] Enabling a more distributed training pattern has also been found to improve skill acquisition and retention.[20]

In general, study participants gave positive feedback regarding their experience and reported improved confidence in their basic laparoscopic skills. Overall, participants agreed that SDL can be an effective means for learning surgical skills. However, the majority of participants reported their skill acquisition improved when directed coaching was provided, with a large proportion preferring more formal instruction. This was especially true for Cohort 1 participants who did not have access to supervised training. Those who did train within the MSU believed that the supervision aided in their skills acquisition.

The majority of participants were motivated to want to continue SDL but still found it difficult to allocate time to attend. While participants thought on-going participation in the LSSP course would be useful, they were slightly less likely to think on-going participation would be feasible. These results reinforce the importance of providing formally scheduled and supervised training sessions in addition to self-scheduled SDL.[66] Supervised training and feedback is particularly essential at the commencement of training, as well as intermittently during training itself, to avoid the acquisition of bad habits and to reinforce what has been learnt.[42]

The MSU met participants' needs with regards to comfort and location for training. Although there were logistical aspects, such as parking location and power source access, which needed to be considered, the MSU was readily welcomed at each site. The MSU is easily deployed and quick to set up, making it an ideal alternative training location when other infrastructure and resources are limited. Hospitals could consider combining funding and resources to establish an SBE program utilising the MSU on a rotational basis.

The SDL room was provided by local staff within the sites visited. The room location and size varied between sites, depending on the local facilities. The overall response from participants regarding SDL facilities was positive. They valued having access to simulation equipment at their site of employment. These results are comparable to previous studies,[55,58] and indicate that formal training facilities or simulation laboratories are not necessary; as long as the trainees can be free from clinical interruptions and extended access hours are available.

The LSSP course used simple box-trainer simulators to teach basic laparoscopic skills including depth perception, instrument handling and co-ordination. Importantly this course was able to compensate for the diverse range of participants' previous surgical experience, with a large proportion of participants finding the simulators easy to use and the tasks appropriate. Participants believed the LSSP course would be most appropriate for pre-SET RMOs and surgical interns. Previous studies have found that more senior trainees often prefer higher fidelity training simulators, such as a virtual reality simulator or live animal models, in order to practice whole or part-procedures rather than skills tasks.[77] The content of future simulation programs could be altered to accommodate senior trainees and teach more advanced skills tasks or surgical procedures.

Costs associated with training are also an important factor to consider when developing training programs. While SDL may mitigate costs associated with employing trainers and scheduling supervised training sessions, the facilities and resources (i.e. consumables) required for on-going training can potentially result in significant costs. All training consumables were supplied, and enrolment was at no cost to the participant. Results found that the probability of future enrolment dropped significantly with increasing cost for enrolment. Participants were not willing to pay more than $50 (AUD) to enrol if the course was offered outside of the project; noting this amount is unlikely to cover costs of consumables let alone on-going running costs. These results may be affected by the fact that the majority of participants were medical students, who, in addition to not currently requiring the skills being taught, may also have a limited income. Furthermore, the LSSP course was implemented as a voluntary research project, and as such, no formal qualifications or university credit were awarded for participation. Participants enrolled for personal interest only, and may have been more willing to pay if they received formally recognised qualifications in return. Nevertheless, if the LSSP course was to be implemented long-term, costs of training may need to be subsidised by the training provider or employer.

The ability to generalise the findings discussed in this paper may be limited by the high proportion of participating medical students. As students, they may not have complete insight into the needs of trainees, and therefore the usefulness or feasibility of the LSSP course. However, as potential future surgical and gynaecological trainees, their opinions should still be considered.

While every attempt was made to standardise the SDL training rooms, locations were limited by the facilities available at each site. Although the majority of sites provided 24-hour access to the simulators, a small number were only available within office hours, or required participants to obtain a key for after-hours access. There were a few participants who reported being hindered by these shorter access hours.

CONCLUSIONS AND RECOMMENDATIONS

As a result of the post-course survey this research has been able to confirm the appropriateness of the implemented LSSP training program. Participants found practice in either the MSU or during the SDL period assisted in the development of their technical skills.

The MSU provides a practical and convenient format to deliver simulation facilities to both rural and metropolitan training hospitals and could be deployed on a rotational basis. While participants believed SDL is an effective way to develop basic laparoscopic skills, they preferred a more formal, supervised teaching format. Self-scheduled SDL sessions do not completely mitigate the barriers associated with busy work schedules. On-going feasibility of the LSSP course could be improved if the supervised training sessions within the MSU were rostered, and protected time was provided for SDL sessions. Costs of training would need to be subsidised by the training provider or employer in order to achieve enrolments.

2.6 An Analysis of Preferences for the Delivery of Surgical Simulation Training

STATEMENT OF AUTHORSHIP

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CO-AUTHOR CONTRIBUTIONS

By signing the Statement of Authorship, each author certifies that:

- the candidate's stated contribution to the publication is accurate (as detailed above);
- permission is granted for the candidate to include the publication in the thesis; and
- the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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Overall Percentage (%)	40%		
Certification	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the first co-author of this paper.		
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ABSTRACT

Objective

To report on participants' perceptions on the utility of simulation-based education (SBE), their preferred SBE format, and how to improve accessibility.

Background

SBE has evolved as an effective tool to address the learning needs of healthcare professionals. Although many courses have proven to be beneficial, the optimum format for the delivery of simulated laparoscopic skills training remains unknown.

Methods

Medical Students, junior doctors, and surgical and gynaecology trainees were invited to participate in the Laparoscopic Simulation Skills Program. Participants were asked to complete qualitative questionnaires to obtain their perceptions of surgical SBE, and preferences for the format of training delivery.

Results

Participants agreed that there were benefits of laparoscopic SBE. What motivated them to participate in simulation course was the time of the sessions, the location of simulators and the cost of the training. They noted a preference for the course being held in their workplace, with structured sessions, and feedback. In addition they noted that a course should be promoted by their employer as mandatory. The biggest barrier for their participation in SBE however, was lack of time.

Conclusions

It is important to consider participants perspectives when developing and implementing SBE activities. The results of this study give a better insight into the needs and preferences of participants with regard to the ideal format for training delivery, and the barriers associated with access to training. A commitment is needed from training providers to focus on participant needs to overcome these barriers and thus ensure optimum training outcomes.

INTRODUCTION

Medical and surgical education have changed. The classical 'see one, do one, teach one' philosophy has become increasingly hard to practice. Ethics and medical politics have made it clear that patient safety must be the priority, and surgical training is no exception.[12,82,83] Simulation-based education (SBE) has evolved as an effective tool to address the learning needs of healthcare professionals while maintaining the health and safety of patients. The quality and size of published evidence showing the utility of SBE and its role in the acquisition of both technical and non-technical surgical skills has grown exponentially. Many educational programs have examined how medical students, trainees and qualified doctors need a safe environment in which to learn new skills.[11,63,84,85] In surgical education, especially laparoscopy training, SBE is playing an increasingly important role.[86-88] Although many simulated skills courses have proven to be beneficial,[12,85] the optimum format for the delivery of laparoscopic simulation training is still unclear.

To address this ambiguity, the Royal Australasian College of Surgeons (RACS) implemented the Laparoscopic Simulation Skills Program (LSSP). The aim of the LSSP was to determine the best format for delivery of simulated laparoscopic skills training. In this program, a questionnaire was used to record participants' perceptions on the utility of laparoscopic simulation training, barriers and motivators for attending training, as well as preferences for SBE delivery. The results of this survey are presented in this article.

METHODS

Participants

Medical Students, Interns, Resident Medical Officers (RMOs), and trainees from the RACS Surgical Education and Training (SET) program and The Royal Australian and New Zealand College of Obstetricians and Gynaecologists (RANZCOG) were invited to participate.

Intervention

A post-course questionnaire was used to record participant's perceptions on each of the following topic areas:

- The utility of laparoscopic SBE
- Elements of a successful simulation skills program
- Barriers to accessing simulation skills training

This questionnaire included a combination of Likert-scale, multiple-choice, and ranking questions, as well as short answer sections.

Ethical considerations

Written informed consent was obtained from all participants. Multi-site ethics approval was granted by the Human Research Ethics Committee at the Queen Elizabeth Hospital (HREC/15/TQEH/76); where this approval was not recognised local site approvals were obtained. Research Governance Approval was obtained from all hospitals prior to site access.

RESULTS

A total of 207 participants enrolled in the project and 156 (75%) completed the post-course questionnaire; the frequency of respondents per participant type is listed in Table 14 below.

Table 14 Response frequency by participant type

Participant type	Number of respondents
Medical Students	105
Interns	23
Resident Medical Officers (RMOs)	21
SET & RANZCOG Trainees	7

RANZCOG, Royal Australian and New Zealand College of Obstetricians and Gynaecologists; SET, Surgical Education and Training.

It is important to note that not all participants answered each question adequately (for example, some participants failed to answer all or part of a question), therefore only those responses that sufficiently answered the question have been included (and are reported in the analyses).

The utility of laparoscopic SBE

Participants were provided with a series of statements regarding the utility of laparoscopic SBE. They were asked to indicate their level of agreement with these statements using a five-point Likert scale (where 1 was 'Strongly disagree', 3 was 'Neutral' and, 5 was 'Strongly agree'). The frequency of these responses and their average score is provided in Table 15 below.

Table 15 Participants' perspectives of laparoscopic SBE

Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree	Avg.
Surgical trainees and consultants should be required to demonstrate proficiency on a laparoscopic simulator before operating on patients when it comes to using new instruments and technologies (i.e. staplers, graspers, implants and other devices) (154)	1	7	16	88	43	4.06
Surgical trainees should be required to demonstrate proficiency on a laparoscopic simulator before being allowed to operate on a patient (155)	1	4	29	81	40	4.00
Laparoscopic skills learnt in the simulation laboratory are transferable to the operating theatre (155)	0	1	31	96	27	3.96
Laparoscopic skills learned in the simulation laboratory are comparable to those learnt in the operating room (155)	0	9	63	72	11	3.55
Time spent participating in laparoscopic simulation can replace time spent in the operating room (154)	14	74	51	13	2	2.45

Numbers in brackets represent the number of responses to the individual question; MSU, Mobile Simulation Unit; SDL, self-directed learning; Avg., average Likert-scale response, where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree. SBE, Simulation Based Education.

Results clearly indicate a positive perception of the utility of simulation-based laparoscopic training. A total of 79% (123/155) of participants either 'agreed' or 'strongly agreed' that skills learnt in simulation laboratories are transferrable to the operating theatre (average response

3.96). In addition, 78% (121/155) of participants either 'agreed' or 'strongly agreed' that trainees should demonstrate proficiency on a laparoscopic simulator before being allowed to operate on a patient (average 4.00). Moreover, 85% (131/154) of participants either 'agreed' or 'strongly agreed' that surgical trainees and consultants should demonstrate proficiency on a laparoscopic simulator before operating using new instruments or technologies (average 4.06).

It was also identified, however, that participants do not perceive simulation training alone as the only answer. Participants were less likely to agree (average 3.55) that the skills learnt on the simulator are comparable to those learnt in the operating theatre (only 53%: 83/155 'agreed' or 'strongly agreed', whereas 41%: 63/155 were 'neutral'). More than half (57%: 88/154) of the participants did not believe that time spent training on a simulation can replace time spent training in theatre (average 2.45).

Elements of a successful simulation skills program

Motivators

Participants were asked to rank, from most important 1 to least important 8, factors that may influence their decision to participate in a simulation skills program. Table 16 lists each influencing factor, and is ranked in descending order according to the average score.

Table 16 Factors influencing decisions to participate in simulation training*

Influencing Factor	Average score
Timing of sessions (e.g. in rostered time/protected time/in own time/study leave)	3.31
Location (e.g. on site of current rotation vs. off-site)	3.85
Cost involved to the individual	3.92
Part of Assessments (e.g. formative/summative assessments)	4.24
Mandatory participation	4.72
Consultant recommendation to attend	4.99
Type of simulator available for use (bench-top, virtual reality, mixed model, etc.)	5.39
Eligibility for Continuing Professional Development points.	5.59

*Noting answers were ranked from 1 to 8, where 1 was the most important and 8 the least important. 138 responses were used in this analysis. (Average score: total score / number of responses)

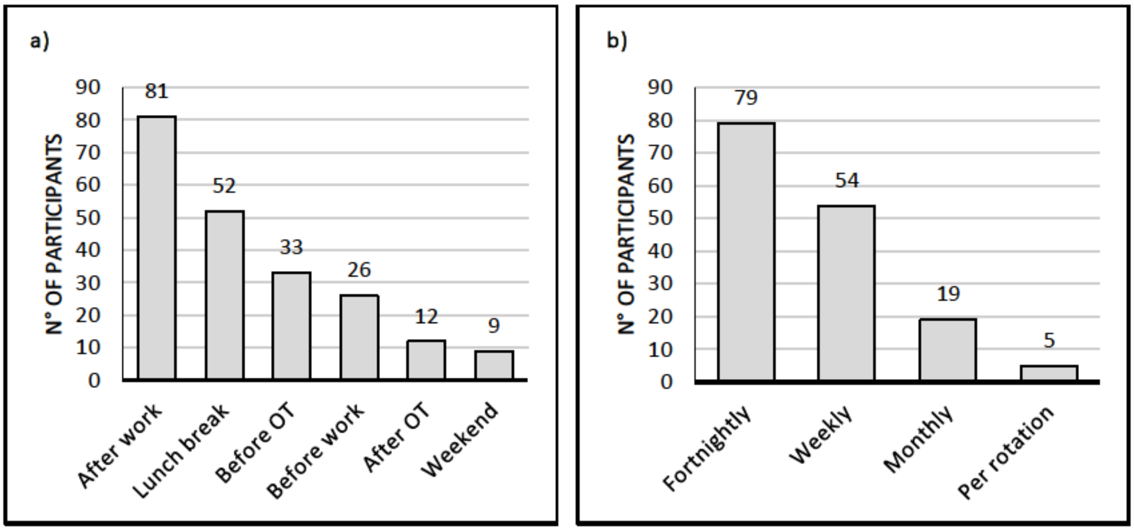
Results identified that 'timing of sessions', the 'location of the training' and 'cost' were considered the greatest influence on a participants' motivation to attend simulation training.

Scheduling

Two multiple choice questions were used to identify participant preferences for the timing and frequency for scheduling simulation training. (See Figure 16)

If simulated laparoscopic training was included in their working week, the majority of participants (52.6%: 81/154) would prefer sessions to be scheduled 'After Work'. The 'Weekend' was the least preferred option (5.8%: 9/154). Participants were asked to identify what they believed would be the optimum frequency for this type of training. Participants had a preference for 'Fortnightly' sessions (50.3%: 79/157); this was followed by 'Weekly' (35.3%: 54/153), 'Monthly' (12.1%: 19/157), and lastly by, 'Per rotation' (3.2%: 5/157) sessions. It should be noted that participants were able to select more than one option for each of the above questions.

Figure 16 Preferred training session times (a) and frequency (b)



Note: Participants were able to select more than one response. OT, operating theatre. N°, number.

An ideal laparoscopic skills course

Participants were asked what they believed constituted an ideal laparoscopic skills course. Again, participants were required to state their level of agreement with each statement using a five-point Likert scale where 1 was 'Strongly disagree', 3 was 'Neutral' and, 5 was 'Strongly agree'. (See Table 17)

Participants indicated that location of training was an important factor to consider (average response 4.54), as was providing rostered sessions in protected time (to ensure availability to attend) (average 3.85). Participants were neutral regarding paying for the simulation training themselves (average 3.10).

Although participants agreed that fortnightly training sessions would be useful (average 4.03), they were slightly less likely to think that fortnightly sessions would be feasible (average 3.61). Nearly three-quarters (74%: 113/153) of participants supported the use of mandatory simulation training (average 3.92); however, they believed voluntary training would not necessarily lead to reduced participation.

Participants had a preference for structured teaching sessions with feedback (average 4.25) compared to a self-directed learning format (average 3.32). In general, they did not have a strong opinion either way regarding a group training environment (average 2.94).

Barriers to accessing simulation skills training

Participants were asked to provide their opinions regarding the barriers affecting participation in simulation training. This involved selecting one or more options from a multiple choice question. Table 18 lists the options given to participants, ranked from most popular to least popular according the number of participants who selected each response.

A total of 153 participants responded to this question, and a total of 295 responses were given, noting that participants were able to select more than one option. Overwhelmingly, availability of free time (or lack of it) was seen as the greatest barrier for attendance with 86% (131/153) of respondents selecting this option.

Table 17 Ideal elements of a laparoscopic skills course

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Avg.
I would be more likely to attend simulation training when held at my site of employment/training (153)	0	0	2	66	85	4.54
When learning new technical skills, I prefer structured teaching and feedback (153)	0	2	17	75	59	4.25
Having weekly/fortnightly mandatory sessions would be useful as part of my employment and training (153)	0	3	21	97	32	4.03
Simulated laparoscopic training should be a mandatory component of the surgical curriculum (153)	0	5	35	81	32	3.92
Simulation sessions should be protected time (e.g. no pagers or other interruptions) and rostered rather than ad hoc (152)	1	12	26	83	30	3.85
Having weekly/fortnightly mandatory sessions would be feasible as part of my employment and training (153)	0	13	50	74	16	3.61
I would be less likely to participate if simulated laparoscopic training is voluntary (153)*	8	65	40	36	4	2.76
When learning new technical skills, I prefer to plan my own teaching & learn at my own pace (e.g. SDL) (153)	2	27	54	60	10	3.32
I would be willing to pay for simulated laparoscopic skills training sessions myself (153)	5	40	50	51	7	3.10
I learn better in a group environment (153)	3	49	60	36	5	2.94

Avg., average Likert-scale response; SDL, self-directed learning.
Responses have been ranked according to average Likert-scale score (where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree).
*As this question is negatively stated, the 'disagree' and 'strongly disagree' has been considered; this results in a double negative, i.e., a positive, thereby enabling its' correct ranking amongst the other questions. Numbers in brackets represent the number of responses to the individual question.

Table 18 Barriers to participation in simulation training

Barrier to participation in simulation training	Number (%) who selected this response
Availability of free time to participate	131 (85.6)
Availability of equipment	47 (30.7)
Interruptions (i.e. pagers, phone calls)	32 (20.9)
Availability of sessions times	31 (20.3)
Lack of relevance to my practice	27 (17.6)
Lack of support from Supervisors	19 (12.4)
Other*	8 (5.2)

*For example, other costs associated with surgical training, general motivation.

DISCUSSION

SBE has become an important tool for the training of healthcare professionals. In surgery, SBE has proven to be effective with skills acquired in a simulated environment being transferable to the operating theatre.[11,12,86] The utility of simulation, especially for laparoscopic skills training, is now widely recognised,[12] and the above results indicate that the participants of this study support these views. It was the general opinion of participants that trainees should be able to demonstrate proficiency on a laparoscopic simulator before operating on patients, as well as before using any new instruments or technologies. Although participants did not believe that time spent training on simulators could replace clinical time spent in theatre, there is no doubt that in times of demanding curricula, time constraints and laws ensuring patient safety, there is a need as well as a demand to supply medical students, junior doctors and trainees with an additional, safer learning environment.[12,82,83]

When developing SBE training programs, it is important to consider factors that may inhibit participant´s ability or motivation to train, and to implement strategies to address these factors. This research identified that the timing of sessions was considered as the most important factor influencing motivation to participate in SBE. Similarly, lack of available time was seen as the greatest barrier. Tight schedules, busy shifts and time constraints are often reported in the literature as having a negative impact on training attendance.[66,89,90] It is perhaps not surprising that participants preferred training format revolved around minimising interruptions and maximising availability: rostered rather than ad hoc sessions; scheduled after work rather than during a shift; and, structured teaching with feedback (which may improve training efficiency). In addition, attendance at fortnightly sessions is more likely to be achievable than weekly sessions, while still providing regular practice time. It has been reported that scheduling training sessions within protected time and declaring mandatory training attendance associated with punitive measures for poor attendance may increase the participation and SBE course completion rates.[66,90,91] This would be a strategy supported by participants in this study.

Location of the training was selected as the second most important factor impacting participation. As time constraints inhibit participation when simulation training is held on-site,[91] busy surgical trainees are even less likely to be able to spare time to attend training held off-site. To better facilitate attendance, every effort should be made to provide simulation training at the trainees' site of employment, whether that be in a purpose-built simulation centre, in a quiet room away from clinical interruptions, or in a mobile training facility.

The cost of the training for the individual, although less important, was still an important influence for participation in training. This finding might be explained by the high proportion of medical students in the study sample. Nevertheless, if the SBE was to become a mandatory component of training, costs my need to be subsidised by the employer or training provider.

Interestingly the type of simulator available and the eligibility for Continuing Professional Development (CPD) points were not ranked as important influencing factors for participation. Once again, this may be explained by the junior level of training of the study participants, with CPD points usually being more relevant at advanced educational levels. These results are in contrast to previous research showing that simulator type is important, with more advanced trainees preferring live models and junior trainees preferring more basic models.[77]

Limitations

Two limitations to this study were identified. Firstly, although the study achieved good participant retention, not all participants who enrolled in the study completed the post-course questionnaire, therefore their opinions remain unknown. Secondly, medical students made up a large proportion of participants. They may lack knowledge regarding the demands of surgical training and the skills needed in the operating theatre. Their opinion might be biased through this lack of experience.

CONCLUSIONS

Participants had a positive perception of the utility of laparoscopic simulation based training and reported that the lack of available free time limited their commitment in SBE activities. Participants clearly identified a format of training they believed would be most beneficial; this included mandatory SBE sessions delivered in protected time, at their site of employment, with structured teaching and feedback. There is no doubt that motivators are fundamental in the success of a training course, but its compulsory incorporation as part of the working week could be the critical factor to assure attendance. For the successful delivery of SBE, it is imperative to ensure the support and commitment of training providers and employers in order to implement strategies to overcome the barriers to training identified by this study.

2.7 Recruitment Barriers in Surgical Education Research

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CO-AUTHOR CONTRIBUTIONS

By signing the Statement of Authorship, each author certifies that:

- the candidate's stated contribution to the publication is accurate (as detailed above);
- permission is granted for the candidate to include the publication in the thesis; and
- the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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Overall Percentage (%)	40%		
Certification	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the first co-author of this paper.		
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BACKGROUND

In surgical education research, enrolment of a sufficient number of surgeons is vital for the successful implementation of projects. The Royal Australasian College of Surgeons (RACS) is conducting a multi-centre project investigating the efficacy and feasibility of a simulated laparoscopic skills course – titled the Laparoscopic Simulation Skills Program (LSSP). The primary target population for recruitment to the LSSP are surgical trainees and junior doctors, yet their enrolment and participation has been low compared to other eligible groups.

It has been reported that motivators for doctors participation in clinical research correlates to their desire to update their own knowledge and the possibility of helping patients.[89] Our project has focussed on the first of these motivators and we have continuously refined communication processes to better engage, enrol and retain our target population. We describe the benefits and pitfalls of the engagement methods used by the LSSP to provide prospective researchers with strategies to improve enrolment of doctors in future research.

STRATEGIES AND IMPLICATIONS

Official Contact

Initial contact has been made via Officers in Medical and Surgical Administration and Medical Education. Officers are asked to distribute (via email) recruitment information using group distribution lists.

Pros

Mass email targets large populations quickly and easily. Moreover, using formal channels can add credibility to the project.[92] This method maintains the confidentiality of prospective participants, minimising any influence researchers may have regarding enrolment.

Cons

Email distribution depends on local staff being available and willing to assist. Also, work email inboxes can become overloaded with multiple emails, many of which may not be relevant to the individual, risking the recruitment email being overlooked or ignored. We found that not all doctors check their work email frequently. Therefore emails need to be distributed early to ensure they are read before recruitment closes, noting that if sent too early, the information may be forgotten.

Advertising Flyers

Advertising flyers outlining basic project details and participant eligibility criteria were created. These flyers have been emailed to Officers in Medical and Surgical Administration and Medical Education at each hospital and a request made for the flyers to be posted in areas visited by potential participants.

Pros

Designed to be simple and informative, flyers attract potential participants' attention at multiple locations. They can act as a recurrent reminder for individuals to enrol.

Cons

Posting of flyers relies on either researchers or local hospital staff availability. If posted by local hospital staff, there is a risk of inappropriate placement or not getting posted at all. As a popular advertisement strategy, flyers can also saturate notice boards. Flyers can remain unnoticed by the target group, or can attract the wrong people (for example patients or other health workers).

Local Consultant Involvement

Support of local hospital Consultants or training Supervisors can be an important influence on trainee participation.[92]

Pros

Informing Consultants about research that could have benefits for their junior doctors, may allow junior doctors to be temporarily released from their clinical obligations to participate. Consultants can also help "spread the word" during Departmental meetings.

Cons

It is not always feasible to contact individual Consultants prior to research commencing. The participation of junior doctors could be discouraged if the Consultant considers the research to be unhelpful or irrelevant. On the other hand, if individuals are influenced to participate by their Consultant without a real interest in the project, they may withdraw from, or lack commitment to, project requirements.

Word-Of-Mouth

Word-of-mouth has been a strong influencing factor for participation in the LSSP. We encourage participants to spread the word among their peers at every opportunity (when responding to enquiries, at the time of enrolment, and during practice sessions).

Pros

This method is easy, quick and free. The information given by enthusiastic peers could sound more appealing. It can also reach populations that the previous methods did not. For example an enrolled surgical trainee may encourage their junior doctors or medical students to enrol. Word-of-mouth enables researchers to reach social networks indirectly, with some participants uploading project information on personal social network groups.[93]

Cons

This method depends on the willingness of participants, and their ability to transmit information accurately and motivate others.

Social Media

Social media has taken on a greater role within many social and professional special-interest groups. We have been able to contact the local medical school surgical society groups to upload information on their web and social media pages.

Pros

Social media is popular amongst all professional levels and offers a quick and free method of accessing group members. Researchers can target groups that share an interest in the research topic.[94]

Cons

The uploading of project relies on assistance from the administrators of those groups. Knowledge of existing special interest social media groups is also necessary.

Face-to-Face Recruitment

This method has been characterised by spontaneous visits to the simulation van by curious individuals previously unaware of the LSSP.

Pros

If performed by the researchers, it ensures the correct information is distributed, and interested individuals can immediately enquire regarding the project. It has the potential to reach a large audience if directed at the target group (for example, at a Department meeting).

Cons

This method is especially contingent on access and opportunity. It can be time consuming if performed one-on-one. If performed by a third party, there is a risk that incorrect or incomplete information is delivered.

CONCLUSION

Although surgical trainees and junior doctors are likely to benefit the most from this research project, obtaining adequate number of participants has been difficult. Difficulty lies in conveying the benefits of a research project to the motivators of individuals. Through the course of the LSSP, we have implemented and revised several strategies to improve engagement. The approaches reported above enabled LSSP project researchers to increase the number of, and level of activity amongst our target population. Researchers should be aware of the need to use several recruitment methods simultaneously, and to be flexible in their approach towards engaging with the participant motivators.

CHAPTER 3: SIMULATION FOR NON-TECHNICAL SKILLS TRAINING

3.1 Overview

For centuries, surgical practice has focussed on acquisition of expert technical skills. Reviews of adverse events in hospitals, however, have demonstrated that most incidents are a result of failure in communication and other non-technical skills, rather than technical proficiency.[95]

Consequently, in the 2000s, non-technical skills training began to be incorporated into surgical programs internationally, and in 2008, the Royal Australasian College of Surgeons (RACS) introduced non-technical skills competencies into the SET curriculum. In 2013, a study enrolling then current surgical trainees was undertaken to investigate the efficacy of a didactic course for the training in non-technical skills. Participants were assessed using during an operating theatre team simulated scenario. The scenarios were recorded and stored on a RACS database. In 2014, these scenarios were repeated, this time enrolling qualified surgeons. A retrospective analysis of the video-data was undertaken to compare the non-technical skills of SET trainees with that of experienced surgeons who trained prior to the introduction of SET. The aim of this study was to assess the effect of years of professional experience on non-technical skills, and whether or not ongoing non-technical skills training is required.

In addition to ensuring patient safety, non-technical skills are also essential for the effective functioning of inter-professional relationships. During the implementation of the LSSP, the issue of discrimination, bullying, harassment and sexual harassment (DBSH) within the Australian surgical profession was brought to the national and international headlines.[96] While RACS has already developed a number of programs to educate against DBSH,[97-99] it is still an issue that needs to be addressed further. With this in mind, a subsequent non-technical skills study was undertaken, again analysing video-data of team simulations, but this time focussing on the surgeon's response to harassment of a colleague. The aim of this study was to assess whether or not surgeons intervene during episodes of harassment, and if SBE may have a role in the future education and training of surgeons for the eradication of DBSH.

The following subchapters contain articles presenting the findings of the above research, both of which have been published.

3.2 Non-Technical Skills of Surgical Trainees and Experienced Surgeons

STATEMENT OF AUTHORSHIP

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PRINCIPAL AUTHOR

Name of Principal Author	Hannah Gostlow		
Contribution to the Paper	Conception of the work, data acquisition, analysis and interpretation, manuscript writing and critical revision, and acted as corresponding author.		
Overall Percentage (%)	80%		
Certification	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the principal author of this paper.		
Signature		Date	8/1/2018

CO-AUTHOR CONTRIBUTIONS

By signing the Statement of Authorship, each author certifies that:

- the candidate's stated contribution to the publication is accurate (as detailed above);
- permission is granted for the candidate to include the publication in the thesis; and
- the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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Contribution to the Paper	Data acquisition and evaluation of manuscript.		
Signature		Date	15/01/18

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Contribution to the Paper	Supervised conception of the work, and manuscript evaluation and critical revision.		
Signature		Date	8/1/2018

ABSTRACT

Background

In addition to technical expertise, surgical competence requires effective non-technical skills to ensure patient safety and maintenance of standards. Recently the Royal Australasian College of Surgeons implemented a new Surgical Education and Training (SET) curriculum that incorporated non-technical skills considered essential for a competent surgeon. This study sought to compare the non-technical skills of experienced surgeons who completed their training before the introduction of SET with the non-technical skills of more recent trainees.

Methods

Surgical trainees and experienced surgeons undertook a simulated scenario designed to challenge their non-technical skills. Scenarios were video recorded and participants were assessed using the Non-Technical Skills for Surgeons (NOTSS) scoring system. Participants were divided into subgroups according to years of experience and their NOTSS scores were compared.

Results

For most NOTSS elements, mean scores initially increased, peaking around the time of Fellowship, before decreasing roughly linearly over time. There was a significant downward trend in score with increasing years since being awarded Fellowship for six of the 12 NOTSS elements: considering options (score –0.015 units per year), implementing and reviewing decisions (–0.020 per year), establishing a shared understanding (–0.014 per year), setting and maintaining standards (–0.024 per year), supporting others (–0.031 per year) and coping with pressure (–0.015 per year).

Conclusion

The drop in NOTSS score was unexpected and highlights that even experienced surgeons are not immune to deficiencies in non-technical skills. Consideration should be given to continuing professional development programmes focusing on non-technical skills, regardless of the level of professional experience.

INTRODUCTION

Traditionally, surgical curricula have been directed at the acquisition of theoretical knowledge and technical skills.[100] It is now recognised that surgical competence requires more than just technical expertise to ensure patient safety and maintenance of standards.[101-103] Analysis of adverse events in healthcare has found that many errors originate from failure in communication and other cognitive and social skills, rather than failure of technical skill.[95,103,104] Skills in leadership, decision-making, situational awareness, and communication and teamwork (otherwise known as non-technical skills) have long been a part of formal training in other high-risk professions such as aviation and anaesthetics.[104] The importance of this formal training has gathered greater awareness among the surgical profession, and non-technical skills are now taking on a larger role within surgical curricula.[105,106]

The Royal Australasian College of Surgeons' (RACS) Surgical Education and Training (SET) program consists of 4–6 years of surgical training, depending on the surgical specialty. After completing the mandatory internship and Resident Medical Officer (RMO) years (typically three years), trainees are eligible to enter the SET program. Trainees are awarded Fellowship of the RACS at the completion of SET. In 2008, a new SET curriculum was implemented incorporating nine core competencies considered essential for a skilled surgeon.[43] This change acknowledged the importance of non-technical skills in surgical practice, with four of the nine core competencies based on these skills.[107]

In 2013, a single-blinded, randomised study[108] was conducted to investigate the effect of a didactic non-technical skills training workshop on the Non-Technical Skills for Surgeons (NOTSS) score of surgical trainees undertaking simulated scenarios within a functional operating theatre. Participants in the study were assessed using the previously validated NOTSS scoring system.[109] Based on findings from this research, a second study was conducted using the same simulated scenario, and assessed the non-technical skills of experienced surgeons who completed their training before the introduction of SET. The present study sought to compare the NOTSS scores of the experienced surgeons with the trainees' scores to measure the relationship between years of professional surgical experience and the NOTSS score.

METHODS

This study used video data available from two research projects involving a common simulated scenario. The original study by Pena and colleagues,[108] undertaken between April and July 2013, was conducted within functioning operating theatres at two metropolitan teaching hospitals in Adelaide, Australia. An e-mail was distributed to all SET trainees and recent Fellows inviting them to participate in the study. Notices were also posted on e-bulletin boards at the participating hospitals. Participants in the original study completed an introductory simulation session before being assessed on a different scenario using the NOTSS scoring system (forming their baseline score). One cohort subsequently undertook a non-technical skills training workshop,[110] before all participants were reassessed. To ensure the present comparison was equitable, only the trainees' baseline NOTSS scores were used in the present analysis.

The second study was conducted in an immersive simulated operating theatre constructed during the RACS Annual Scientific Congress, Singapore, in May 2014. Conference delegates were invited to attend the simulation sessions and participate in the study. These participants undertook the same scenario that was used for the baseline assessment of trainees, and were also assessed using the NOTSS scoring system.

Trainees were eligible to participate in the original study if they had no previous experience with operating room simulation for non-technical skills training. No restrictions were placed on the experienced surgeons with regard to previous non-technical skills training.

Ethics approval was granted for each study by the RACS Human Research Ethics Committee (original study EC0028729, approved 4 March 2013; second study EC0028731, approved 17 February 2014). Informed, written consent was obtained from all participants.

Simulated scenario

The simulated scenario required participants to take over as the operating surgeon for the closure of an emergency trauma laparotomy. Soon after entering the room, the simulated patient would begin to deteriorate and blood transfusion was required. This was complicated by the possibility that the patient was a Jehovah's Witness. During the scenario, a series of other stressors (such as distractions, interruptions and team factors relating to communication) were introduced. The roles of anaesthetist, scrub nurse, surgical consultant and circulating/scout nurse were played by scripted confederates. Confederates were assigned roles similar or identical to their real occupations to give the scenario more fidelity. The scenario was created by experts in surgery, anaesthetics, nursing and psychology, and was designed to challenge participants' non-technical skills. Although the scenario was of a trauma laparotomy, technical expertise was not required or assessed. The scenario was tested independently on volunteer surgeons before the start of the original study. The non-technical skills assessed during the scenario are applicable to all surgical specialties. Details of the scenario are available in Appendix D.1.

Following the simulation session, participants received a 20–30-min one-on-one structured debriefing session facilitated by a general practitioner with expertise in the field of human factors. Each simulation session was video recorded and the videos were stored on a RACS database.

Data collection

Table 19 Non-Technical Skills for Surgeons (NOTSS) taxonomy, version 1.2

Situational Awareness	Decision-Making	Communication and Teamwork	Leadership
Gathering information	Considering options	Exchanging information	Setting and maintaining standards
Understanding information	Selecting and communicating options	Establishing a shared understanding	Supporting others
Projecting future state	Implementing and reviewing decisions	Coordinating team activities	Coping with pressure

All elements are scored on a four-point scale: 1, poor (performance endangered or potentially endangered patient safety, serious remediation is required); 2, marginal (performance indicated cause for concern, considerable improvement is needed); 3, acceptable (performance was of satisfactory standard but could be improved); 4, good (performance was of a consistently high standard, enhancing patient safety; it could be used as a positive example for others). Alternatively, the element could be scored 'not applicable' or 'not observed'. Maximum possible total score is 48. Adapted from Flin et al.[111]

The video recordings were reviewed independently by two assessors after each data collection phase had been completed. Videos from the original study (2013) were assessed separately from those of the second study (2014), and the NOTSS scores stored on the RACS database. The same assessors, one consultant surgeon and one human factors expert, performed the assessments for both studies. Both assessors completed the RACS NOTSS course[110] for training in the NOTSS scoring tool before the video recordings were evaluated. Table 19 outlines the four NOTSS categories; situational awareness, decision-making, communication and teamwork, and leadership. Each of the four categories contain three elements that are assigned a score based on a four-point scale (1, poor; 2, marginal; 3, acceptable, 4, good). The maximum possible NOTSS score is 48.[111]

Statistical analysis

Sample size for the present analysis was based on enrolments in the previous studies. Inter-rater reliability was assessed using Gwet's Agreement Coefficient 2 (AC2)[112] using linear weights, and each of the 12 NOTSS elements was assessed separately. Inter-rater reliability scores differed slightly for each NOTSS element. In general, one assessor tended to score slightly higher than the other. The mean of the two assessors' scores was used for the analysis. Full reporting of inter-rater reliability is available in Appendix D.2. All statistical analyses were undertaken in the statistical software R (v.3.2.2).[113]

Trainees were categorised into 'junior' (SET 1–4) and 'senior' (SET 5 to 3 years after Fellowship). To compare junior versus senior trainees, a mixed-effects model was fitted to each participant's mean score using the lme4 package. The fixed effects in this model consisted of the SET level group, 12 NOTSS elements and their interaction, while the participants were modelled as random effects to take into account the correlation between NOTSS element scores for each individual.

Experienced surgeons were classed as 'junior' and 'senior', referring to 0–20 and more than 20 years respectively after being awarded Fellowship. A mixed-effects model similar to that for trainees was fitted.

Mean NOTSS scores were analysed with regard to years since being awarded Fellowship; SET trainees were assigned a negative value for this variable. For example, SET year 1 trainees were assigned a value of –6 to denote that they still had 6 years of training (on average) before being awarded Fellowship. Fellows were allocated a numerical value equal to their years since Fellowship. A separate restricted cubic spline was fitted to years since Fellowship for each NOTSS element. The question of whether there is a decrease in the average score for each NOTSS element after Fellowship could not be answered from the previous, non-liner models. Consequently, a similar mixed-effects model with linear trend for years since Fellowship, instead of a restricted cubic spline, was fitted to data for participants who had achieved Fellowship (including those within the first 3 years of award).

RESULTS

Participants in the first study (herein referred to as trainees) comprised 40 surgical trainees: 32 SET year level 1–6 trainees and eight surgeons who had been awarded RACS Fellowship in the previous 3 years (2009–2012). Participants in the second study consisted of 30 experienced surgeons who obtained RACS Fellowship between 3 and 40 years previously. Demographics of the two groups are shown in Table 20.

Table 20 Participant demographics

	Trainees (*n* = 40)	**Experienced surgeons** (*n* = 30)
Sex ratio (M : F)	34 : 6	25 : 5
Training level		
SET 1	8	–
SET 2	10	–
SET 3	4	–
SET 4	1	–
SET 5	8	–
SET 6	1	–
Fellow (1–3 years)	8	–
Time since obtaining Fellowship (years)		
≤ 10	–	9
11–20	–	3
> 20	–	18
Experience (years)*	–	22.1 (22.5, 3–40)
Specialty		
Cardiothoracic surgery	1	1
ENT surgery	2	5
General surgery	22	16
Neurosurgery	2	1
Orthopaedic surgery	2	2
Plastic surgery	3	2
Urology	4	0
Vascular surgery	4	1
Paediatric surgery	0	2

*Values are mean (median, range) time since award of Fellowship. ENT, otorhinolaryngology; SET, Surgical Education and Training.

Junior versus senior trainees

A summary of the mean score per NOTSS element for each trainee subgroup is provided in Table 21. The interaction between SET level group and NOTSS elements was statistically significant (*P* = 0.002). Senior trainees (SET 5–6/junior Fellows) generally achieved higher scores than the junior trainees (SET 1–4) with the exception of situational awareness – gathering information and leadership – supporting others. The degree of difference in score varied for each NOTSS element, ranging from 0.05 (communication and teamwork – establishing shared understanding) to 0.39 (leadership – coping with pressure).

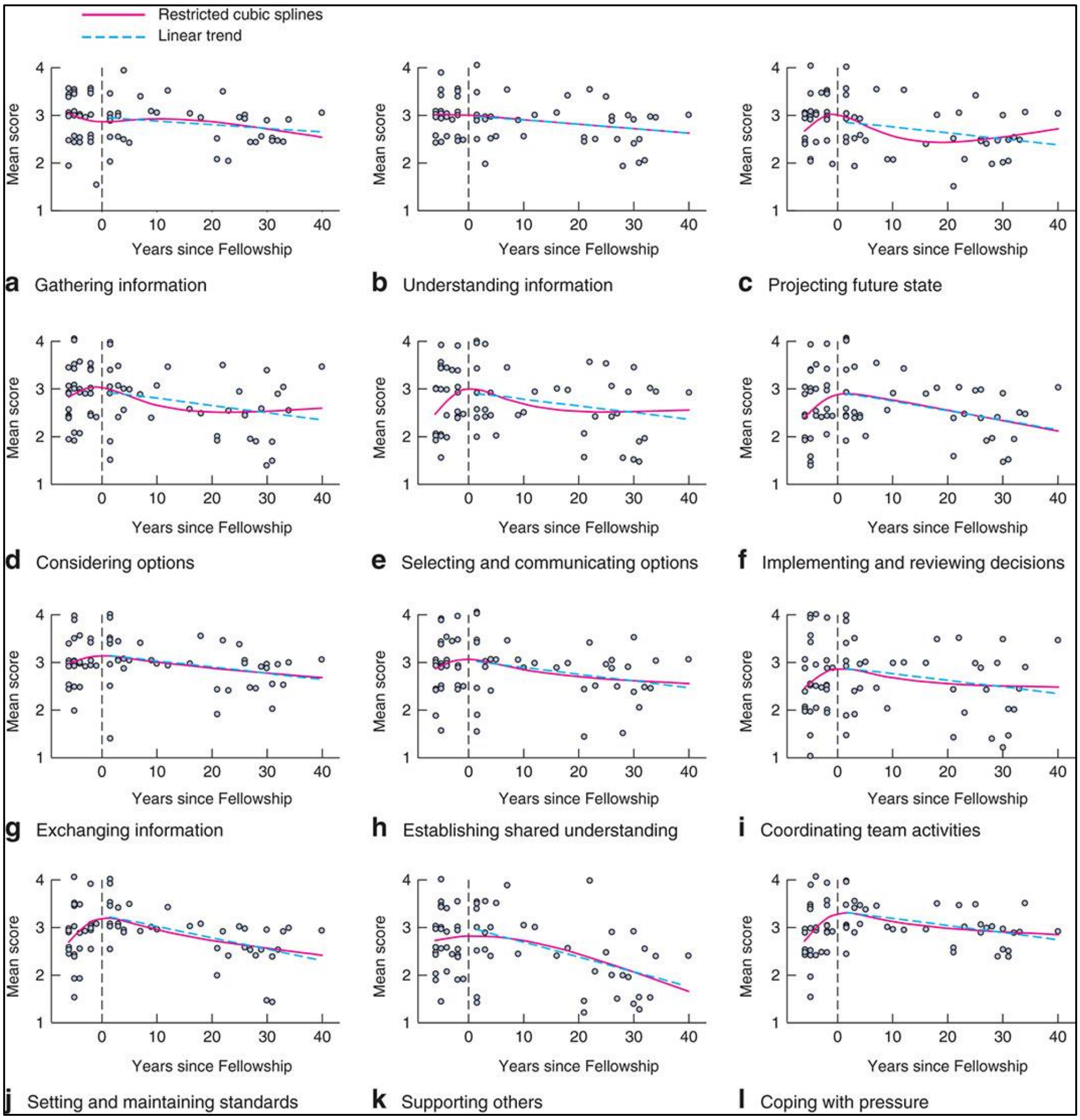
Junior versus senior experienced surgeons

The interaction between the experienced surgeon group and NOTSS elements was statistically significant (*P* = 0.008). Senior experienced surgeons achieved lower scores than the less experienced surgeons for all NOTSS elements (Table 21). The degree of difference in score varied for each NOTSS element, ranging from –0.88 (leadership – supporting others) to -0.16 (situational awareness – understanding information).

Effect of years since achieving Fellowship

A scatter plot of the mean scores for each NOTSS element versus years since being awarded Fellowship showed that generally there was a small increase in mean NOTSS score as trainees progressed towards Fellowship (Figure 17). For most NOTSS elements, this increase peaked at, or shortly after, being awarded Fellowship and then decreased roughly linearly over time. The

Figure 17 Scatter plot of the mean NOTSS scores versus years since Fellowship



Scatter plot of the mean Non-Technical Skills for Surgeons (NOTSS) scores versus years since being awarded Fellowship for each participant in the categories a–c situational awareness, d–f decision-making, g–i communication and teamwork and j–l leadership. Black dashed line indicates time of award of Fellowship; points to the left of this line denote Surgical Education and Training (SET) trainees; points to the right denote experienced surgeons. Fitted model curves (restricted cubic splines) are shown (solid red line), along with linear trend lines based only on years after Fellowship (dashed blue line).

peak and subsequent drop in NOTSS score was most evident in decision-making – selecting and communicating options and leadership – setting and maintaining standards.

For comparison and interpretation, the mixed-effects model was refitted using a separate linear trend for years after Fellowship for each NOTSS element, using only scores for all Fellows. A summary of the intercept and slope for the fitted regression lines for each NOTSS element is shown in Table 22, and the fitted lines (linear trend) are displayed in Figure 17. There was a significant linear trend in NOTSS score with increasing number of years since award of Fellowship for six of the 12 NOTSS elements. For decision-making, two of the three elements dropped significantly: implementing and reviewing decisions (mean score decreased by 0.020 units per year of experience, or 0.20 units for every 10 years) and considering options (–0.015 per year). One communication and teamwork element (establishing a shared understanding) decreased significantly (–0.014 per year). Scores for all three elements of the leadership category dropped

Table 21 Summary of Non-Technical Skills for Surgeons scores for trainees and experienced surgeons

	Mean (SD) NOTSS score					
	Trainees			Experienced surgeons		
	SET 1–4	SET 5–6/ Fellow*	Diff.	0–20 years†	> 20 years†	Diff.
Situational Awareness						
Gathering information	3.00(0.45)	2.85(0.55)	–0.15	3.04(0.45)	2.69(0.39)	–0.35
Understanding information	3.02(0.38)	3.09(0.44)	0.07	2.88(0.43)	2.72(0.46)	–0.16
Projecting future state	2.78(0.52)	3.06(0.50)	0.28	2.67(0.54)	2.50(0.49)	–0.17
Decision-Making						
Considering options	2.91(0.63)	3.00(0.66)	0.09	2.88(0.38)	2.50(0.64)	–0.38
Selecting and communicating options	2.63(0.73)	2.97(0.62)	0.34	2.83(0.54)	2.50(0.73)	–0.33
Implementing and reviewing decisions	2.53(0.73)	2.91(0.67)	0.38	2.83(0.49)	2.33(0.57)	–0.50
Communication and Teamwork						
Exchanging information	3.04(0.52)	3.15(0.58)	0.11	3.13(0.23)	2.78(0.43)	–0.35
Establishing shared understanding	2.98(0.57)	3.03(0.72)	0.05	3.00(0.21)	2.61(0.58)	–0.39
Coordinating team activities	2.61(0.81)	2.88(0.76)	0.27	2.79(0.50)	2.47(0.78)	–0.32
Leadership						
Setting and maintaining standards	2.83(0.60)	3.18(0.47)	0.35	3.13(0.23)	2.56(0.48)	–0.57
Supporting others	2.80(0.60)	2.71(0.69)	–0.09	2.96(0.50)	2.08(0.77)	–0.88
Coping with pressure	2.87(0.61)	3.26(0.50)	0.39	3.25(0.26)	2.92(0.35)	–0.33

*Between 1 and 3 years since obtaining Fellowship; †since obtaining Fellowship; Diff., difference; NOTSS, Non-Technical Skills for Surgeons; SET, Surgical Education and Training.

Table 22 Summary of intercept and slope for fitted regression lines

	Intercept	Slope
Situational awareness		
Gathering information	2.97 (2.67, 3.26)	–0.008 (–0.022, 0.007)
Understanding information	3.00 (2.71, 3.29)	–0.009 (–0.023, 0.005)
Projecting future state	2.89 (2.59, 3.18)	–0.013 (–0.027, 0.002)
Decision-making		
Considering options	2.97 (2.68, 3.26)*	–0.015 (–0.030, –0.001)*
Selecting and communicating options	2.94 (2.65, 3.23)	–0.014 (–0.028, 0.000)
Implementing and reviewing decisions	2.96 (2.66, 3.25)*	–0.020 (–0.034, –0.006)*
Communication and teamwork		
Exchanging information	3.19 (2.89. 3.48)	–0.013 (–0.027, 0.001)
Establishing shared understanding	3.06 (2.77, 3.35)*	–0.014 (–0.029, 0.000)*
Coordinating team activities	2.92 (2.63, 3.22)	–0.014 (–0.028, 0.000)
Leadership		
Setting and maintaining standards	3.28 (2.99, 3.58)*	–0.024 (–0.038, –0.010)*
Supporting others	3.01 (2.72, 3.31)*	–0.031 (–0.045, –0.017)*
Coping with pressure	3.36 (3.07, 3.66)*	–0.015 (–0.029, –0.001)*

Values are intercept and slope, with 95 per cent confidence intervals in parentheses, for the linear regression of mean scores versus years since obtaining Fellowship. *Significant result based on confidence interval excluding zero.

significantly: setting and maintaining standards (–0.024 per year), supporting others (–0.031 per year) and coping with pressure (–0.015 per year). There was no significant decrease in score for any of the elements of situational awareness.

Interaction of non-technical skills training and experienced surgeons

Nearly half of the participating experienced surgeons (13 of 30) had undertaken previous non-technical skills training. The restricted spline model was applied as above and allowance made for shift of the curve (per NOTSS element). There were no significant differences in mean NOTSS scores for those who had versus those who had not previously undertaken non-technical skills training (*P* = 0.320).

DISCUSSION

The NOTSS score peaked shortly after being awarded Fellowship, and then generally dropped as years of experience increased; this was an unexpected finding. The authors believe that the difference between NOTSS scores for experienced surgeons and trainees is largely an indication of a shift in medical and surgical education, rather than a true deterioration in skill.

Trainees were excluded from participating in the original study if they had undertaken formal non-technical skills training. However, senior trainees still scored higher than junior trainees – indicating that new SET curriculum has a beneficial effect on non-technical skills development. Although the older generation of surgeons was raised in an environment where non-technical skills were not encouraged specifically, the importance of non-technical skills is now embedded in the core competencies of the new SET curriculum.[107] SET trainees are assessed repeatedly on their non-technical skills during the SET selection process, as well as in ongoing formative and summative assessments throughout training itself. Additionally, simulation training, including team simulation, has taken on a larger role in undergraduate and postgraduate clinical education. Greater familiarity with simulation in general may also have had an impact on NOTSS scores.

Scores for the elements considering options, and implementing and reviewing decisions are determined by involving all team members in discussion regarding an alternative course of action, as well as updating all team members if there is any change in plan. The significant decrease in score for these elements of decision-making indicates that more experienced surgeons may not be seeking the opinions of other team members, informing team members of potential problems, reconsidering their plan when conditions change, or calling for help when required. This is also reflected in the significant drop in score for communication and teamwork – establishing shared understanding, which requires the surgeon to encourage input from all team members and to make sure the whole team is comfortable with the decisions being made. The more experienced surgeons may be used to working in situations where they make the final clinical decision or where there may be limited additional staff (for example, there may be no other senior experienced surgeon available to call for help). The awarding of points for the elements of decision-making is reliant on the surgeon explicitly articulating their thought processes. For experienced surgeons, decisions are often made implicitly. Trainees on the other hand, typically operate alongside their supervisor, even when they are performing as the primary operating surgeon. Consequently, they are more likely to work in an environment where they need to explain their clinical reasoning, ask for guidance, or have the supervisor take over in a crisis.

The significant decrease in score for all three elements of the leadership category (including the 2 elements with the overall greatest drop) is perhaps the most concerning. Traditionally, the surgeon has been recognized as the leader of the operating theatre team;[106] however, the desirable qualities of a good leader are changing. The NOTSS system favours a newer, more horizontal leadership structure, with emphasis placed on allowing all team members to take part in the decision-making process and encouraging them to speak up if they have any concerns. The NOTSS leadership elements promote the importance of teamwork among individuals within the operating theatre team through proper introductions (setting and maintaining standards), therefore allowing appropriate delegation of tasks (supporting others, coping with pressure), support of colleagues (supporting others) and tailoring their leadership style to the needs of the team (supporting others). The two leadership elements with the greatest drop (setting and maintaining standards, supporting others) are essential skills for an experienced surgeon when considering their interactions with surgical trainees. Formal leadership training is rarely conducted, but its importance continues to grow as emphasis on non-technical skills training increases.

A score of 1 indicates poor performance for that NOTSS element. According to the NOTSS system, this performance 'endangered or potentially endangered patient safety and serious remediation is required'.[111] A score of 2 is still considered marginal and indicates cause for concern. A number of participants received these low scores. There is a clear need for non-technical skills training even beyond the awarding of Fellowship. This begs the question of the optimum format for delivery of non-technical skills training to surgeons throughout their career. Research has tended to focus on the validity and feasibility of specific non-technical skills assessment tools, whereas quantitative evidence regarding the actual method of delivery is lacking.[102,114] Similarly, although the challenge in teaching non-technical skills to qualified surgeons has been recognized for some time,[100] literature surrounding all forms of training has focused on surgical trainees and medical students rather than qualified surgeons.

Interestingly there was no statistically significant difference in scores between participating experienced surgeons who had completed non-technical skills training and those who had not. Although some training courses may increase knowledge about non-technical skills, more needs to be done to translate this awareness into practice. Pena and colleagues[108] found that a didactic non-technical skills training course was not effective in improving trainees' NOTSS scores over simulation-based training alone. In that study, both cohorts of trainees who undertook simulated scenarios followed by one-on-one debriefing sessions showed a significant improvement in performance from baseline to final assessment for all NOTSS categories in two of three scenarios.[108] This supports the evidence that the efficacy of simulation-based training relies on structured debriefing sessions.[115,116]

Attention is now shifting to more proactive training methods, such as surgical coaching, that incorporate the theories behind structured debriefing. The coach works in collaboration with the learner surgeon to recognize, set and achieve personal learning goals.[117,118] This allows the learner to maintain autonomy over their learning, and preserve an image of authority – important factors to consider if non-technical skills training is to be accepted among experienced surgeons.[119]

Experienced surgeons may feel that non-technical skills training is not important (that non-technical skills are not needed) or that training is unnecessary (that they already have adequate non-technical skills).[100] If non-technical skills assessment and training is performed exclusively for the purpose of remediation, there is a risk that surgeons will reject the intervention for fear of humiliation. Greater uptake may be achieved if non-technical skills training is implemented as part of a mandatory department-wide, quality assurance program, rather than singling out individuals for remedial training.[119]

The present analysis may be limited by the sample size and reliance on a pre-existing data set. In addition, further information on the non-technical skill training undertaken by some experienced surgeons may have added to the analysis. It was not possible to analyse the effect of type of non-technical skills training or how long ago it was undertaken, and whether or not any skills gained from this training subsequently deteriorated over time. Participant exclusion criteria differed slightly between the original and second study. Trainees in the original study had undertaken an introductory simulation session before being assessed. Although familiarity with the simulation set-up may have had a small influence on their baseline score, the introductory scenarios differed significantly in content and are unlikely to have had any 'train to the test' effect. Furthermore, by undertaking both intragroup (junior versus senior) as well as intergroup (trainee versus experience surgeon) comparisons, the alterations in skill levels per cohort are accurate and their comparison is valid. The effect of sex on NOTSS score was not explored in this study.

Although a statistically significant decrease in NOTSS score was noted between junior and senior experienced surgeons, the clinical significance of this finding remains to be determined. However, it has been established previously that many adverse events in healthcare can be attributed to failures in non-technical skills such as situational awareness and communication.[95] Further research would need to be conducted within the live operating theatre environment to determine the effect of specific non-technical skills training programs on clinical outcome. Prospective, longitudinal studies would be required to investigate whether there is any formal decline in non-technical skills over the course of a surgeon's career, and whether recurrent training is required.

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3.3 Do Surgeons React? A Retrospective Analysis of Surgeons' Response to Harassment of a Colleague During Simulated Operating Theatre Scenarios

STATEMENT OF AUTHORSHIP

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Name of Principal Author	Hannah Gostlow		
Contribution to the Paper	Conception of the work, data acquisition, analysis and interpretation, manuscript writing and critical revision, and acted as corresponding author.		
Overall Percentage (%)	60%		
Certification	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the principal author of this paper.		
Signature		Date	7/1/2018

CO-AUTHOR CONTRIBUTIONS

By signing the Statement of Authorship, each author certifies that:

- the candidate's stated contribution to the publication is accurate (as detailed above);
- permission is granted for the candidate to include the publication in the thesis; and
- the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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MINI ABSTRACT

Discrimination, bullying, harassment and sexual harassment are problematic in the surgical profession. Using a simulated theatre scenario, this study assesses surgeons' reactions to harassment of a colleague. Results confirm the need for increased education and training in this area.

ABSTRACT

Objective

To assess and report on surgeons' ability to identify and manage incidences of harassment.

Background

The Royal Australasian College of Surgeons is committed to driving out discrimination, bullying, harassment and sexual harassment from surgical training and practice, through changing the culture of the workplace. To eradicate these behaviours it is first critical to understand how the current workforce responds to these actions.

Methods

A retrospective analysis of video data of an operating theatre simulation was conducted to identify how surgeons, from a range of experience levels, react to instances of harassment. Thematic analysis was used to categorise types of harassment and participant response characteristics. The frequency of these responses was assessed and reported.

Results

The type of participant response depended on the nature of harassment being perpetuated and the seniority of the participant. In the 50 instances of scripted harassment, active responses were enacted 52% of the time, acknowledgement responses 16%, and no response enacted in 30%. One senior surgeon perpetuated the harassment (2%). Trainees were more likely to respond actively compared to consultants.

Conclusion

It is apparent that trainees are more aware of instances of harassment, and were more likely to intervene during the simulated scenario. However a large proportion of harassment was unchallenged. The hierarchical nature of surgical education and the surgical workforce in general needs to enable a culture in which the responsibility to intervene is allowed and respected. Simulation-based education programs could be developed to train in the recognition and intervention of discrimination, bullying, harassment and sexual harassment.

KEY WORDS

Bullying discrimination and sexual harassment, continuing professional development, simulation, surgical education.

INTRODUCTION

Despite being prohibited by law, and contrary to the Medical Board of Australia Code of Conduct,[120] discrimination, bullying, harassment and sexual harassment still occur in many healthcare environments.[121-123] These behaviours are more common in professions, such as medicine, where significant hierarchies exist.[124] A recent systematic review of discrimination and harassment during specialty training programs found a higher incidence of these behaviours in surgery compared to other medical professions.[125]

In early 2015, the issue of discrimination, bullying, harassment and sexual harassment within the surgical profession made public media headlines.[96] In response, the Royal Australasian College of Surgeons (RACS) established an Expert Advisory Group to investigate and report on the extent of these unlawful behaviours, and to produce recommendations on how to eradicate them. The Expert Advisory Group conducted a prevalence survey of College Fellows, Trainees and International Medical Graduates and found that 49.2% of respondents had been the victim of discrimination, bullying and/or sexual harassment at some point in their career.[122]

RACS has long held a position against discrimination, bullying, harassment and sexual harassment[126] and, through the Expert Advisory Group, recommended that institutions take greater responsibility and become more proactive in improving workplace culture, reprimanding perpetrators, and empowering victims and bystanders to intervene.[97]

In this study, we use simulation to assess a surgeon's response to the harassment of a colleague. Simulated scenarios have previously been utilised to train and assess non-technical skills such as leadership, communication and situational awareness.[108,127,128] The aim of this study was to assess and report on the surgeons' ability to identify and manage incidences of harassment.

METHODS

Intervention

This study utilised existing video data recorded between 2013 and 2014, and included surgical trainees and consultant surgeons undertaking a 5 to 10-minute simulated operating theatre scenario designed to challenge their non-technical skills. The videos were originally recorded as part of a study investigating the efficacy of a didactic training course for the development of non-technical skills, with the scenario being used to test the participants' non-technical skills at baseline and after completion of the course. The scenario involved the participant taking over as the operating surgeon in a simulated trauma case. During the scenario, the patient's condition would deteriorate and blood transfusions were required. This was complicated by the possibility that the patient was a Jehovah's Witness. Despite this information, the anaesthetist would insist on continuing with a blood transfusion. The scout nurse, also a Jehovah's Witness, was opposed the blood transfusion. Depending on the timing of the participant's intervention, this conflict would trigger scripted harassment behaviours from the anaesthetist. The participant was required to lead the team through the crisis and resolve the event.

The roles of consultant trauma surgeon, anaesthetist, scrub nurse and scout nurse were played by scripted confederates. Confederates were assigned roles similar or identical to their real profession in order to give the scenario more fidelity.

It is important to note that the harassment is part of the intervention, is intentional, and occurs within the scope of the scenario. The focus of this study is to examine the response of the participant (see Table 23 for an overview of categories of scripted harassment).

Participants

Two cohorts of participants were enrolled into this study. The first consisted of 40 surgical trainees (training year level 1-6, *n*=32) and surgeons who had been awarded RACS Fellowship in the previous three years (2009-2012) (Fellows, *n*=8). The second group consisted of 30 consultant surgeons who obtained RACS Fellowship between 3 and 40 years prior. All participants gave informed, written consent for the assessment of their non-technical skills during a crisis scenario, and for the recordings to be stored on the RACS database for future analysis. Ethics approval was granted by the Royal Australasian College of Surgeons Human Research Ethics Committee.

Data-set

A total of 70 videos were reviewed and assessed using predefined inclusion criteria. This criteria was applied to ensure that the same antagonist (a confederate anaesthetist) was present in all videos, and that at least one instance of harassment occurred. For the purpose of this study, harassment was defined as unwanted, unwelcome or uninvited behaviour that makes a person feel humiliated, intimidated or offended.[129]

Video Assessment

Video assessments were undertaken by two assessors (authors C.V.V. and H.G.). The videos were viewed and incidences of harassment were identified. The verbal and nonverbal information from participants and scenario confederates was recorded; verbal information was transcribed verbatim, and physical gestures described.

All videos were viewed by both assessors and a categorisation schema developed according to commonly identified actions. Thematic analysis was used to define five main categories of harassment: Rude, Ridicule, Belittle, Patronise, and Religious. In addition to the verbal component, some instances of harassment also included episodes of unwanted physical contact or intimidation. For example: standing up close, pointing in the scout nurse's face, or placing a hand on the scout nurse's back to usher her forward. These instances were noted, and were categorised according to the main verbal content. Participants' response to the harassment were also categorised according to common themes; Reprimand, Interrupt/stop, Distract/divert, Acknowledge (ineffective action), Acknowledge (no action), and No response.

All videos were viewed again, and the categorisation schemas applied. Discussion was held between the two assessors and categorisation achieved through consensus.

RESULTS

Twenty-one videos met the inclusion criteria (involving 11 trainees and 10 consultants). Thirty-seven per cent of participating trainees and 40% of participating consultants were female. Demographic details of the participants are shown in Table 24.

During the videos, there were 50 comments made by the Anaesthetist that met the authors' definition of harassment. Between 1 and 5 harassing comments were made during each video. The content of harassment varied slightly between videos, and depended on the reactions of the participating surgeon. The categories of harassment, with example comments, are presented in Table 23.

Table 23 Observed categories of scripted harassment (from Anaesthetist to Scout Nurse)

Harassment	Instances	Description	Example^
Rude	15	Comments that are deliberately and unnecessarily discourteous or impolite.	"Yes, but you don't have to assault him. You just have to get the [expletive] blood, M*"
Ridicule	12	Comments made in a sarcastic tone, aimed at intimidating or ridiculing the scout nurse, or pressuring her to perform her work faster.	"Chop chop M*, Where's the blood?" "The blood M*. You seem to be empty handed. You've gone to a barbecue without the beer. Just get the blood for me!"
Belittle	10	Dismissing or diminishing the views of the scout nurse as irrelevant or unimportant.	"We've not asked you to go with this debate, we've just asked you to bring the blood in" "It's not about *YOUR* comfort. It's about this patient's survival"
Patronise	8	Behaving or treating the scout nurse in a condescending manner. Portraying superiority over the scout nurse. "Put her in her place".	"I don't think it's *YOUR JOB* to tell me what to realise. I think it's *YOUR JOB…* (to get the blood)" "*YOU* don't *TELL* me anything, M*, you might want to *INFORM* me"
Religious	5	Negative comments made about the scout nurse due to her religious beliefs.	"Is it natural for a Jehovah's Witness not to take instructions from their senior? Is that part of your religion?"

^Examples of harassment incidences/comments made by the confederate anaesthetist
*Name of confederate scout nurse has been withheld to maintain confidentiality

Table 24 Participant demographics

Trainees (*n*=11)		**Consultants (*n*=10)**	
M:F	7:4	M:F	6:4
General Surgery	6	General Surgery	5
OHNS^	1	OHNS^	2
Urology	2	Orthopaedics	1
Plastic Surgery	1	Paediatrics	1
Neurosurgery	1	Vascular	1

^Otolaryngology Head and Neck Surgery

Participant reactions

It can be seen in Table 25 that participants failed to acknowledge a large proportion (30%, 15/50) of the incidences of harassment. A further eight incidences (16%, 8/50) were acknowledged, but either not acted upon (4/50) or the participant response was ineffective (4/50).

Techniques to actively stop the harassment, such as distraction (13/50) and interruption (13/50), represented 52% (26/50) of the overall participant responses. Belittling harassment was more likely to receive an active response compared to other forms of harassment, with 80% (8/10) of these incidences receiving an active response (Table 26). Interruption techniques were more likely to be used when physical intimidation was involved, regardless of the verbal content of the harassment (see Table 26). This typically involved the participant directly addressing each team member by name, holding up their hands in a "stop" or "time out" signal, and remarking "wait" or "hold-on" etcetera. In scenarios where the anaesthetist had stepped away from the patient or anaesthetic machine to confront the scout nurse, some participants also stepped away from the operating table and positioned themselves between the anaesthetist and scout nurse. Distraction techniques were also used to coax the anaesthetist back to the anaesthetic machine, or divert attention away from the conflict. Diverting comments would be made directly to the anaesthetist or scout nurse or without addressing any specific individual.

Table 25 Observed response of the participant to harassment of the scout nurse

Response	Instances	Description	Example^
Reprimand	0	Directly confront anaesthetist/ perpetrator regarding inappropriate behaviour towards scout nurse.	No examples observed in the data-set
Interrupt/ Stop	13	Specific comment to another person (using their name directly). Stepping in-between team members if physical intimidation occurs.	"Ah, D*, Just a second" (Participant's hands up at both anaesthetist and scout nurse in "stop" position, looks at each of them while talking to them directly) "M*, D*, Stop there for a moment, ok." (Hands raised in a "stop" position) "Guys, guys. Can I just ask for a bit of time out?" (Hands up in "time-out" T-shape)
Distract/ Divert	13	Comment or question made by participant, aimed at distracting or diverting attention of one or more team members (usually back to the patient).	"How's the BP doing?"
Acknowledge (ineffective action)	4	Comment or noise made by the participant, but either ignored or not heard by other team members. Or comment made to general room, without specific directions/purpose.	"Ok, Well… just…." (Talking to the room, no-one listens) Or lifting finger/hand without making comments
Acknowledge (no action)	4	Comment, noise or gesture made by the participant indicating they noticed the harassment, but did not take action.	"Oh, ok, … alrighty" "Umm"
No response	15	No response at all. Either ignored or did not hear the comment.	Continuing to look inside the mannequin's abdomen, adjusting lighting, or continuing to suture
Contribute to or perpetuate harassment†	1	Being rude and continuing to pressure scout nurse to perform a duty she feels is morally wrong.	"We're not going to argue about this sister…… get the blood as doctor has asked you to…. Your religious beliefs are irrelevant"

^Example reactions of the participating surgeon.
*Names of confederate scout nurse and anaesthetist have been withheld to maintain confidentiality.
†One (consultant) participant perpetuated the harassment towards the scout nurse.

Table 26 Participants' response to types of harassment

	Rude	Ridicule	Belittle	Patronise	Religion	TOTAL
Reprimand	0	0	0	0	0	0
Interrupt/ stop	2 (1)	4 (3)	5 (1)	1	1	13
Distract/ divert	4 (2)	2	3 (1)	3	1	13
Acknowledge, ineffective	1 (1)	0	0	2	1	4
Acknowledge, no intervention	1	2	1	0	0	4
No response	6	4	1	2	2	15
Contribute to or perpetuate harassment^	1	0	0	0	0	1
TOTAL	15	12	10	8	5	50

Numbers in brackets indicate number of incidences of physical intimidation in association with the verbal comments. ^One (consultant) participant perpetuated the harassment towards the scout nurse.

In one instance (2%, 1/50), a senior participant perpetuated the harassment by the Anaesthetist (Tables 25 and 26). Comments included "Well, how about you get it and bring it into theatre and then we can argue about it because we might have a dead patient otherwise!" (response to scout nurse when she states that she is uncomfortable giving blood) and "We're not going to argue about this sister. Can you please get the blood as doctor has asked you to? We'll take responsibility for it. It is our decision to give it. And your religious beliefs are irrelevant" (after scout nurse states she is a Jehovah's Witness, and does not want to get the blood).

No participants reprimanded the Anaesthetist for his behaviour. Consultants were more likely than trainees to ignore or fail to react to harassment (see Table 27).

Table 27 Comparison of trainee versus consultant response to harassment of colleague

Reaction Type	Trainees (*n*=11)	Consultants (*n*=10)
Reprimand	0	0
Interrupt/Stop	9	4
Distract/Divert	7	6
Acknowledge (ineffective action)	1	3
Acknowledge (no action)	2	2
No response	5	10
Perpetuate harassment	0	1

DISCUSSION

This study utilised a simulated theatre scenario to observe and assess surgeons' responses to incidences of harassment of a colleague. A range of harassment types were demonstrated by the anaesthetist within the scenario, with varying responses by the participating surgeons.

Key findings

This research identified that participants were more likely to respond "actively" if there was an element of physical intimidation or unwanted contact, whereas rude or ridiculing comments, on their own, were more likely to be ignored.

There is a misconception among some healthcare professionals that certain bullying or harassment behaviours, such as intimidation and ridicule, are effective and necessary teaching methods.[130-132] These behaviours are often learned from predecessors,[97] and accepted as the norm due to the strong hierarchical nature of the medical and surgical profession.[97,124,133,134] The participants simply may not have recognised the ridicule or rude comments as harassment. This may be one explanation as to why they did not intervene.

This study used a trauma scenario with a deteriorating patient. The lack of response from some participants may also reflect the critical nature of the scenario. Musselman et al[130] surveyed consultant and trainee surgeons' reactions to video scenarios of interactions (involving intimidation, belittling etc.) between trainees and their supervisors. Participants in that study were more likely to rationalise the actions of the perpetrator if the behaviour was perceived to have a positive effect on clinical care, education or safety. It is important to also consider factors surrounding the situation, and the consequences of any intervention while a medical crisis in in progress.[135] It may be that our participants' responses to the harassment would be entirely different if the scenario was of a routine, uncomplicated procedure, or if it was not a simulated scenario.

In general, trainees were also more likely to respond actively compared to consultants. This may be attributed to changes in surgical training and the greater emphasis placed on non-technical skills in the newer surgical curricula.[107] It was an unanticipated finding that one senior participant also contributed to the harassment of the scout nurse. These findings may also be representative of cultural changes in society in general. Younger generations have been exposed to school and community campaigns against discrimination, bulling, harassment and sexual harassment, whereas the older generations have not.

Interestingly, while many participants were able to diffuse the situation, not one participant directly challenged or reprimanded the anaesthetist for inappropriate behaviour towards the scout nurse. Within the confines of a retrospective study, it is difficult to assess whether or not the participant would have discussed the anaesthetist's actions with him after the case had finished.

The issue of when a witness should intervene is difficult, as policies either do not exist or vary between institutions. There were a number of instances where it seemed the participant wanted to interrupt, but was unsure how to do so (eg, looking up from the abdomen, holding their finger or hand up as if to say something, but still remaining silent). Many participants seemed to understand that the behaviour was inappropriate and not improving the clinical situation, but were unsure of how to resolve the conflict. This confirms the need to provide better education in the recognition and management of discrimination, bullying, harassment and sexual harassment, to provide surgeons with tools for intervening.

It is important to note that the simulations in this study were undertaken in the years prior to the increased publicity around discrimination, bullying, harassment and sexual harassment. RACS has since come a long way by publically acknowledging and apologising[136] for discrimination, bullying harassment and harassment against its members and trainees, and developing an Action Plan[98] to eradicate these behaviours. Initiatives such as the "Let's Operate with Respect" campaign and introduction of mandatory online "Operating with Respect"[99] training modules are important first steps. There is however scope to extend these programs further. Simulation is used in many high-risk professions for the training of technical and non-technical skills. It offers a safe environment for learning and would be well-suited for education and training in discrimination, bullying, harassment and sexual harassment. Simulated scenarios could be developed to include various aspects of these behaviours, giving the participants opportunity to develop skills in managing each situation. Similarly, simulated scenarios (in the form of demonstration videos) could also be used as a teaching tool to educate RACS members about the range of behaviours that constitute discrimination, bullying, harassment and sexual harassment, and with the aim of improving interactions between colleagues. Given the generational differences seen in this study, training modalities may need to be tailored for different levels of professional experience.

Limitations

While it is interesting to note that the proportion of females recruited into this study broadly reflects the proportion of professionals within the College; noting Females comprise twenty-eight per cent of Royal Australasian College of Surgeons trainees and eleven per cent of Fellows,[137] we have not assessed whether sex influences the likelihood of responding to harassment.

This was a retrospective study using video of a simulated scenario originally designed to test participant's overall non-technical skills during a crisis, rather than their response to harassment specifically. The critical nature of the scenario case may have had an effect on the responses from the participants, who may have been more concerned with the technical aspects of the case. However, the management of harassment falls under the "supporting others" and "setting and maintaining standards" elements within Leadership category of the Non-Technical Skills for Surgeons scoring system.[111] Furthermore, a crisis situation does not mitigate the fact that clinicians should act professionally at all times and abide by the Medical Board of Australia Code of Conduct.

CONCLUSIONS

The findings from the recent Expert Advisory Group survey confirm that discrimination, bullying, harassment and sexual harassment exist within the surgical profession. This study demonstrates that not all harassment is recognised by surgeons, and when it is recognised, it is not always challenged. There is a considerable need to improve surgeons' situational awareness, and provide tools to confront offenders.

RACS is committed to the eradication of discrimination, bullying, harassment and sexual harassment. Mandatory training modules are being developed and implemented. Using simulated harassment scenarios, training in the recognition and intervention of these behaviours could be incorporated into other non-technical skills education programs. This would not only serve to educate members regarding recognition of all forms of discrimination, bullying, harassment and sexual harassment, but also train strategies on how to intervene.

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CHAPTER 4: DISCUSSION AND CONCLUSION

4.1 Discussion

The Laparoscopic Simulation Skills Program (LSSP) is one of the largest studies of its type, enrolling 207 participants from diverse levels of surgical experience and over multiple sites. Importantly, the results of the LSSP provide a uniquely Australian perspective. Prior to the LSSP, the Royal Australasian College of Surgeons (RACS) has had to rely on international studies that are often of small size and single institution, the results of which may not be applicable to the Australian surgical training environment.

The bulk of research into simulation for surgical education has focused primarily on technical skills and has often neglected to obtain the views of the learners themselves. The comprehensive, mixed-methods design of the LSSP enabled the researchers to obtain both objective skills acquisition (pre- and post-intervention testing) and attendance data, in addition to qualitative survey data that can be used to enhance understanding of the needs and preferences of those who will ultimately be undertaking the training program. This information can be used by future training providers to better tailor simulation-based education programs to the needs of their learners.

The aim of the LSSP was to help determine the optimum format for the delivery of simulated laparoscopic skills training, and to improve access to this training, especially in rural and remote training locations. Key objectives of the project were to investigate the efficacy and feasibility of self-scheduled, self-directed learning for the acquisition of basic laparoscopic skills.

Skills acquisition data demonstrated that SDL has, to a certain degree, the potential to be effective for the development of basic laparoscopic skills but only under the right conditions. Overall skill acquisition was dependent on the number of practice sessions undertaken, rather than where the training took place. Those who did undertake SDL did actually improve, and many participants, including medical students, reached expert proficiency standards in more than one task. Skills data for Cohort 2 indicated there was little additional benefit of SDL training after training in the MSU, signifying that the majority of learning had been completed during the MSU week. This is perhaps not surprising given what is known about the benefits of feedback during training.[15,21,23,24] The individualised feedback given to the Cohort 2 participants who returned for supervised training in the MSU enabled these participants to target their skills and partake in more deliberate practice. Participants in Cohort 1 on the other hand, had to rely on self-assessment of their skills, and be proactive in utilising the training resources made available to them (i.e. YouTube links and written information regarding task performance and assessment scoring). On informal questioning of a number of participants, it was clear that the written and YouTube resources were rarely used by the members of either cohort. Neither cohort practiced a great deal during the SDL period, significantly limiting the overall efficacy of the LSSP self-scheduled, SDL course.

Furthermore, it had been anticipated that there would be a greater uptake of the MSU training resources. After great enthusiasm at enrolment, and considering participant survey data indicated a preference for mentored training, it was a surprise that over 40% of Cohort 2 participants failed to return to the MSU for practice under guidance of the trainers. Previous research has shown that feedback should be formally scheduled as trainees are unlikely to request feedback on their own.[58] There may have been a greater difference observed between cohorts if MSU training sessions for Cohort 2 were scheduled in advance and a minimum requirement set for the number of practice sessions attended (or practice attempts made per task). In the current format, participants did not reach their full learning potential.

To date, access to simulation activities within the Australian SET program has been limited.[47] The LSSP was able to successfully demonstrate the utility of a MSU for the delivery of surgical SBE activities to both rural and metropolitan training locations. The MSU was relatively easy to accommodate at each site and participants valued the facilities. Still, there is much room for the visitation schedule to be refined. A rotating MSU visitation schedule could be implemented around the country. If the visitation schedule was known further in advance or given a more consistent roster (i.e. one week every month), trainees would be more likely to know the resource was available, plan their attendance more easily, and training could become a routine part of the working week.

The LSSP has shown the MSU to be a feasible option for the standardised delivery of SBE activities. However, access to SBE is dependent not only on the provision of simulation equipment and facilities, but also the opportunity to use them. A reoccurring theme identified from the systematic review (Chapter 2.2) and LSSP questionnaire responses (Chapter 2.4) demonstrated that access to and attendance at simulation is highly dependent on overriding clinical duties. This is a common issue identified by education researchers. LSSP participants were keen to develop their skills. However, as healthcare professionals, they are ultimately employed to provide care for patients. During the working week, the clinical team's primary focus is on the patient care rather than educational outcomes for the trainee. It was hoped that greater training flexibility with self-scheduled, self-directed practice sessions would be able to overcome this barrier. While the SDL format meant the program was relatively straight-forward to implement, participants still found it difficult to attend sessions. As discussed in Chapter 2.2, voluntary self-scheduled sessions are a not a feasible training format unless strategies are in place to allow trainees to attend practice.

For SDL to be both effective and feasible, minimum standards for practice attendance and skills achievement would need to be set. Education research has shown that performance-based end-points are more effective than time-based or repetition-based training when it comes to skill outcome[15] and motivation to train.[28,62] All LSSP participants were made aware of the learning objectives and were provided with both written and verbal information clearly outlining the pre-defined proficiency targets. As this was a voluntary project, separate from employment and education requirements, training to proficiency was not seen as a necessity for the participants. Participants were encouraged to practice in a distributed pattern but no incentives were offered for practice attendance or for the proficiency targets to be achieved. In addition, there were no consequences if the proficiency targets were not met. Participants in the LSSP needed to be motivated solely by intrinsic factors such as enjoyment or personal satisfaction in skill development. While a number of participants, including medical students, were able to reach the proficiency targets during their enrolment, the majority did not train nearly enough to do so.

Further extrinsic factors, such as those identified in Chapter 2.2, are vital in motivating and enabling achieving practice session attendance. Success has been shown with programs where trainees must reach a pre-defined minimum level of proficiency before attendance at mandatory weekly training sessions can be relaxed.[27,28] Periodical assessments are conducted, and weekly remedial training sessions prescribed if the trainee fails to show continued improvement. Reaching proficiency on a simulator prior to live operating is another method that could be employed to improve simulation training attendance.

Skills acquisition is enhanced and motivation is improved when learning is in context.[6] During the introductory enrolment session and subsequent MSU training, the trainers did try to provide clinical relevance by relating the skills tasks back to the real life theatre environment. For medical students, who may not have any previous exposure to the operating theatre, this may have had limited effect on motivation to train as it was not relevant to their current practice (i.e. they currently have no real need for the skills). The LSSP was not intended to be a comprehensive curriculum. However, if a LSSP style course was to be implemented long-term, motivation and skills development could be enhanced by the addition of a surgical theory component. Potential theory subjects include sterile technique, theatre protocols, and perioperative care. Teaching could be delivered in the form of face-to-face tutorials (by MSU staff either within the MSU or within the local hospital), or via online (SDL) modules, or a combination of both. In addition, during rotational visits to each hospital, the MSU staff could perform periodical progress assessments and refresher training to ensure trainees keep on track with skills acquisition, and achieve proficiency-based training targets. Individualised feedback, remedial training and supervised deliberate practice could be performed while the MSU is on site.

Greater support from surgical departments and supervisors is essential for enabling access to SBE activities. Surgical departments need to introduce policies such as protected time, paid training time, and whole-of-department support for the benefits of SBE, to ensure any activities that are implemented remain feasible. Attendance data and survey responses indicated that any scheduled sessions should be conducted in the late afternoons or after a shift. Participants also preferred the sessions to be at least once a fortnight or once a week. It should not be considered unreasonable for surgical departments to provide trainees with a minimum of 1 hour a fortnight of protected time to be dedicated to formal training sessions. It is not yet known how frequently or for how long training should be undertaken to maximise skills acquisition and prevent deterioration. This is likely to depend heavily on the individual trainee and other opportunities to practice their surgical skills within the real theatre environment. Variation between trainees is another reason the implementation of periodical assessments, and a mixture of both self-scheduled and formally rostered training sessions should be considered.

Laparoscopic skills are essential for the modern surgeon and are particularly difficult to master. By aiming the three LSSP skills tasks at more novice surgeons, it was hoped to be able to fill the known gap[47] that exists for junior trainees when it comes to supply and demand for simulation training activities, and provide junior trainees with important foundation skills. In fact, post-course survey data indicated participants felt that the LSSP course would be most suitable for pre-SET RMOs - that is, even less experienced doctors. In Australia, surgical doctors are frequently inducted as functioning members of the operating theatre team while working as pre-SET RMOs, beginning with surgical assisting and even starting to perform basic procedures such as laparoscopic appendicectomy. The LSSP skills tasks were considered by many participants to be too basic for established SET trainees.

An LSSP style course could be introduced either in the pre-SET stage, or early in the commencement of SET. The content of the course could be adapted as learners progress, with introduction of more advanced skills tasks and simulated surgical procedure (e.g. colonoscopy, cholecystectomy) as the learners refine their surgical skills. This would ensure all SET trainees are at the same standard of foundation skills within their first 6 to 12 months of training, especially if periodical assessments, with or without remedial training, are also performed. Similar programs, often referred to as 'boot camps' have been established internationally with success.[32] Technical skills taught during boot camps can often include: basic suturing, chest drain insertion, arterial catheterisation and laparoscopy, in addition to surgical theory. If implemented nationwide, national objective assessment standards could be developed and enforced.

There was strong interest from the participating RANZCOG trainees (including senior trainees) for ongoing MSU and simulated laparoscopic skills activities. Future simulation activities could be developed in collaboration between RANZCOG and RACS. The burden of cost for training delivery (consumables, petrol/maintenance, staffing, insurance etc.) could be shared not only between hospitals, but also the individual surgical departments and training providers.

It was clear from the qualitative data that interest and enthusiasm for incorporating SBE into the surgical training curriculum is strong. Overall participants saw the benefit of simulation training and increased effort should be made by training providers to better develop and provide this valuable teaching resource.

4.2 Problems Encountered During Research and Limitations of the Study

The implementation of multi-site research is logistically challenging, particularly when more than one state or territory is involved. The LSSP was a Low and Negligible Risk (LNR) study.[138] As such, an online National Ethics Application Form (NEAF) application was made and promptly approved by the Human Research Ethics Committee (HREC) in the project's home state of South Australia. Although the approval came under National Mutual Acceptance[139] (NMA, an approval process designed to streamline multi-site ethics approval and eliminate red tape), each participating site also had individual HREC and Research Governance Office (RGO) approval requirements. In a limited number of cases, where NMA was not accepted, separate ethics applications had to be made. This was time-consuming but ultimately necessary to ensure all sites were satisfied with the research protocol.

It was initially intended to conduct a pilot study site visit before the project proper. However, due to a number of delays within the RGO, final approval was not granted until the late in the afternoon of the proposed first day of MSU week. Recruitment and advertising material could not be distributed prior to this time. The decision was made to cancel the pilot visit. As the training and assessment methods had been established during a previous RACS research project,[80] cancellation of the pilot site is unlikely to have had a significant impact on the rest of the study. Subsequent applications to the individual RGOs were submitted with a greater lead time to prevent recurrence of this issue.

The duration required to receive approval from the individual RGOs was variable, with one site (a metropolitan Adelaide hospital) taking nearly three months to grant access. This did have a negative impact on the lead time for recruitment advertising at that site, and potentially affected the number of participants recruited. Nevertheless, once approval was granted, the project was received enthusiastically by surgical departments and medical educators, as well as the participants who were able to enrol. Only one site initially proposed for inclusion in the visitation schedule declined to be involved in the LSSP. This was due to separate simulation research activities already being conducted at that site. A repeat visit to a pre-existing site was arranged in its place.

Participant recruitment for the project was, in many cases, difficult to achieve and maintain. As detailed in Chapter 2.7, numerous avenues for project advertising were employed to capture the attention of as many eligible individuals as possible. As recruitment advertising was largely distributed by Surgical Department Secretaries and Medical or Surgical Administration and Medical Education Officers, the total number of eligible individuals at each site is difficult to ascertain. It had been decided that recruitment material should be distributed by a third party to ensure confidentiality of potential participants and prevent influence from the researchers.

Difficulties with recruitment were recognised early and steps were taken to rectify this. The site visitation schedule was periodically reassessed, and available dates for additional site visits identified. Every attempt was made to avoid site visits during change of rotation (for doctors) and holiday or exam periods (for medical students). In general, local surgical consultants, medical education and administration staff showed great enthusiasm for the learning opportunities offered by the project and welcomed a second, and sometimes third visit. A second visit was made to two rural hospitals and one metropolitan hospital, and a total of three visits each were made to two of the major South Australian metropolitan hospitals.

Overall enrolments in the LSSP were reasonable for surgical education research, however the number was still lower than expected. Of the 207 participants enrolled, 87 were doctors. This is an improvement on many simulation and surgical education research studies, where surgical trainee participant numbers can be in the single figures.[58] However, 87 participating doctors is likely only a proportion of the eligible doctors at each site. It is difficult to account for those who were eligible, but who ultimately did not enrol. This may have been to lack of interest, lack of time, or even lack of awareness about the project visit. It is known that there were a number of individuals, mainly junior doctors, who had enquired about the project prior to the site visit, but were unable to present to the MSU for enrolment during MSU week. There were also a number of individuals who enquired about the project after the site visit had already been completed.

Difficulties with recruitment and ongoing participation in healthcare and education research have been described elsewhere.[89,90] Other studies have utilised compulsory education time for participation in surgical education research. This was outside the scope of the LSSP as it was investigating self-scheduled training. Furthermore, it would not have been possible to coordinate participant rosters due to the large scale of the study and wide variation in levels of experience of the participants. Stopping short of mandating participation, or awarding employment or study credit or prizes for participation, it is unlikely that more could have been done to encourage enrolment in this project. Simulation and surgical education research in general needs to be better supported by training providers, hospitals and individual surgical departments to facilitate participation and foster more robust results.

The high proportion of participating medical students does have implications for the ability to generalise the results of the LSSP. Medical students may not have insight into the needs and demands of junior doctors and SET trainees. Nevertheless, their views are still important as prospective surgical trainees. Their involvement has shown that that SDL and MSU learning format can potentially be effective even for the most novice of surgeons. In addition, participation in the LSSP may have helped to create enthusiasm amongst the medical students for both SBE and a future career in surgery.

MSU parking and SDL simulator room locations were dictated by the accessibility of the required power supply for the MSU and appropriate desk space for the SDL simulator. While high-visibility MSU parking sites were preferred in order to publicise the project to new recruits and serve as a visual reminder to those already enrolled, parking locations were dependent on not only parking space access, but also access to a suitable external 15 Amp power source. In some cases, it was necessary to locate the MSU at the rear of the hospital in the service truck loading bay. This is not an area commonly frequented by medical employees or students, and a small number of participants made comment that they had difficulty locating the MSU.

As described in Chapter 2.5, there were similar limitations to available rooms for the SDL simulators. For example, locations included surgical team offices, the hospital library, operating theatre holding bay or meeting rooms, and even a large storage cupboard within the surgical department. Participants in this and other studies[55,58] favoured access to SBE at their site of employment, and in general, the locations provided were deemed adequate for the participants needs, as long as access hours were not restrictive.

These logistical issues, although not exceptionally detrimental, are issues that would need to be considered if a program similar to the LSSP was to continue on a permanent basis. If implemented on a rotational basis long-term, hospitals may be inclined to establish more easily accessible external power source and reserved parking, and rooms for the SDL simulators. In addition, a regular visitation schedule would increase awareness among the learners regarding the physical locations of the MSU and SDL room.

Despite reminder emails being sent, there was very limited response from educators and surgical supervisors to the Educator questionnaire (only 13 responses after the first six site visits, with the majority of respondents from one hospital). While preliminary data shows surgical supervisors support SBE, there was insufficient data for accurate conclusions to be made.

The analysis of non-technical skills presented in Chapters 3.2 and 3.3, was based on retrospectively collected data from pre-existing video recorded scenarios. As such, it was not possible to obtain any additional information from the participants. The two studies could have been enhanced by the inclusion of further details such as: the non-technical skills training undertaken by some of the experienced surgeons (Chapter 3.2); participants views as to whether they noticed the harassment towards the colleague or would have intervened after the trauma case was resolved (Chapter 3.3); and the views of all participants with regards to the optimum format for delivery of non-technical skills training and education in discrimination, bullying, harassment and sexual harassment.

4.4 Conclusions and Considerations for Future Research

The surgical training environment is ever changing to adapt to the demands of patients, the challenges of the healthcare system and a limited healthcare and education budget. There is a demand for more standardised training and objective assessments. Excellence in both technical and non-technical skills are essential for any surgeon in order to maintain standards of care for the health and safety of patients and colleagues. Simulation-based education has been shown to provide an effective adjunct to more traditional training methods. However access to simulation activities, especially in rural and remote training locations, is often limited and the best format for delivery is yet to be established.

Results from the LSSP provide RACS and other training providers with an important insight into the needs and the preferences of Australian doctors with regards to the delivery of simulation-based surgical training. These findings will enable training providers to develop better simulation training activities in the future.

The results of the LSSP show that self-scheduled, self-directed, simulation-based training has the potential to be effective for basic laparoscopic technical skills acquisition, but its feasibility as a long-term training method depends on the ability of trainees to be able to attend practice sessions. Given the known benefits of structured feedback, the accelerated skill acquisition demonstrated by Cohort 2 participants, and the qualitative survey data results, skills training should be implemented as a combination of both self-scheduled SDL and supervised training, to allow flexibility, ensure trainees' attendance, and maximise training efficacy.

Further strategies identified by the LSSP for improving access and enabling attendance include the introduction of regular scheduled sessions, in protected time (with covering personnel), and by delivering the training at the site of employment (for example, via a MSU on a rotating visitation schedule). Mandating training, rather than primarily voluntary participation, would also promote attendance, noting that consequences for non-attendance would need to be introduced in order to have full effect. LSSP participants welcomed mandated simulation-based training, and had a preference for training sessions to be scheduled once a fortnight, and after a shift. With refinement in the visitation schedule, it would be feasible to deliver surgical simulation training from the MSU.

Incorporating the lessons learned from the LSSP, RACS and other training program providers can begin refining the delivery of simulation-based education to rural and remote trainees. The next step is to develop a more comprehensive curriculum that integrates teaching and objective assessment in both practical (technical) skills and surgical theory. This curriculum could be implemented around the country in a boot camp style to ensure minimum national standards for surgical training are set and achieved.

Non-technical skills are equally important for surgical competence and maintenance of standards. Further research is needed into the optimal format for incorporating structured non-technical skills training into SET and as a part of continued professional development programs for fully qualified surgeons. In addition, more effort needs to be given to promoting cultural change within the surgical profession with regards to discrimination, bullying, harassment and sexual harassment. Again simulation-based education can provide a safe and effective environment for this to occur, and training should be made compulsory for all surgeons, regardless of their level of experience. Peer coaching may play an important role, especially for fully qualified surgeons, and is a method currently receiving a lot of research interest.

Finally, the ultimate goals of any training intervention are not only improved skills acquisition, but also training efficiency, cost effectiveness, and most importantly improved patient safety and health outcomes. In order to assess effectiveness of simulation in all these areas, comprehensive data comparing outcomes pre- and post-intervention need to be obtained and analysed, and any interventions continuously reassessed. Greater involvement and support from training providers and individual surgical departments is needed to encourage participation in surgical education research to better the standards of the profession.

APPENDICES

List of Appendices

Appendix A.1 Outline of integrated curricula included in review

Author Date Country	Participants	Hours involved	Protec ted* time	Theoretical Component	Technical Skills Component	Structure	Materials	Assessments	Notes
Stefanidis et al 2008[27], 2010[28] Charlotte, North Carolina, USA	PGY1-4 15 trainees participated in efficacy study	Weekly sessions 1 hour (20min theory, 40min skills) Scheduled 11-12noon on each resident's post call day (but can train any day if preferred) Monthly maintenance sessions once proficiency reached Compulsory	YES Paged 30min prior as reminder Co-ordinator takes pager during session	FLS^ program materials (CD disc 1) and SAGES "Top 14 procedures every practicing surgeon should know" Articles from literature	PGY 1-2: Basic laparoscopic skills tasks PGY 3-4: Advanced lap skills and procedures (cholecystectomy, ventral hernia repair) once basic skill proficiency achieved 5x FLS tasks 9x VR simulator tasks (camera navigation 0 and 30 degree, hand-eye coordination, grasp & clip, ball drop, cutting, clip application, cautery, object translocation)	Tasks adjusted to level of training Proficiency based training - Must reach proficiency in first 3 FLS tasks before moving on to suturing (task 4&5) Once proficiency demonstrated on 2 consecutive attempts, then must demonstrate proficiency an additional 10 times each task Maintenance sessions once proficiency achieved → Return to weekly sessions if skill level is lost Name of best performing trainee is publically posted on the training stations Best performer and best attendee awarded a prize at end of year	FLS^ tasks and box trainer VR simulator (LapMentor) Expert-derived proficiency goals ('experts' from their department. Average performance of the experts + 2 standard deviations) "Best goals" (average of the 2 the best expert scores)	Baseline (pre-course = 2 repetitions of each of the 14 tasks) Post-course (end of academic year)	PGY5 excluded from the study as were already FLS accredited

Appendix A.1 continued

Author Date Country	Participants	Hours involved	Protec ted* time	Theoretical Component	Technical Skills Component	Structure	Materials	Assessments	Notes
Panait et al[29] 2010 New Haven, Connecticut USA	Directed at Senior residents 14 PGY 1-4 and 9 PGY3-4 participated in the study	Completion at their own pace Proficiency-based Compulsory	?NO		Modules based on Basic course but with increased level of difficulty 16 practice modules Grasping cutting, clip applying, lifting & grasping, running the bowel fine dissection, and precision & speed 5 examination modules	Must complete Basic prior Practice modules can be repeated as many times as necessary to pass them All modules must be passed before progressing to examination modules (max 5 attempts per exam module	VR simulator (LapSim)	VR simulator assessment (once they have passed the practice modules) If fail any component of an exam module, the whole curriculum must be repeated from the beginning	Residents must successfully complete both Basic and Advanced curriculum Does not detail the average time needed to complete course, & how this impacts on clinical training ?Is training done during duty hours
Edelman et al[30] 2010 Detroit, Michigan, USA	All first year trainees (16) 'Surgical Residents'	Weekly sessions for 16 weeks Up to 4 hours per session Compulsory	YES	FLS^ program materials	Laparoscopic Basic Skills – 4xFLS tasks on FLS box, VR simulator (METI SimSurgery basic tasks) Open Surgical Skills – knot-tying, needle manipulation, wound suturing, intestinal anastomosis and vascular repair	Pre-defined training goals/proficiency scores as per FLS program Independent practice Some feedback given, but minimal structured teaching	FLS^ program materials FLS box and VR simulator	Pre-test week 1 Post-test week 16 Retention test: 7-8mths after completion of course (for the study only)	Also held as an elective for final year medical students before entering residency. Med student use has shown to improve performance when PGY1
Gonzalez et al[31] 2010	All first year trainees PGY1 7 trainees	1-month rotation during PGY1 Exact hours not stated	YES	FLS program materials, didactic teaching,	Laparoscopic Basic Skills – FLS tasks on FLS box, VR simulator, Animate model	4x 1-weekly modules including one-on-one teaching of basic laparoscopic and open surgical techniques	FLS program materials FLS box and VR simulator	Weekly mock FLS assessments	No formal assessment session described

Appendix A.1 continued

Miami, Florida, USA		Compulsory		Self-guided reading	Open Basic Surgical Skills	Independent practice Debriefing sessions	Access to local industry representatives		1 trainee per rotation
Fernandez et al[32] 2012 Springfield, Massachusetts USA	All first year trainees 30 trainees over 4 years	1 and 3 hour weekly sessions for 9 weeks Compulsory	YES	Yes – Basic skills, anatomy,	Procedural skills – knot-tying, suturing, instrument handling, airway management, laparoscopy, basic life support, central venous catheter & chest tube insertion Simulated patient scenarios – surgical emergencies, trauma, shock, cardiac/respiratory management	"Boot Camp" 9x modules Pre-reading Pre-testing Briefing/de-briefing sessions	Simulators not specifically described Nationally recognised assessment tools (ABSITE, OP-Rate)	Weekly written and skills assessments Post-test week 9	

*Protected time = time allocated to training without interruptions (i.e. pager is held and ward duties are covered by someone else)

^FLS, Fundamentals of Laparoscopic Surgery program, Society of American Gastrointestinal and Endoscopic Surgeons (SAGES). FLS certification is a requirement for American Board of Surgery accreditation

Appendix A.2 Outcomes from training curricula included in review

Author	Attendance rates	Training Assessments	Training Outcomes	Participant perspective	Patient Outcomes	Statistics and reporting	Interpretation	Limitations
Stefanidis et al 2008,[27] 2010[28] Charlotte, North Carolina, USA	Initial attendance (voluntary) 6% improved to 71% after educator employed Median weekly session attendance rate improved post introduction of 'best goals' training incentive (competition between trainees) 51% (range 8-96%) compared to pre-incentives 21% (range 0-54%)(p<0.001)	FLS and VR simulator testing pre- and post- 12 month training period Comparison of scores and attendance before and after introduction of training incentives	Improved in: Time to complete task by 97% (range 18-230%) Errors made by 17& (range 0-24%) Motion efficiency by 57% (range 26-114%) Trainees with attendance rate >30% were able to achieve proficiency goals in a median of 7 (range 3-14 of 14 tasks) and 'best goals' in 3.5 (range 1-9) tasks Trainees with attendance <30% were not able to achieve any proficiency goals Attendance rates of those who achieved proficiency were higher compared to those who did not (60% vs. 20% respectively p<0.01)	On 20-point Visual Analogue Scale (20= higher) Impact of performance goals on motivation = 15 (range 1-18) Impact of setting 'best goals' = 13 (range 1-18) Impact of naming best performer = 10 (range 1-16)	Not reported	Statistical analysis techniques are described Adequate reporting Effective use of graphs	Curriculum is effective for skill acquisition **Skill acquisition was higher in those who attended more sessions** **Personal performance goals have greater impact than competition in motivating to train** **Voluntary training is not effective in achieving attendance** **Mandatory training must be accompanied by consequences for non-attendance**	Small sample size Some inadequacies in reporting: i.e.?total time spent on training Proficiency based on average scores of "expert" at the institution
Panait et al[29] 2011 New Haven, Connecticut USA	23 volunteered Attendance not reported (self-directed proficiency based rather than	Results are of study after implementation of this curriculum	Difference in baseline FLS score (post Basic course) juniors vs. seniors was not statistically significant (p>0.05)	Not reported	Not reported	Statistical analysis techniques are described Adequate reporting	**Curriculum is effective for skill acquisition** Improvement in junior scores is likely partly related to effect of	Small sample size Does not state when this was implemented

Appendix A.2 continued

	time-based curriculum)	FLS testing after Basic course (compulsory) Advanced course completed FLS testing repeated post Advanced course	Mean score for all residents post training was significantly improved when compared to pre-test (p<0.02) Seniors had an increase in score larger than for the group as a whole (p<0.01) Results compared against laparoscopic clinical case volume during the study period: Juniors: Mean FLS score improvement was significantly higher in those who had completed >30 cases vs. those who had done <30cases (p=0.01) Senior: Mean FLS score was similar in residents with >50 vs <50 cases (p>0.05)			Column graphs comparing junior and senior trainees	experience with theatre cases **Senior resident improvement seems to be solely related to the course (as experience in theatre during that time did not have a significant impact)** Training in the advanced curriculum is perhaps more useful for senior residents than junior residents	curriculum or what year the study was done. Compares junior and senior results, No control group Does not detail the average time needed to complete the course, and how this impacts on clinical training Is training done during duty hours (mandatory)

AppendixA.2 continued

Author	Attendance rates	Training Assessments	Training Outcomes	Participant perspective	Patient Outcomes	Statistics and reporting	Interpretation	Limitations
Panait et al[29] 2011 New Haven, Connecticut USA	23 volunteered Attendance not reported (self-directed proficiency based rather than time-based curriculum)	Results are of study after implementation of this curriculum FLS testing after Basic course (compulsory) Advanced course completed FLS testing repeated post Advanced course	Difference in baseline FLS score (post Basic course) juniors vs. seniors was not statistically significant (p>0.05) Mean score for all residents post training was significantly improved when compared to pre-test (p<0.02) Seniors had an increase in score larger than for the group as a whole (p<0.01) Results compared against laparoscopic clinical case volume during the study period: Juniors: Mean FLS score improvement was significantly higher in those who had completed >30 cases vs. those who had done <30cases (p=0.01) Senior: Mean FLS score was similar in residents with >50 vs <50 cases (p>0.05)	Not reported	Not reported	Statistical analysis techniques are described Adequate reporting Column graphs comparing junior and senior trainees	**Curriculum is effective for skill acquisition** Improvement in junior scores is likely partly related to effect of experience with theatre cases **Senior resident improvement seems to be solely related to the course (as experience in theatre during that time did not have a significant impact)** Training in the advanced curriculum is perhaps more useful for senior residents than junior residents	Small sample size Does not state when this was implemented into the curriculum or what year the study was done. Compares junior and senior results, No control group Does not detail the average time needed to complete the course, and how this impacts on clinical training Is training done during duty hours (mandatory)

Appendix A.2 continued

Edelman et al[30] 2010 Detroit, USA	All attended at each session of mandatory 16-wk curriculum However, did not record for how long during the 4hr session they attended 9/16 (59%) did not return for voluntary training, 3/16 came back for 1 session, 4/16 came back 2-6 times when given opportunity to voluntarily practice between curriculum post-test and retention testing	Baseline (wk1) and final (wk16) FLS^ task completion times (Task completion time is inversely proportional to performance) Also assessed 7-8 months post completion of curriculum (retention testing for a study)	The post course task completion time was significantly improved in all 4 FLS tasks (p<0.001) compared to pre-test There was no statistically significant difference in task completion time between post-test and retention testing for peg transfer (p=0.726) and pattern cut (P=0.114) There was statistically significant (longer) task completion time for extracorporeal knot tying (<0.0001) and intracorporeal knot tying (p<0.029) at retention testing (indicating a deterioration in performance) Relative retention rates: Peg transfer = 103%, Pattern cut = 85%, Extracorporeal knot = 47%, Intracorporeal knot = 59% Relative	Not reported	Not reported	Retrospective analysis of 2008-9 year Statistical analysis techniques are described P value <0.05 was considered significant Scores reported in tables for all individuals as well as the average group score (+/-SD)	Course is successful in skill acquisition **However skill maintenance is an issue** When left to voluntarily train after the completion of the formal course, the majority did not return **Likely need to mandate ongoing maintenance training** ?duration and intervals – may only be needed for poorer initial performers	Does not measure/report skill in other tasks taught Does not describe how training was structured (?self-determined) or if they practiced all tasks evenly (this may impact on skills learned) Likely no particular order as this was how it was structured in the medical student curriculum Does not accurately measure time spent on training or practice attempts made (up to 4 hours per session)

Appendix A.2 continued

Author	Attendance rates	Training Assessments	Training Outcomes	Participant perspective	Patient Outcomes	Statistics and reporting	Interpretation	Limitations
			retention equal to or greater than 100% denotes complete retention or improvement in score (<100% indicates deterioration)					Likely to retain skill if practiced more i.e. did they practice most on peg transfer? Does not state how long course has been running or how many have undertaken it
Gonzalez et al[31] 2010 Miami, Florida, USA	Seven trainees 1-month rotation (mandatory) Does not report attendance or time commitments	Weekly mock FLS assessments Motion analysis for VR* training and open procedures was not performed/recorde d	Not reported	Post-course survey 10-point Likert scale regarding the course (10 = more positive result) Overall experience of rotation 9.4 Exposure to lap. procedures 9.6 Exposure to open procedures 8.9 Preparation for theatre 9.4 Feel comfortable performing lap. cholecystectomy 9.2	Not reported	Retrospective analysis of one year of curriculum	**Curriculum enjoyable and positive trainee experience** Cannot quantify technical skill acquisition	Very small sample size Technical skill may not be formally assessed during curriculum Limited data reported

Appendix A.2 continued

				Feel comfortable with hand-sewn anastomosis 8.7 Stapled anastomosis 9.4 Rating of resources available 7.8 -9.8 for various simulators, equipment and teaching (lowest score for VR simulator)				
Fernandez et al[32] 2012 Springfield, Massachusetts USA	Mandatory curriculum 30 residents over 4 years Actual attendance not reported	Weekly written and practical skills assessments Simulated patient encounters and practical skills lab work	Cognitive skill performance improved between pre-test and post-test (81+/-11 vs. 89+/-7, p<0.001) Boot camp test results correlated with nationally validated training assessment tools	Feedback was "overwhelmingly positive"	Not reported	Statistical analysis techniques are described Adequate reporting Appropriate use of graphs	Course is successful in skill acquisition	Exact contents of assessments not described

^FLS = Fundamentals of Laparoscopic Surgery program, Society of American Gastrointestinal and Endoscopic Surgeons (SAGES). FLS certification is a requirement for American Board of Surgery accreditation
*VR = Virtual Reality simulator

Appendix B.1 Project Visitation Schedule and Enrolled Participants

Site Visit Number	Hospital^	ASGC-RA	MSU Week	Final	Total Enrolled	Completions per participant type			
						Trainees†	RMOs	Interns	Students
1	A	RA3	15.06 - 19.06.2015	10.07.2015	5	1	-	1	2 (1)
2	B	RA2	29.06 – 03.07.2015	24.07.2015	5	-	0 (1)	-	3 (1)
3	C	RA3	31.08 – 04.09.2015	25.09.2015	11	0 (1)	1 (2)	-	6 (1)
4	D	RA1	07.09 – 11.09.2015	02.10.2015	23	-	1 (1)	3	18
5	E	RA1	09.11 – 13.11 2015	04.12.2015	19	-	3 (3)	4 (1)	4 (4)
6	F	RA1	16.11 – 20.11.2015	11.12.2015	11	1	5 (2)	2 (1)	-
7	G	RA2	08.02 – 12.02.2016	04.03.2016	16	4	2	2 (4)	3 (1)
8	D.2	RA1	04.04 – 08.04.2016	29.04.2016	14	-	0 (5)	0 (3)	4 (2)
9	H	RA2	02.05 – 06.05.2016	27.05.2016	11	-	-	3 (3)	3 (2)
10	D.3	RA1	20.06 – 24.06.2016	15.07.2016	2	-	-	-	2
11	I	RA2	04.07 – 08.07.2016	29.07.2016	22	-	0 (2)	2 (1)	17
12	C.2	RA3	01.08 – 05.08.2016	26.08.2016	13	1 (1)	3	1	7
13	E.2	RA1	15.08 – 19.08.2016	09.09.2016	16	-	1 (2)	0 (1)	9 (3)
14	F.2	RA1	29.08 – 02.09.2016	23.09.2016	5	-	-	-	5
15	J	RA2	12.09 – 16.09.2016	07.10.2016	15	-	-	2 (5)	7 (1)
16	G.2	RA2	26.09 – 30.09.2016	21.10.2016	4	-	2	1	1
17	E.3	RA1	10.10 – 14.10.2016	04.11.2016	15	-	0 (1)	1	12 (1)
				Total enrolled	**207**	**9**	**37**	**41**	**120**
				Did not complete assessment requirements	57	2	19	19	17
				Total completions	**150***	**7**	**18**	**22**	**103**

ASGC-RA, Australian Standard Geographical Classification – Remoteness Area categories (RA1 = Major City, RA2 = Inner Regional, RA3 = Outer Regional, RA4 = Remote, RA5 = Very Remote Australia); RMO, Resident Medical Officer.

^Five hospitals were visited on more than one occasion (numerals 2 and 3 indicate second and third visit, respectively).

†Includes trainees from both the Royal Australasian College of Surgeons and the Royal Australia and New Zealand College of Obstetricians and Gynaecologists

*Completed final skills assessment. Numbers in brackets represent enrolled participants who did not complete assessment requirements (therefore excluded from skills acquisition analysis)

Appendix B.2 Assessment Requirements

Description of tasks included in the intervention

Peg Transfer

Equipment

- 2 Maryland graspers
- Peg-board
- Six coloured objects

Time

- ‘Upper’ time limit: 300 seconds
- ‘Proficient’ time limit: 48 seconds

Penalties

To reach proficiency in this task the participant must not incur any penalties, that is, all coloured objects must be successfully transferred. A penalty is given for every object not transferred (those objects that fell outside the field of vision). The number of objects not transferred is recorded. Noting that dropped objects that land with in the field of vision can be picked up with the instrument that dropped them and transferred without penalty.

Pattern cutting

Equipment

- 1 Maryland grasper
- 1 pair of endoscopic scissors
- 1 large clip (used to hold the cutting gauze)
- 1 piece of gauze

Time

- ‘Upper’ time limit: 300 seconds
- ‘Proficient’ time limit: 98 seconds

Penalties

The penalty mark for this task is determined in relation to the excess area that a trainee creates through inaccurate cutting. A penalty is given for any white areas that a trainee creates through inaccurate cutting away from the black line. To measure penalties the trainer is required to cut the white areas and re-arrange them on the scoring grid to determine how many squares (and half squares) of penalty exist.

Intracorporeal knot-tying

Equipment

- 2 needle holders
- 1 15cm suture
- 1 pair of endoscopic scissors
- 1 Penrose drain
- 1 foam block

Time

- ‘Upper’ time limit: 600 seconds
- ‘Proficient’ time limit: 112 seconds (with up to 1mm penalty score)

Penalties

Three separate types of penalty can be incurred by completing this task incorrectly. Penalties include distance from target marks, unclosed opening and poor suturing, these are assessed as follows:

- The distance from the suture entry and exit marks is measured and recorded in millimetres
- The gap in the top opening of the drain is measured and recorded in millimetres
- If the knot is poorly tied then it is judged as being either ‘Insecure’, ‘Slipping’, or ‘Knot comes apart’, and the corresponding penalty code is recorded
- Pulling the drain off the foam block will result in an automatic fail.

Appendix B.3 Assessment Requirements

Assessment score sheet

Participant Number:			
Date:			
Assessment:	Baseline	MSU	Final
Site:			
Assessor:			

Confirm Participant Handedness: Right   Left

PEG TRANSFER

The peg transfer exercise requires you to lift one of the six objects with a grasper first using your non-dominant (i.e. left) hand and transfer the object mid-air to your dominant hand. Then, place the object on a peg on the other (i.e. right) side of the board. Repeat the process with the remaining objects. There is no importance placed on the colour of the objects or the order in which they are moved. Once all six objects have been transferred, the process is reversed. Each object is lifted with a grasper using your dominant hand, and transferred mid-air to your non-dominant hand, then replaced on the pegs on the original side of the board.

You have five minutes to complete this task, but please be aware that taking five minutes or more will result in a score of 0. Timing for this task begins when you grasp the first object and ends upon the release of the last object. Each transfer must be mid-air, without using pegs or block for assistance. A penalty is assessed for any object dropped outside of the field of view.

PEG TRANSFER ASSESSMENT
Cut off time: 300 seconds (5 minutes)

Time to complete task	
Pegs not transferred	

PATTERN CUTTING

This cutting exercise requires you to cut directly on the black circle stamped on a square piece of gauze suspended between clips. One hand should be used to provide traction on the gauze using the grasper, and to place the gauze at the best possible angle to the cutting hand. If you wish, you may exchange instruments at any time during this task. You must start cutting from an edge of the gauze. This exercise requires you to use both hands in a complementary manner.

You have five minutes to complete this task, but please be aware that taking five minutes results in a score of 0. Timing starts when the gauze is grasped and ends upon completion of cutting the marked circle. There are two layers of gauze, but the error scoring is based on the marked, top layer only.

PATTERN CUTTING ASSESSMENT
Cut off time: 300 seconds (5 minutes)

Time to complete task	
Penalty Area	

INTRACORPOREAL KNOT –TYING

This suturing task requires you to place a suture precisely through two marks on a Penrose drain that has been slit along its long axis. You are then required to tie the knot using an intracorporeal knot, which must include one double throw followed by two single throws on the suture. You must transfer the needle to the other hand between each throw. You must also ensure the knots are square and won't slip.

You must tie the knot tightly enough to close the slit in the drain; however, be careful not to pull the drain off of the foam block, because this will result in an automatic fail.

You have 10 minutes to complete this task, but please be aware that taking 10 minutes results in a score of 0. Timing begins when both instruments are visible on the monitor and ends when both tails of the suture material are cut.

INTRACORPOREAL KNOT-TYING ASSESSMENT
Cut off time: 600 seconds (10 minutes)

Time to complete task	
Penalty Area: mm from edge of pre-drawn dots	
mm gap in incision	
security of knot	

Secure knot = 0
Slipping knot = 10
Knot comes apart = 20

Appendix B.4 Pre-Course Questionnaire

Thank you for taking part in this research project to establish whether or not a practical Simulated Laparoscopic Short Course is able to effectively teach operative laparoscopic skills. Please complete the following survey. If you have any questions, please speak with the Trainer.

Your responses will remain confidential.

Please circle your answers.

Participant ID Number:______________

DEMOGRAPHIC INFORMATION:

1) **Gender:** Male Female

2) **Please indicate your current year of training:**

Medical Student	Intern	Pre-SET RMO	SET 1
SET 2	SET 3	SET 4	SET 5

3) **If currently in a SET program, which specialty?** ______________

4) **If not currently in a SET program, do you intend to pursue a career in surgery?**
YES NO UNDECIDED

LEVEL OF SURGICAL EXPERIENCE

5) **In your current position, approximately how much time do you spend in the operating theatre each week?**

0 hrs.	<5 hrs.	5-10 hrs.	11-20 hrs.	>20 hrs.

6) **In your current position, approximately what proportion (%) of time in the operating theatre do you spend in the following roles?**
(i.e. None, 1-25%, 26- 50%, 51-75%, 76-100%)

Role	% Time	Role	% Time
Observer (not scrubbed in)		Primary Operating Surgeon	
Observer (scrubbed in)		Supervisor (scrubbed in)	
Assistant		Supervisor (not scrubbed in)	

SIMULATION TRAINING AVAILABILITY AND PARTICIPATION

7) **In your current position, approximately how much time do you spend learning basic surgical skills _outside_ of the operating theatre each week?** (i.e. At home, office at work, in simulation laboratory)

0 hrs.	<5 hrs.	5-10 hrs.	11-20 hrs.	>20 hrs.

8) **Do you have simulation skills equipment at your current site of employment/training?**

YES NO UNSURE

If yes, what type of simulator(s)? (You can select more than one)

Cadavers	Mannequin-based Models	Virtual Reality Models	Low-fidelity Laparoscopy
Desk-top Models (suturing/knot tying)	Colonoscopy/ Endoscopy	Low-fidelity Arthroscopy	Simulated Operating Theatre

9) **Do you currently have adequate opportunities to access these simulators?** (e.g. suitable simulation laboratory open times, sufficient free time to attend, rostered sessions)

YES NO NOT APPLICABLE

10) **Do you make use of the equipment available?**

YES NO NOT APPLICABLE

If YES, how frequently do you use this equipment?

Less Than Once a Month	1-2 Times Per Month	1-2 Times Per Week	More Than Twice a Week

11) **Does the available simulator equipment available actually meet your training needs?** (e.g. quality of equipment, appropriate skill level, relevance to practice)

YES NO NOT APPLICABLE

MOTIVATION FOR PARTICIPATION IN THIS STUDY

12) **Please indicate how strongly you agree or disagree with each of the following statements with regards to your motivation for participation in this project:**

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am interested in surgery as a career					
I am interested in surgical simulation					
I want to learn new skills					
I want to practice/refresh specific skills					
I was influenced by peers					
I was influenced by my Supervisor					
I don't have access to simulation equipment elsewhere					

PERCEPTIONS OF LAPAROSCOPIC SURGICAL SKILLS OF TRAINEES

13) **Please indicate your opinion on how well prepared surgical trainees are for *laparoscopic* operative techniques *before* entering the operating theatre:**

	Not prepared at all	Only slightly prepared	Neutral	Well Prepared	Very well prepared
Intern and ***Pre-SET RMO's*** preparation for laparoscopic operative techniques					
Junior trainee's ***(SET 1 – SET 2)*** preparation for laparoscopic operative techniques					
Senior trainee's ***(SET 3 and above)*** preparation for laparoscopic operative techniques					

14) **Do you feel your laparoscopic skills are appropriate *for your level* of training?**

NO (below expected level)	YES (at expected level)	YES (better than expected)

PERCEIVED BENEFITS OF LAPAROSCOPIC SIMULATOR USE

15) Please indicate how strongly you agree or disagree with the following statements:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I lack confidence when performing laparoscopic surgery					
I would like to develop more confidence in my laparoscopic abilities					
Participation in simulated laparoscopic skills training would give me more confidence when operating on patients					
Participation in simulated laparoscopic skills training will help me to learn skills faster					
Participation in simulated laparoscopic training is important to me					
I have ample opportunities to learn laparoscopic skills within the operating theatre, ***without*** the need for simulation training					

16) Please indicate how strongly you agree or disagree with the following statements regarding the use of *laparoscopic skills simulators* in preparing surgical trainees for laparoscopic surgical techniques:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Surgical skills simulators can help prepare ***Intern*** and ***Pre-SET RMO's*** for laparoscopic operative techniques					
Surgical skills simulators can help prepare junior trainees ***(SET 1 – SET 2)*** for laparoscopic operative techniques					
Surgical skills simulators can help prepare senior trainees ***(SET 3 and above)*** for laparoscopic operative techniques					

Appendix B.5 Post-Course Questionnaire

Participant ID Number:____________________.

PERCEPTIONS OF THE SIMULATED LAPAROSCOPIC SHORT COURSE

1) **Please indicate how strongly you agree or disagree with the following statements regarding the Simulated Laparoscopic Short Course provided during this research project:**

MSU = Mobile Simulation Unit   SDL = Self-Directed Learning

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/A
QUALITY OF SUPPORT PROVIDED						
I was provided with sufficient support during training and assessment (MSU participants only)						
SDL training was sufficient for my training needs						X
The addition of the MSU training aided in my skills development (MSU participants only)						
My skills acquisition is improved when directed coaching is provided						X
I would have liked more formal instruction						X
QUALITY OF TRAINING FACILITIES & SIMULATOR EQUIPMENT						
The MSU met my needs (e.g. comfort/temperature, noise levels, location)						X
The SDL location met my needs (e.g. temperature, noise levels)						X
During SDL, the location of simulation equipment was easily accessible						X
The simulator tasks were appropriate for my level of training						X
I thought the simulators were easy to use						X
The consumables supply was sufficient for my training needs						X

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
SESSION AVAILABILITY					
I was able to book session times which suited my schedule					
I found it difficult to dedicate time to attend SDL (e.g. due to work/social commitments, supervisor unwilling to allow time)					
PARTICIPANT OUTCOMES & FEASIBILITY AS AN ONGOING COURSE					
Participation in this course has given me more confidence when it comes to my ability to perform basic laparoscopic skills					
Self-directed learning is an effective way to develop surgical skills					
I felt motivated to want to continue SDL					
I would continue to use the simulators regularly if made available at my workplace					
Participation in this program would be ***useful*** on an ongoing basis					
Participation in this program would be ***feasible*** on an ongoing basis					
I would have enrolled in this course if it had cost me $50					
I would have enrolled in this course if it had cost me $100					
I would have enrolled in this course if it had cost me $150					
I would have enrolled in this course if it had cost me $200					

2) **For which training level do you think the Simulated Laparoscopic Short Course is most appropriate?** (You can select more than one)

Surgical Interns	Pre-SET RMOs	Junior SET 1 – SET 2	Middle SET 3 – SET 4	Senior SET 5

*** The following questions relate to simulated surgical skills training <u>in general.</u>*

<u>SKILLS ACQUISITION AND TRANSFER TO THE OPERATING ROOM</u>

3) **Please indicate how strongly you agree or disagree with the following statements regarding simulated skills training *<u>in general</u>*:**

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Laparoscopic skills learnt in the simulation laboratory are transferable to the operating theatre					
Laparoscopic skills learned in the simulation laboratory are comparable to those learnt in the operating room					
Time spent participating in laparoscopic simulation can replace time spent in the operating room					
Surgical Trainees should be required to demonstrate proficiency on a laparoscopic simulator ***before*** being allowed to operate on a patient					
Surgical Trainees and Consultants should be required to demonstrate proficiency on a laparoscopic simulator before operating on patients ***when it comes to using new instruments and technologies*** (i.e. staplers, graspers, implants and other devices)					

<u>PERCEIVED BARRIERS AND ENABLERS OF SURGICAL SIMULATION TRAINING</u>

4) **Please select who you think should be responsible for financing simulation sessions:**

Individual Trainee	Royal Australasian College Of Surgeons	Hospital/Employer

5) **Please select when you would be most likely to use a laparoscopic simulation laboratory:**

During rostered hours (only if mandatory)	During rostered hours (even if voluntary)	In addition to normal shift (before/after work)	During leave time/weekends

6) If simulated laparoscopic training was included in your working week, please select the most appropriate time to schedule sessions:

Before work	After work	Weekends
In lunch break	Before an operating list	After an operating list

7) Please select how frequently you would want to attend these sessions:

Once a week	Once a fortnight	Once a month	Once per rotation/semester

8) In relation to simulation skills training *in general*, please rank the following factors' influence on your decision to participate: (1= most important, 8 = least important)

- ☐ Timing of session (e.g. in rostered time/protected time/in own time/study leave)
- ☐ Cost involved to the individual
- ☐ Location (e.g. on site of current rotation vs. off-site)
- ☐ Consultant recommendation to attend
- ☐ Part of assessment (e.g. formative/summative assessments)
- ☐ Type of simulators available for use (bench-top, virtual reality, mixed model etc.)
- ☐ Mandatory participation
- ☐ Eligibility for Continuing Professional Development (CPD) points

9) What do you perceive as the greatest barriers to participation in simulation training? (You can choose more than one)

Availability of free time to participate	Availability of session times	Availability of equipment	Interruptions (i.e. pagers)
Lack of relevance to my practice	Lack of support from Supervisors	Other (Give details)	

AN IDEAL SIMULATED LAPAROSCOPIC SKILLS COURSE

10) **Please indicate how strongly you agree or disagree with the following statements regarding *your ideal* skills course:**

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
When learning new technical skills, I prefer structured teaching and feedback					
When learning new technical skills, I prefer to plan my own teaching & learn at my own pace (e.g. SDL)					
I learn better in a group environment					
I would be more likely to attend simulation training when held at my site of employment/training					
Simulated laparoscopic training should be a ***mandatory*** component of the surgical curriculum					
I would be ***less*** likely to participate if simulated laparoscopic training is ***voluntary***					
Simulation sessions should be protected time (e.g. no pagers or other interruptions) and rostered rather than ad hoc					
Having weekly/fortnightly mandatory sessions would be ***useful*** as part of my employment and training					
Having weekly/fortnightly mandatory sessions would be ***feasible*** as part of my employment and training					
I would be willing to pay for simulated laparoscopic skills training sessions myself					

11) **Do you have any additional comments about the Simulated Laparoscopic Short Course, or about surgical simulation skills training in general?**

Thank you for taking part in the Laparoscopic Simulation Skills Program. Your time, commitment and comments are appreciated.

Appendix B.6 Educator Questionnaire

Thank you for taking the time to complete this questionnaire as part of the Laparoscopic Simulation Skills Program. This project aims to establish whether or not a Simulated Laparoscopic Short Course is able to effectively teach operative laparoscopic skills, and to what degree a period of formal training and self-directed learning impacts on the acquisition of skills.

The purpose of this survey is to gather information from Surgical Education and Training (SET) Trainee Supervisors and Educators regarding their perceptions on various aspects of simulated surgical skills training in order to develop a feasible curriculum for the training of future surgeons.

Your responses will remain confidential.

<u>DEMOGRAPHICS</u>

Please provide the following demographic information:

1) Hospital Name: ____

2) Your Role and Title:____

<u>TRAINEE PREPARATION FOR LAPAROSCOPIC OPERATIONS</u>

3) With regards to laparoscopic operative techniques, please indicate your opinion on how well prepared surgical trainees are *<u>before</u>* they enter the operating theatre:

	Not prepared at all	Only slightly prepared	Neutral	Well prepared	Very well prepared
Intern and ***Pre-SET RMO's*** preparation for laparoscopic operative techniques					
Junior trainee's ***(SET 1 – SET 2)*** preparation for laparoscopic operative techniques					
Senior trainee's ***(SET 3 and above)*** preparation for laparoscopic operative techniques					

ROLE OF SIMULATED SKILLS TRAINING IN SURGICAL EDUCATION

The surgical curriculum has traditionally been delivered in a Mentor-Apprentice arrangement. Simulated skills training is increasingly being used to enhance/compliment apprentice training methods.

4) What simulation training activities do you have personal experience with?

____
____
____

5) What are your impressions of simulation skills training in general?

____
____
____
____

6) a. What do you see as the greatest benefits of simulation training?

____
____
____
____

b. What are the pitfalls/barriers?

____
____
____
____

7) Do you think it would be beneficial for trainees commencing SET to undertake a practical Simulated Laparoscopic Short Course at the start of their first training year? (e.g. Teaching laparoscopic instrument handling & camera operation, dexterity/motor skills, depth perception, basic techniques of cutting & laparoscopic suturing etc.)

YES NO

8) Do you think simulation activities are appropriate for the following groups?

a. Medical Students:	YES	NO
b. Interns:	YES	NO
c. Pre-SET RMOs:	YES	NO
d. Junior SET Trainees (SET 1-2):	YES	NO
e. Senior SET Trainees (SET 3 onwards):	YES	NO

9) **Please indicate how strongly you agree or disagree with the following statements:**

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Laparoscopic skills learnt in the simulation laboratory are transferable to the operating theatre					
Laparoscopic skills learned in the simulation laboratory are comparable to those learnt in the operating room					
Time spent participating in laparoscopic simulation can replace time spent in the operating room					
Trainees who use simulation are better prepared for the operating theatre environment					
Trainees should be required to demonstrate proficiency on a lap. simulator ***before*** being allowed to operate on a patient					
Trainees should be required to demonstrate proficiency on a laparoscopic simulator before operating on patients ***when it comes to using new instruments and technologies*** (i.e. staplers, graspers, implants and other devices)					
Having weekly/fortnightly mandatory sessions would be ***useful*** for trainees in my department					
Having weekly/fortnightly mandatory sessions would be ***feasible*** for trainees in my department					
Trainee participation in simulated laparoscopic training is important to me					
Participation in simulated laparoscopic skills training helps trainees to learn skills faster					
Participation in simulated laparoscopic skills training gives trainees more confidence when operating on patients					
The use of simulation training will reduce my teaching load in the operating theatre					
Simulation training improves patient safety					

SIMULATION AVAILABILITY

10) What simulation training facilities are available within your department?

(You can select more than one)

a. Desk-top simulators (i.e. suturing, knot tying)
b. Low-fidelity laparoscopy models
c. Arthroscopy models
d. Colonoscopy/endoscopy
e. Virtual Reality models
f. Mannequin-based models
g. Simulated operating theatres
h. Cadaver models
i. Other (give details)____

____

11) Are trainees within your department allocated any dedicated time to participate in simulation? If yes, give details.

YES NO

Details:____

____

12) What simulation facilities would you like to see occurring within your department?

____

____

____

BARRIERS TO SIMULATION TRAINING ACCESS AND PROGRAM DEVELOPMENT

13) What do you believe are the biggest factors impairing trainee's access to simulation training? (e.g. Cost of equipment, time/scheduling restraints, physical space to house simulation equipment, attitudes of other Supervisors)

____

____

____

____

14) Who is responsible for providing simulation training within your department/hospital?

____

____

15) Who do you think should be responsible for developing simulation training programs within your department?

____

____

Appendix C.1 Impact of Participant Training Level

Author	Results	Interpretation
Van Dongen et al[55]	Total study enrolments = 22 (seven PGY1-2, seven PGY3-4, and eight PGY5-6) Attended ≥1 training session pre-incentive: 2/22 (one PGY2 and one PGY5) Attended ≥1 training session post-incentive: 7/22 (two PGY2, two PGY3, one PGY5 and two PGY6)	Training level had limited impact on participation
Stefanidis et al[28]	Motivation ratings of setting goals, in general, correlated positively with attendance rates (*r*=0.75, p<0.01) but negatively with PGY level (*r*=-0.67, p<0.02) Only junior residents were able to achieve 'best goals' Junior resident attendance and motivation was said to be higher and "the residents with the lowest skills lab attendance, who were mainly seniors, related the importance of having best goals low" and there was "limited interest by senior residents."	Limited interest of senior trainees
Seymour[56]	Junior residents (PGY1-2) training session attendance: range 10-38 sessions each Senior resident (PGY 3-5) training session attendance: 3-23 sessions each One PGY5 failed to train at all Junior residents attended more training sessions than seniors: 18+/-3 vs. 9+/-2, p<0.01 Survey: limited senior attendance was due to senior's training time conflicting with theatre responsibilities	Inconclusive Junior trainees had better training compliance, however senior trainee simulation session schedule conflicted with theatre schedule, impacting on their ability to attend simulation
Chang et al[46]	Attended ≥1 training session = 80% (4) of PGY1, 40% (2) of PGY2, and 60% (3) of PGY3, 0% of PGY 4-5 Completed training curriculum (attended ≥3 sessions in 3 months) = 4/29 (three PGY1, one PGY2)	Limited interest of senior trainees

PGY = Post Graduate Year

Appendix C.2 Preferred Hours of Training

Author	Simulator availability	Results	Interpretation
Petrucci et al[45]	Unlimited availability Off-site simulation centre	Survey: (level of agreement on a 10-point scale, 10 = strongly agree) - Felt motivated to practice in their free time: C = 7.0+/-1.9 vs. W = 6.5+/-2.7, p=0.73 - Would make training a priority in their free time: C = 5.4+/-2.3 vs. W = 5.2+/-3.2, p=0.94 C = Control group, W = Website intervention group	Somewhat motivated to practice in spare time
Korndorffer et al[54]	Intervention group (home trainer) = Available out-of-hours at home Control group = Unlimited availability in simulation centre	Focus group interview: Method of training - Home-trained: 80% avoided training while fatigued. Stopped when became frustrated or tired - Centre-trained: All still trained while fatigued. The "fatigue factor made it more frustrating". They "got bored"	Training methods differ at home vs. simulation centre
Van Dongen et al[55]	Unlimited availability Simulator located in resident general (common) room near wards	Simulator usage times: - During night shift = 58% of training sessions - Does not state % training during day shifts, or whilst off-duty Survey: Reason for non-attendance at training: - 13/15 (86.67%) of those who did not attend = due to lack of time during the day	Inconclusive Lack of available time is a barrier to training
Chang et al[46]	Unlimited availability In-hospital simulation laboratory	Simulator usage times: - During working hours = 70% - Post-call = 26% - While off duty = 4% (1/29)	Practice during work hours is preferred

AppendixC.2 continued

Author	**Simulator availability**	**Results**	**Interpretation**
Van Empel et al[57]	Available out-of-hours at home	Survey 1 statement: (level of agreement on a 5-point scale) - "I would prefer practicing in skills lab in working hours rather than at home out-of-hours" (76 respondents): 31.6% agree, 38.2% neutral 30.2% disagree Survey 2: 18 respondents Problems faced with training at home (faced by individual vs. perceived problems experienced by others) - Lack of time: 10/18 vs. 8/18 (55.5% vs. 44.4%) - Capacity at home: 5/18 vs. 6/18 (27.7% vs. 33.3%) Suggested improvements to encourage practice: - 2/18 (11.1%) recommend enabling work hour practice	Inconclusive/Neutral Lack of available time still a barrier to training for home-based simulation
Burden et al[58]	Unlimited availability Simulator located in a room within Gynaecology Department	Simulator usage times: - Within normal working hours (09:00-17:00) = 60.8%, 95% CI 57.3-64.2 - Does not state % training during night shifts or whilst off-duty	Practice during work hours is preferred

Appendix C.3 Impact of Setting Performance Goals

Author	**Comparison (Training Incentive)**	**Results**	**Interpretation**
Petrucci et al[45]	Impact of collaborative intervention website (incl. knowledge of scores) on attendance compared to control group who did not have access to website.	Survey Statement: On 10-point scale, 10 = strongly agree: - "Reaching proficiency score motived me to practice": C = 8.9+/-1.2 vs. W = 7.6+/-1.7, p=0.13	Proficiency goals may motivate participation
Stefanidis et al[28]	Attendance in the 5 months pre- and post-introduction of training incentives 'Best goals' set and public naming of resident who achieved best goal	Survey: On a 20-point scale, 20 = highest impact - Impact of setting overall performance goals on motivation to attend: 15 (range 1-18) - Impact of setting best goal on motivation to attend: 13 (range 1-18) Motivation ratings of setting goals correlated positively with attendance rates (r = 0.75, p<0.01) and negatively with PGY level (r = -0.67, p<0.02)	Proficiency goals may motivate participation
Van Empel et al[57]	Survey of motivations and barriers to practicing on a take-home suturing simulator	Survey: 18 respondents - 2/18 stated absence of pre-defined training goals was a problem they faced - 3/18 perceived this to also be a problem faced by others) Suggestions to increase motivation: 18 respondents - Set learning goals (5/18 agreed, 27.8%) - Set midway assessments (4/18 agreed, 22.2%) - Set obligatory assessments (4/18 agreed, 22.2%)	Proficiency goals may motivate participation

C = Control group. W = Website intervention group. PGY = Post-Graduate Year Level

Appendix C.4 Impact of Competition and 'Competitive Gaming'

Author	Comparison	Results	Interpretation
Petrucci et al[45]	Impact on attendance rates of collaborative intervention website including knowledge of peers' results compared to control group who did not have access to website.	Survey Statements: (level of agreement on 10-point scale, 10 = strongly agree) - "I would be motivated to practice by knowing my peers were practicing": C = 8.9+/-1.2 vs. W = 6.4+/-3, p=0.07 - "I would be motivated to practice by knowing if my peers were achieving higher scores": C = 7.8+/-1.7 vs. W = 5.7+/-2.9, p=0.12 - "I would be motivated to practice if I was being compared to seniors/staff": C = 7.7+/-2.5 vs. W = 5.6+/-3.5, p=0.25 Intervention group only: - "I felt more motivated to practice being part of a group": 5.7 +/- 2.4 - "I pushed myself more after seeing the progress of others": 4.5 +/- 3	Competition had limited perceived effect on motivation
Van Dongen et al[55]	Attendance pre and post introduction of training incentives Bi-weekly measurement and naming of best performer, prize awarded	Attended ≥1 training session: - Pre-incentives = 2/22 - Post-Incentives = 7/22 Total time spent on training: - Pre-Incentives = 163min (average total 81.5min per participant) - Post-Incentives = 738min (average total 105.4min per participant)	Competition had minimal effect on participation rates
Stefanidis et al[28]	Attendance in the 5 months pre- and post- introduction of training incentives 'Best goals' and public naming of resident who achieved best goal	Median weekly attendance rates at scheduled training sessions: - Pre-Incentives = 21% (range 0-54% per session) - vs. Post-Incentives = 51% (range 8-96% per session) p<0.001 Survey: On a 20-point visual analogue scale (where 20 = highest impact): - Impact of posting name of best performer: 10 (range 1-16)	Competition had limited effect on participation rates

Appendix C.4 continued

Verdaasdonk et al[59]	Online inter-hospital competition Motivation to join competition Laptop awarded to the best score	31 participants from 7 hospitals enrolled Participant demographics (laparoscopic surgical experience): - 52% were intermediate experience (<50 laparoscopic procedures performed) - 16% were novice (no experience) - 16% were beginner (camera navigation only) - 16% were expert (>50 laparoscopic procedures performed) Survey Statement: - "I was motivate to join the competition in order to win": >50% of participants agreed (rather than "for fun", "felt obliged", or "to learn laparoscopic skills")	Competition may attract more senior trainees to participate

C = Control group. W = Website intervention group

Appendix C.5 Impact of Personal Enjoyment and Relevance to Training

Author	Survey	Interpretation
Van Dongen et al[55]	Reason for non-attendance at training: - 13/15 (of those who did not attend) = lack of time during the day - 1/15 = not interested to train, had other priorities - 1/15 = fully occupied due to ICU traineeship and maternity leave	Lack of interest/enjoyment is not a common reason for non-attendance
Stefanidis et al[28]	Survey: Motivation for attending training sessions (choice of two options): - "Internal Motivations" = 60% of participants agreed - "Mandatory nature of the course" = 40% agreed	Participants are motivated to learn
Chang et al[46]	Survey Statements: (level of agreement on an 4-point scale) - "The simulator was easy to use" = 96% agree - "I enjoyed using the simulator" = 95% agree - "The simulator improved my skill" = 87% agree, 13% strongly agree - "The simulator is a suitable substitute for theatre time" = 50% disagree, 8% strongly disagree Reason for non-attendance at training: - Lack of interest 11% - Off-site rotation 44%, lack of time 39%	Lack of interest/enjoyment is not a common reason for non-attendance Simulators are easy to use
Van Empel et al[57]	Survey Statements: (level of agreement on a 5-point scale) - "The simulator was easy to set up at home" = 71.8% agree, 9% disagree, 19.2% neutral - "I have interests other than laparoscopic surgery" = 15.2% agree, 29.1% neutral, 50.6% disagree	Lack of interest/enjoyment is not a common reason for non-attendance Simulators are easy to use
Burden et al[58]	Focus-group interviews: (themes) Positives: - Appreciated being able to use surgical equipment away from the constraints of theatre - Increased confidence, psychomotor skill improvement, and less stress during practice compared with theatre - Simulator was fun/provided a game feeling and had realistic graphics Negatives: - Lack of realism/tactile feedback - Lack of integration into the training curriculum (some supervisors unaware that trainees had LapSim experience) - Frustrated by having to complete modules in a prescribed order	Inconsistent results between participant focus-groups

Appendix C.5 continued

Verdaasdonk et al[59]	Survey Statement: (on a 10-point scale, 10 = enormous): - "I am motivated to learn laparoscopic skills" = 9 (range 1-10)	Participants are motivated to learn

ICU = Intensive Care Unit

Appendix C.6 Impact of Work Hour Restrictions

Author	Results	Interpretation
Petrucci et al[45]	90% of participants felt that the following made it difficult to practice: clinical duties, long work hours, off-site simulation centre, ongoing activities on the ward.	Lack of time and conflict with clinical duties are barriers to participation in simulation
Korndorffer et al[54]	Focus group interviews: - Issues regarding duty hours were not raised despite training at the centre being considered part of duty hours whereas home training was not. - Challenges faced by centre-trained participants: Needing to "change schedules and reschedule, "answering phones" while training and being "rushed most of the time"	Lack of time and conflict with clinical duties are barriers to participation in simulation
Van Dongen et al[55]	Survey Statement: (level of agreement on a 5-point scale) "I would like more time to train": "Majority" agree or strongly agree Of the 15 who did not undertake training, reasons were: - 13/15 (86.67%) = lack of time during the day - 2/15 = not interested in training/other priorities (incl. maternity leave) Suggestions to increase participation - 9/22 make it mandatory, 2/22 need for diminished work pressures, 2/22 more initiative was needed by the residents	Lack of time and conflict with clinical duties are barriers to participation in simulation
Seymour[56]	- Highly variable number of training sessions were undertaken - Trainees still prioritised clinical duties over training duties, despite simulation sessions being mandatory	Lack of time and conflict with clinical duties are barriers to participation in simulation
Chang et al[46]	Survey: Reasons for not using the simulator: - 44% off-site rotation - 39% no time - 11% no interest - 6% focussed on research Survey Statement: (level of agreement on a 4-point scale) - "I would use the simulator more if the working week was less than 80 hours/week" (51 respondents): 65% agree, 31% strongly agree, 4% disagree - "Simulator sessions could replace time spent in theatre": 50% disagree, 8% strongly disagree, 42% agree	Lack of time is a barrier to participation in simulation

Appendix C.6 continued

Van Empel et al[57]	1st Survey Statements:[a] (level of agreement on a 5-point scale) 80 respondents - "I would like more time to train": 62.5% agree (30% neutral, 7.5% disagree) - "I'd train more if it was obligatory": 50.1% disagree (28.8% agree, 21.3% neutral) - "Training should be obligatory before entering theatre" (77 respondents): 76.6% agree (14.3% neutral, 9.1% disagree) - "I have practiced enough on the box trainer": 42.5% agree (23.8% neutral, 33.7% disagree) - "I get enough MIS practice without the box trainer": 83.8% disagree (2.5% agree, 13.8% neutral) - "I have insufficient laparoscopic training time during residency": 45% agree (37.5% neutral, 17.5% disagree) 2nd Survey: 18 respondents: Problems faced with training at home (faced by individual vs. perceived problems experienced by others) - Lack of time: 10 vs. 8 (55.5% vs. 44.4%) - No motivation: 0 vs. 4 (0% vs. 22.2%) Suggestions for improvements to encourage at home practice: - Enable work hour practice 2/18 (11.1%)	Lack of time is a barrier to participation in simulation (even at home) Trainees believe they don't get enough laparoscopic experience without simulation
Burden et al[58]	Focus-group Interviews: - In both groups, time restrictions in work schedules emerged as predominant barrier to using the simulator - Participants prioritised clinical duties as simulator training was not compulsory	Lack of time and conflict with clinical duties are barriers to participation in simulation

ICU = Intensive Care Unit. MIS = Minimally Invasive Surgery

[a]Results have been combined by authors Van Empel et al so that Disagree = strongly disagree + disagree, and Agree = strongly agree + agree

Appendix C.7 Impact of Simulator Location

Author	Location	Results	Interpretation
Petrucci et al[45]	Off-site simulation centre	90% felt that the following made it difficult to practice: off-site simulation centre, clinical duties, long work hours, ongoing activities on the ward	Locating the simulator away from sites of training has a negative impact on participation
Korndorffer et al[54]	Home trained vs. off-site simulation centre trained H = Home trained C = Centre Trained	Total training time: H = 458+/-290min vs. C = 356+/-133min ** Total number of practice attempts made: H = 86+/-35 vs. C = 85+/-34 ** Individual training sessions attended: H = 13+/-7.8 vs. C = 7.2+/-2.7, $p<0.05$ Survey: Method of training - H = 80% avoided training while fatigued, and would stop when frustrated or tired. Divided training time for each session between peg and suture tasks. - C = All still trained while fatigued. The "fatigue factor made it more frustrating" and they "got bored". 90% used all the training time in each session devoted to one task Survey: Challenges to training - H = Equipment related: "oblique angle made it difficult" and "bright white glare in the box" - C = Schedule related: including the need to "change schedules and reschedule" and "answering phones" while training and being "rushed most of the time"	Training location did not influence total time spent training or the number of attempts made at each task Home-trained participants undertook distributed learning (shorter, more frequent sessions, with both tasks practiced during each session)
Van Dongen et al[55]	Simulator located in General Room near wards	Only 1/22 participants suggested moving the location of the simulator to increase participation	Make-shift simulation centre does not have a great impact on motivation
Chang et al[46]	Simulation laboratory within hospital	Reasons for not using simulator: - 44% off-site rotation - 39% no time - 11% no interest - 6% focussed on research instead	Locating the simulator away from sites of training has a negative impact on participation

Appendix C.7 continued

Van Empel et al[57]	At-home simulator	1st Survey Statements:[a] (level of agreement on a 5-point scale) 80 participants - "I prefer practicing in skills lab in working hours" (76 responses): 31.6% agree, 38.2% neutral, 30.2% disagree - "The box trainer is easy to set up at home" (78 responses): 71.8% agree (19.2% neutral, 8% disagree) 2nd Survey: (18/80 responded to this survey) Problems faced with training at home (faced by individual vs. perceived problems experienced by others) - Capacity at home 5 vs. 6 (27.7% vs. 33.3%) - Monitor quality: 1 vs. 3 (5.6% vs. 16.7%) - No suturing material: 0 vs. 3 (0% vs.16.7%) - No motivation: 0 vs. 4 (0% vs.22.2%) Improvements to encourage at home practice: - Improve monitors 2/18 (11.1%) - Enable work hour practice 2/18 (11.1%)	Potential for technical difficulties when simulator is not in a simulator laboratory No strong preference for simulation centre vs. home training
Burden et al[58]	Simulator located in room near Gynaecology Department	Focus-group Interviews: "Many" participants liked the simulator being in a quiet, non-clinical area away from clinical interruptions.	Make-shift simulation centre does not have a negative impact on motivation
Verdaasdonk et al[59]	Location within hospitals not described	2 centres entered the competition up to 4 weeks late due to "technical and organisational difficulties with the internet facilities"	Potential for technical difficulties when simulator is not in a standard simulation laboratory Important to have access to technical staff to correct technical issues

** Not statistically significant. [a]Results were combined by authors so that Disagree = strongly disagree + disagree, and Agree = strongly agree + agree

Appendix C.8 Impact of Educator Instruction and Feedback

Author	Feedback	Results	Interpretation
Korndorffer et al[54]	No mentoring Video-recording of sessions to test accuracy of self-reporting of sessions	Focus group interviews: Analysis did not identify the lack of direct, personal feedback as a trainee concern	Inconclusive
Van Dongen et al[55]	VR simulator assessment/ feedback	Survey: Suggestions to help increase motivation/participation 2/18 suggested to have competitive training along with coaching	Coaching/feedback may improve participation
Stefanidis et al[28]	VR simulator assessment/ feedback Weekly scheduled sessions with an Educator	Poor attendance Impact of Educator on motivation was not assessed	Inconclusive
Seymour[56]	Mandatory 1-hour sessions with Educator Additional SDL sessions	Variable attendance Impact of Educator on motivation was not assessed	Inconclusive
Chang et al[46]	Mandatory 2-hour introduction session to simulator Educator/trainer available on request VR simulator assessment/ feedback	No-one requested individual proctoring Survey Statement: (level of agreement on a 5–point scale) - “The introduction session was sufficient”: 67% agree, 25% strongly agree, 8% disagree - “Proctoring is not needed”: 75% disagree, 25% agree	Educator instruction/feedback needs to be structured or scheduled in order to be utilised
Van Empel et al[57]	2 days of formal instruction, separated by 6 weeks of SDL	Survey: Suggestions encourage home practice (18/80 participants responded) - 5/18 recommended set learning goals - 4/18 set obligatory assessments - 4/18 midway assessments	Coaching/feedback may improve participation

Appendix C.8 continued

Burden et al[58]	Educator/trainer available on request Reminder emails sent during study period	No-one requested individual proctoring Modules had to be completed in order before progressing to next level. Median number of failed attempts at the last module attempted: 18 (range 4-57, mean 17.9, 95%CI 5.3-30.5) Focus-group interviews: Focus group 1: Happy with the level of supervision provided. Willing to ask for additional help if required. Praised the simulator for being specific in its feedback. Focus group 2: Reluctant to seek help. Majority felt it would be useful to have someone observing the training sessions on an individual basis, but that group observations would not be helpful.	Inconsistent results Educator instruction/feedback needs to be structured or scheduled in order to be utilised

VR = Virtual Reality. SDL = Self-Directed Learning

Appendix C.9 Impact of Mandatory Training

Author	Training curriculum	Results	Interpretation
Korndorffer et al[54]	Participation in curriculum was a required component of the surgical residency training program, but use of training data for the study was voluntary Encouraged to train at ≥1 hour per week. No ramifications if failed to attend	Both groups trained less than the advised (1 hour per week) total training time Actual Total training time (over 60 days): - Home trained: 458+/-290min - Centre trained: 356+/-133min	'Mandatory' training must have consequences for non-attendance in order to be effective
Van Dongen et al[55]	Use of the simulator was entirely voluntary. Name of participant with most frequent usage and highest proficiency score was announced to the Surgical Department.	Survey Questions: (level of agreement on a 5-point scale, 5=strongly disagree) - "I won't train unless it is obligatory": Disagree 4.26 (SD 1.10) - "Virtual Reality training should be built into the curriculum": "Majority" agree or strongly agree - "Obligatory VR training will improve basic skills": "Majority" agree or strongly agree - "A certain VR simulator level should be achieved before allowance into theatre": Agree/neutral 2.47 (SD 1.39) Suggestions to increase participation: - "Make it mandatory": 9/22 - "Mandate a certain level of skill to be achieved on the simulator before performing in theatre": 3/22	'Mandatory' training may increase participation
Stefanidis et al[28]	Mandatory weekly scheduled session with a trainer No ramifications if failed to attend. Asked to make up the session the next week	Median weekly session attendance: - Pre-incentive: 21% (range 0-54%) - Post-incentive: 51% (range 8-96%)(p<00.1) Motivation for attendance: 60% personal/internal motivators vs. 40% mandatory nature of the course	'Mandatory' training must have consequences for non-attendance in order to be effective

Appendix C.9 continued

Seymour[56]	Mandatory scheduled sessions Attendance at additional voluntary SDL sessions Target minimum training time for mandatory sessions was 1 hour per fortnight per resident	Highly variable number of sessions attended outside the blocked time - Number of sessions attended by each junior resident: range 10-38 - Number of sessions attended by each senior resident: range 3-23 One PGY5 failed to train at all. No disciplinary action taken	'Mandatory' training must have consequences for non-attendance in order to be effective
Chang et al[46]	2-hour mandatory introductory session regarding simulator use (required to attend in order to have ongoing access to simulator). Voluntary use of the simulator after introductory session.	Attendance at mandatory introduction session: 29/51 residents Attended at least 1 training session (post-introduction): 9/29 residents Survey Statement: (level of agreement on a 4-point scale) - "I would use the simulator more if it was mandatory": 41% agree, 23% strongly agree, 36% disagree	'Mandatory' training may increase participation
Van Empel et al[57]	The Advanced Suturing Course (ASC) is a requirement of the residency training program.	Survey Statements:[a] (level of agreement on a 5-point scale) - "I'd trained more if it was obligatory" (of 80 respondents): 50.1% disagree (28.8% agree, 21.3% neutral) - "Training at home must be obligatory to improve basic skills" (of 77): 42.9% agree (27.3% neutral, 29.9% disagree) - "Training should be obligatory before entering theatre" (of 77): 76.6% agree (14.3% neutral, 9.1% disagree) Suggestions to improve attendance/motivation: - 4/18 recommend obligatory assessments - 4/18 recommend midway assessments	'Mandatory' training may increase participation Participants favour mandatory simulator training before being allowed to perform in theatre
Burden et al[58]	Use of the simulator was entirely voluntary.	Focus group interviews: "Majority" welcomed making simulation compulsory Would have found more time to train if the virtual reality simulation training was mandatory with deadlines set for completing modules	'Mandatory' training may increase participation

SDL = Self-Directed Learning. PGY = Post-Graduate Year Level. VR = Virtual Reality

[a]Results were combined by authors Van Empel et al so that Disagree = strongly disagree + disagree, Agree = strongly agree + agree

Appendix D.1 Simulated Theatre Scenario

Case title Haemodynamic instability in a trauma patient who is possibly Jehovah's Witness.

Duration

Initial setup: 15 minutes

Simulation: 7-10 minutes Change of scenario setup: 5 minutes
Debrief: 20-30 minute

Case Stem
The participant plays the role of a senior surgical Trainee who is asked to assist with closing a laparotomy in a patient who has undergone surgery for blunt abdominal trauma. When the participant arrives in the OR, the patient is anesthetized and the surgery is nearly completed. The consultant surgeon is rushed because another critical poly-trauma patient has recently arrived and he needs to assess the new patient. The consultant surgeon gives a brief handover, asks the participant to close the abdomen, and leaves the room. Shortly after the surgeon has gone, the patient starts deteriorating and the anesthetist initiates a discussion about blood transfusion. The scout nurse informs the team that the patient's wife recently telephoned the hospital and said the patient is Jehovah's Witness.

Confederates in the OR
1- Anesthetist
2- Consultant surgeon
3- Scrub nurse
4- Scout nurse

Briefing information given to the participant by the facilitator
Situation: You are in a metropolitan hospital on a really busy day and you have been called down to relieve the chief trauma surgeon in the OR.
Background: The surgeon is just finishing an emergency laparotomy but has been called away to assess another trauma patient urgently.
Assessment: The surgeon will inform you of the details when you receive a handover.
Recommendation: Everyone is really busy, so I suggest you either scrub or get in there as quickly as you can.

Patient History
The patient is a 67-year-old male who arrived at the hospital by the Ambulance service after being the victim of a frontal car collision with a fixed object (tree). The patient was the sole occupant. There is a history of alcohol consumption prior the accident. Glasgow Coma Score (GCS) was 14 at the scene but decreased to 11 in the ED.

On initial examination:
A – Patent airway, cervical spine immobilized
B – Respiratory Rate 22, Thorax stable, Normal & symmetrical breath sounds
C – Heart Rate 100, Radial Pulse present. Moderately pale. Systolic Blood Pressure = 110 mm.
Abdomen: slightly distended and tender. Pelvis: stable.
D – GCS 11 (Eye: 3 Verbal: 3 Motor: 5). Normal pupils.
E – Presence of seat belt sign on the abdomen. Presence of a 4 cm frontal scalp laceration.

The patient underwent a Computed Tomography (CT) scan of the head, neck, chest, abdomen, and pelvis. Abdominal CT revealed a large splenic laceration involving the hilum with active hemorrhage into the peritoneal cavity (splenic injury grade IV), the presence of a moderate amount of free fluid in the abdomen (on the four quadrants) and the presence of free intraperitoneal air. No abnormalities on head, neck or chest CT. Patient was taken from CT to the operating room to undergo emergency laparotomy.

Table A shows the scenario flow.

Table A Simulation flow for Scenario `Hemodynamic instability in a trauma patient who is possibly Jehovah's Witness`.

Phase and patient status	Participant actions expected	Confederates and distraction	Additional information
Phase 1 Anesthetised Stable **A**: HR: 80 bpm O2 Sat: 96% BP:120/80mmHg	- Introduces self to members of OR team and follow OR protocol. - Communicates with the team about the case and progress of the operation. - Is objective and realizes that there is no surgeon scrubbed at the table and scrubs in promptly. - Optimizes operating conditions, moving table and lights. - Recognizes there has been significant blood loss.	- (Surgeon): States the surgery is nearly finished, gives a brief handover and quickly leaves the room to assess a critical patient elsewhere. - (Scrub nurse and scout nurse): Are performing the count of surgical sponges.	**Pre-brief:** Instruct participant to assist in performing trauma surgery. **OR set-up:** - Normal OR equipped for trauma surgery. - Presence of 1,500 ml bright simulated blood in the suction bottle. - Presence of several sponges stained with blood. - The surgical table is too high or low and the surgical lights are clearly in the wrong position for the participant to view the abdomen clearly. **Additional information if requested:** • The procedure has lasted for 90 minutes; the surgeon has performed a splenectomy and repaired a grade II injury to the jejunum. The procedure has been straightforward and unremarkable. • Blood is available, cross-matched and ready. • Urinary output (100 mls during surgery) – The urinary output will not change during the scenario. • 3 liters of crystalloid solution has been given to the patient during the procedure. • Estimated blood loss (2 L). • The postsurgical plan is to send the patient to the intensive care unit. **Trigger:** When the participant is scrubbed and in the surgical field, move to Phase 2.
Phase 2 Anesthetized Stable **A:** HR: 82 bpm O2 Sat: 98% BP:120/70mmHg **B:** HR: 96 bpm O2 Sat: 96% BP:100/68mmHg	- Seeks confirmation that the count is correct before initiation of abdominal closure.	- (Anesthetist): States that the patient's blood pressure has dropped and that he/she is worried. Asks if there is anything wrong with the surgery (the mannequin is dry – no signs of active bleeding).	**Trigger:** When the surgeon initiates the abdominal closure, the anesthetist states that something is wrong with the patient and asks if there is any active bleeding, move to Phase 3

Table A continued

Phase 3 Anesthetized Stable **C**: HR: 100 bpm O2 Sat: 96% BP:94/66mmHg	- Recognizes the emergency of the situation and tries to find a reason for the patient progressive decrease in blood pressure. - The participant should remain calm under pressure.	- (Anesthetist): Is worried about the patient's condition. Asks for blood. - (Scout nurse): Is designated to get the blood and leaves the room.	**Additional information if asked:** • There is no active bleeding. The abdominal cavity is dry, but there are signs of considerable recent bleeding. • No evidence of significant thoracic, pelvic or head trauma. • Results of exams collected at the beginning of the procedure: Lactate 4.2 mg/dL; Platelets 90000/μL; Hb 10.5 g/dL; Bicarbonate 17 mEq/L; BE -8.1 mEq/L; pH 7.29. Finger prick hemoglobin is now down to 7.5 g/dL. **Trigger**: The scout nurse returns to the room and states that the patient's wife telephoned to say he is Jehovah's Witness. Move to Phase 4.
Phase 4 Anesthetized Deteriorating **D**: HR: 110 bpm O2 Sat: 93% BP:90/58 mmHg	- Deals with a deteriorating patient under pressure and deals with a conflict inside the group. - Calls for assistance. - Initiates a balanced discussion of options, pros and cons with team members. Reaches a decision and clearly communicates it.	- (Anesthetist): Is worried because the patient is deteriorating and suggests the patient should receive a blood transfusion. States that there is no official confirmation the patient is Jehovah's Witness. - (Scout nurse): Reminds the team the patient is Jehovah's Witness. The nurse states that he/she will not get the blood. - (Scrub nurse): Asks the scout to help the team.	**Additional information if asked:** • There is no evidence in the notes or any document that proves the patient is Jehovah's Witness. • If the participant asks to contact the patient's wife, she is unavailable. • Prior to surgery, due to the emergency nature of the situation, the patient was not fit to consent himself and no family members were available, so a two-doctor consent was obtained. **Trigger**: The scout nurse states he/she will not bring the blood into the OR as he/she is a Jehovah's Witness as well. Move to Phase 5.
Phase 5 Anesthetized Deteriorating **E**: HR: 122 bpm O2 Sat: 93% BP:88/60 mmHg **F**: HR: 127 bpm O2 Sat: 92% BP:80/57 mmHg	- Asks the team to concentrate on the patient and to stop arguing. - Demonstrates leadership and conflict handling. - Delegates tasks in order to achieve goals and remains calm under pressure.	- (Anesthetist and scout nurse): Argue about giving or not giving blood to the patient. - (Scout nurse): Performs every task delegated by participant except getting the blood. States that giving blood to someone who has refused a blood transfusion is assault and that he/she will not	**Additional information if asked:** • If the participant asks the consultant to be called, he/she is not available. If the participant asks again, the scout leaves the OR and on returning states that the surgeon is performing an emergency thoracotomy and requests the participant to deal with the case.

Table A continued

Phase and patient status	Participant actions expected	Confederates and distraction	Additional information
	- Manages the situation in ways that demonstrate sensitivity to the social, cultural, and psychological needs of the staff. - Asks for another scout to replace the existing scout nurse.	cooperate. If the participant asks the scout nurse to change with another, the scout nurse is to follow the instructions.	
Scenario finishes			

Appendix D.2 Statistical Analyses and Inter-Rater Reliability Calculations

The Data

Two data sets were provided for this analysis – one for experienced surgeons and one for trainee surgeons. While trainee surgeons went through multiple scenarios before and after training, for this analysis, only the results from their first attempt of the scenario were utilised, as these are comparable with the scenario that experienced surgeons underwent.

Results

All statistical analyses were undertaken in the statistical software R (v3.2.2).[1]

Objective

For Fellows, assess the inter-rater reliability between assessors PH and MT, as previously done for SET Trainees.

Data for 30 Fellows was available for this analysis. A summary of how frequently each assessor awarded each score and their average score for each category is presented in Table 1. From these results it appears that both assessors gave similar scores, on average, for most categories, with the biggest exceptions being SA.GI and CT.ESU. Compared with previous work for SET Trainees, assessor PH is not consistently higher, on average, than MT. However, on average, PH scored higher for all Decision Making and all Leadership elements.

The summary in Table 1 ignores the paired nature of the data, i.e. that assessors scored the same participants. A summary of how frequently assessors agreed in their scoring is provided in the following sections.

Table 1: Summary of scores given by each assessor for each category

	SA			DM			CT			L		
	GI	UI	PFS	CO	SC	IR	EI	ESU	CTA	SMS	SO	CP
MT												
1	0	0	1	1	3	3	0	0	2	3	8	0
2	2	6	12	16	9	14	3	4	9	5	9	6
3	24	22	17	6	16	11	24	22	15	19	8	22
4	4	2	0	7	2	2	3	4	4	3	5	2
Ave	3.1	2.9	2.5	2.6	2.6	2.4	3.0	3.0	2.7	2.7	2.3	2.9
PH												
1	0	2	0	1	3	2	1	4	5	0	4	0
2	13	7	17	9	7	8	6	8	8	5	9	0
3	16	19	8	19	16	18	20	16	14	25	14	23
4	1	2	5	1	4	2	3	2	3	0	3	7
Ave	2.6	2.7	2.6	2.7	2.7	2.7	2.8	2.5	2.5	2.8	2.5	3.2

1. Situational Awareness

The frequencies with which assessors awarded each rating for the elements of Situational Awareness are shown in Table 2. In this table, elements on the diagonal (shown in bold font) indicate agreement between assessors MT and PH, while non-zero elements off the diagonal indicate that wither MT scored higher than PH (below the diagonal) or that PH scored higher than MT (above the diagonal).

Table 2: Agreement between assessors for Situational Awareness (MT in rows; PH in columns); bold elements on the diagonal indicate agreement between the two assessors.

	GI				UI				PFS			
	1	2	3	4	1	2	3	4	1	2	3	4
1	**0**	0	0	0	**0**	0	0	0	**0**	1	0	0
2	0	**2**	0	0	0	**2**	4	0	0	**7**	3	2
3	0	11	**13**	0	2	5	**13**	2	0	9	**5**	3
4	0	0	3	**1**	0	0	2	**0**	0	0	0	**0**

With respect to measuring agreement between the two assessors, J Field previously reported both Cohen's κ and Gwet's AC1, and noted that Gwet's AC1 does not suffer the paradoxes of Cohen's κ. For this reason, we only consider Gwet's approach here. In addition, a weighted version of Gwet's AC1, referred to as AC2, can be calculated to take into account the ordinal nature of the assessors' scores.[2] This means that pairs of scores assigned by the two assessors, such as 2&4 are weighted to indicate less agreement than scores such as 2&3 or 3&4.[1] As a result, values of AC2 will generally be higher than AC1, which assumes there is no relationship between neighbouring values and hence treats 2&3, for example, as total disagreement. The AC2 values for the elements of Situational Awareness are shown in Table 3, along with the raw agreement (the proportion of participants for which the assessors agreed – shown in bold in Table 2). From these values it can be seen that the agreement between the two assessors is moderate (AC2: 0.41 to 0.60) to good (AC2: 0.61 to 0.80) when using the interpretation proposed by Altman.[3]

Table 3: Gwets AC2, including lower and upper 95% confidence bounds, and Raw agreement for Situational Awareness.

	AC_2	LCB	UCB	Raw
GI	0.750	0.630	0.870	0.844
UI	0.698	0.545	0.852	0.811
PFS	0.592	0.434	0.749	0.778

[1] The resulting value of AC2 depends on the size of the weights that are assigned, and for this analysis we use linear weights.

2. Decision Making

The frequencies with which assessors awarded each rating for the elements of Decision Making are shown in Table 4.

Table 4: Agreement between assessors for Decision Making (MT in rows; PH in columns); bold elements on the diagonal indicate agreement between the two assessors.

	CO				SC				IR			
	1	2	3	4	1	2	3	4	1	2	3	4
1	**0**	1	0	0	**0**	3	0	0	**0**	3	0	0
2	1	**5**	9	1	1	**2**	6	0	1	**3**	9	1
3	0	1	**5**	0	2	2	**9**	3	1	2	**7**	1
4	0	2	5	**0**	0	0	1	**1**	0	0	2	**0**

The AC2 values for the elements of Decision Making are shown in Table 5, along with the raw agreement (the proportion of participants for which the assessors agreed – shown in bold in Table 4). From these values it can be seen that the agreement between the assessors is moderate (AC2: 0.41 to 0.60) when using the interpretation proposed by Altman.[3]

Table 5: Gwet's AC2, including lower and upper 95% confidence bounds, and Raw agreement for Decision Making.

	AC_2	LCB	UCB	Raw
CO	0.496	0.317	0.675	0.744
SC	0.568	0.386	0.750	0.778
IR	0.528	0.356	0.699	0.756

3. Communication and Teamwork

The frequencies with which assessors awarded each rating for the elements of Communication and Teamwork are shown in Table 6.

Table 6: Agreement between assessors for Communication and Teamwork (MT in rows; PH in columns); bold elements on the diagonal indicate agreement between the two assessors.

	EI				ESU				CTA			
	1	2	3	4	1	2	3	4	1	2	3	4
1	**0**	0	0	0	**0**	0	0	0	**1**	0	1	0
2	0	**1**	2	0	2	**1**	1	0	3	**3**	2	1
3	1	4	**16**	3	1	5	**14**	2	1	4	**8**	2
4	0	1	2	**0**	1	2	1	**0**	0	1	3	**0**

The AC2 values for the elements of Communication and Teamwork are shown in Table 7, along with the raw agreement (the proportion of participants for which the assessors agreed – shown in bold in Table 6). From these values it can be seen that the agreement between the two assessors is moderate (AC2: 0.41 to 0.60) to good (AC2: 0.61 to 0.80) when using the interpretation proposed by Altman.[3]

Table 7: Gwet's AC2, including lower and upper 95% confidence bounds, and Raw agreement for Communication and Teamwork.

	AC_2	LCB	UCB	Raw
EI	0.750	0.599	0.901	0.833
ESU	0.615	0.380	0.849	0.778
CTA	0.499	0.285	0.712	0.756

4. Leadership

The frequencies with which assessors awarded each rating for the elements of Leadership are shown in Table 8.

Table 8: Agreement between assessors for Leadership (MT in rows; PH in columns); bold elements on the diagonal indicate agreement between the two assessors.

	SMS				SO				CP			
	1	2	3	4	1	2	3	4	1	2	3	4
1	**0**	2	1	0	**2**	3	3	0	**0**	0	0	0
2	0	**0**	5	0	2	**1**	5	1	0	**0**	6	0
3	0	3	**16**	0	0	4	**4**	0	0	0	**15**	7
4	0	0	3	**0**	0	1	2	**2**	0	0	2	**0**

The AC2 values for the elements of Leadership are shown in Table 9, along with the raw agreement (the proportion of participants for which the assessors agreed – shown in bold in Table 8). From these values it can be seen that the agreement between the two assessors is good (AC2: 0.61 to 0.80) for SMS and CP, but only fair (AC2: 0.21 to 0.40) for SO when using the interpretation proposed by Altman.[3]

Table 9: Gwet's AC2, including lower and upper 95% confidence bounds, and Raw agreement for Leadership.

	AC_2	LCB	UCB	Raw
SMS	0.750	0.607	0.892	0.833
SO	0.346	0.148	0.544	0.711
CP	0.757	0.634	0.880	0.833

Summary

Previous work in the reliability of the NOTSS assessments for SET Trainees by assessors MT and PH indicated that PH consistently awarded higher scores than MT, and that a reduction in PH's scores by 0.5 made them more consistent with those given by MT (on average).

In contrast, the current analysis for NOTSS assessments of experienced surgeons does not confirm the earlier findings, i.e. assessor PH was not consistently higher than MT. Consequently, no adjustment of scores seems justified. However, on average, PH scored higher for all elements of Decision Making and all elements of Leadership.

For this analysis the values of Gwet's AC2 were calculated as a rater agreement measure, using linear weights. These are similar to Gwet's AC1 (used previously), but take into account the ordering of the scoring system. Because of this, values for AC2 tend to be larger than those for AC1, which ignore the relationship between scores. Using the interpretation proposed by Altman3], the assessors achieved good agreement for six of the twelve NOTSS elements, the exceptions being:

- Situational Awareness: projecting future state (moderate agreement)
- Decision Making: all elements (all moderate agreement)
- Communication and Teamwork: co-ordinating team activities (moderate agreement)
- Leadership: supporting others (poor agreement)

The previous approach for SET Trainees of averaging MT and PH's score for use in further analysis is still applicable here.

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Glossary of terms

NOTSS	- Non-technical skills for surgeons
SA	- Situational Awareness
GI	- Gathering information
UI	- Understanding information
PFS	- Projecting future state
DM	- Decision Making
CO	- Considering options
SC	- Selecting and communicating options
IR	- Implementing and reviewing decisions
CM	- Communication and Teamwork
EI	- Exchanging information
ESU	- Establishing shared understanding
CTA	- Coordinating team activities
L	- Leadership
SMS	- Setting and maintaining standards
SO	- Supporting others
CP	- Coping with pressure

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