Deliberate practice in simulation-based surgical skills training: a scoping review

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ABSTRACT

Background

In recent years there has been a shift from traditional Halstedian methods towards more simulation-based medical education (SBME) for developing surgical skills. Questions remain about the role and value of SBME, although feedback and engagement in repetitive practice have been associated with positive learning outcomes. Regardless of approach, the principles of deliberate practice align with both the Halstedian traditions and ways of implementing SBME. Whilst deliberate practice is well described in the wider literature, the extent to which it is an effective instructional approach in surgical training remains unknown.

Objective

To explore the effectiveness of deliberate practice as an instructional design for developing surgical skills through SBME interventions, as assessed by improvements in trainee performance and/or patient outcomes.

Methods

A combined search was conducted in PUBMED, CINAHL, EMBASE, MEDLINE, PSYCHINFO and Google Scholar. 301 articles were screened and 17 met the inclusion criteria for analysis.

Results

There was heterogeneity of study methods with six randomised control trials, seven pre-test/post-test design, two non-randomised comparisons and two observational studies. All articles demonstrated positive learner outcomes following SBME with deliberate practice, although there was no direct comparison to another instructional method. Two studies demonstrated skill transfer to the clinical environment and one demonstrated improved patient outcomes.

Conclusion

Deliberate practice informed SBME interventions appeared effective for developing surgical skills among trainee surgeons, however the reliability of these conclusions was limited by the modest quality of the research studies and the design elements of deliberate practice were inconsistently applied. There was little evidence that deliberate practice leads to skills retention beyond 30 days, although participant numbers were low and the quality of studies was modest.

ACGME Competency: Practice-Based Learning and Improvement

INTRODUCTION

The impact of working time regulations over the past decade has been especially felt within surgery, resulting in a move away from the Halstedian model of training.[1,2] With less time available to train under the supervision of an expert in theatre, trainees now use more simulation-based medical education (SBME) alongside traditional methods, to develop surgical expertise. The use of SBME has advantages, particularly amongst trainee surgeons, who are able to develop basic skills with relative efficiency, and without compromising their own, or patient safety.

In comparison to no intervention, SBME has a number of benefits.[3] Trainees with access to SBME perform better during operations on live patients when evaluated against objective outcomes measures. Similarly, trainees exposed to SBME demonstrate more efficient hand movements, faster completion and fewer errors.[4,5,6,7] However, when trainees with access to SBME are compared to those trained by traditional forms of instruction, there is little additional learning gain conferred by SBME.[8,9] The uptake of SBME as an educational tool varies widely across surgical sub-specialties [10], often with poor trainee engagement with SBME, [11,12] and trainees reporting limited access and protected time for SBME.[13] A national survey of 1130 UK surgical trainees identified only 41.2% had regular access to a skills simulator and as few as 16.3% had access out of normal working hours.[14] Given the costs associated with SBME are significant, questions remain about the role and value of SBME for the development of surgical expertise among those in training. [15,16]

Beyond the practicalities and pragmatics of SBME, there are also philosophical and pedagogical issues that may explain variability of SBME use across different training programmes. These include the fundamental challenge of suspending disbelief among trainees,[17] through to a perceived dissociation between a SBME task and the corresponding one trainees undertake in real practice.[18] There is also evidence trainees and trainers lack understanding of general SBME methodology and are unfamiliar with those aspects that actually lead to improved educational outcomes.[19] The evidence for SBME against this backdrop is difficult to interpret because these contextual factors specifically relate to the way SBME is embedded within curricula, and the way trainers deliver SBME to trainees. Alongside curricula integration, early reviews in SBME identified that feedback, engagement in repetitive practice and opportunities for learners to practice increasingly challenging tasks without fear of failure were associated with positive learning outcomes.[20,21]

These features align with the principles of deliberate practice as an instructional method. Deliberate practice is a distinct form of teacher-led practice within which trainees are provided structured training tasks that provide opportunity for repetitions and gradual improvement towards a defined goal.[22] Unlike mastery-learning, which shares some of the above conditions but has its roots in behaviourism, a central tenet of deliberate practice is the need to understand the thought processes behind a particular behaviour; to recognise and define the mental representations associated with expert performance and develop a way to construct these in the minds of individuals.[23] The differences may seem slight, but the mastery learning approach focuses on providing opportunities for repeated practice until the optimal behaviour is achieved, whereas the expert-performance with deliberate practice also seeks to develop different types of knowledge alongside the practical skills development under supervision by experts. Whilst deliberate practice is well described in the wider literature, and there is evidence of improved learner outcomes from across different medical domains,[24,25] the extent to which it is an effective instructional approach for delivering improved patient outcomes in surgery remains unknown.

The purpose of this research was to explore the effectiveness of deliberate practice as an instructional design for developing surgical skills through SBME interventions. Given the heterogeneity of empirical research involving SBME interventions across diverse educational contexts, with different reported outcomes, a review of literature was undertaken to map the way deliberate practice as a concept had been applied in practice. A scoping review or scoping study is a form of knowledge synthesis that addresses an exploratory research question aimed at mapping key concepts, types of evidence, and gaps in research related to a defined area or field by systematically searching, selecting, and synthesizing existing knowledge.[26] This approach should be viewed as "hypothesis-generating" rather than "hypothesis-challenging". This scoping review aimed to evaluate the effectiveness of deliberate practice informed SBME interventions in improving trainee performance when demonstrating surgical skills and/or improving patient outcomes.

METHODS

Study identification

A systematic search of the literature was carried out on 24th February 2019 using the search terms ("simulation" OR "simulator" OR "simulat*") AND ("surgical skill" OR "psychomotor skill" OR "surgery") AND ("deliberate practice"). The electronic databases PubMed CINAHL EMBASE Medline PsychInfo were accessed using the NICE Healthcare Databases Advanced Search (HDAS). No time period was specified and the search limited to English language journals. The same search was also carried out using Google Scholar. The search was repeated replacing the term "deliberate practice" with "feedback" AND "assessment" AND "repetition" to capture additional studies that may not have explicitly stated deliberate practice as a description for the SBME, but where the type, intensity and quality of the intervention were synonymous with the deliberate practice as an instructional approach.

Eligibility Criteria

All articles with evidence of an intervention using SBME to teach surgical skills using deliberate practice were included. Likewise, articles were also included with descriptions of methods that encompassed the key concepts of this model as described by Ericsson;[22] repetition, assessment and feedback. Research outcomes beyond initial learner reactions, i.e. reaching Kirkpatrick's hierarchy level 2 or above was also necessary for inclusion in this study [27].

"Surgical skills" were defined as any practical procedure listed as a core competency in UK surgical training curricula. Reference was made to the Intercollegiate Surgical Curriculum Programme (ISCP) for core and specialty surgical training.[28] Articles not presented in the English language were excluded. Articles were also not included when there was no definable SBME intervention described (e.g. literature reviews, studies investigating construct validity for a simulation model and descriptions of educational theory). The intention of the review was to investigate the role of SBME using deliberate practice on the development of practical skills that would otherwise have been developed in the operating theatre, so articles that described non-surgical, or non-technical skills and human factors e.g. team-work or communication, were also excluded.

Article Review & Data Extraction

Duplicate entries were eliminated and the remaining articles objectively screened against the eligibility criteria by a single reviewer (MH). Article titles or abstracts without sufficient relevance to the aim were excluded, as were articles where the full text provided insufficient information about the deliberate practice based SBME intervention. 3 articles that were encountered during a review of references from an excluded secondary review article were also included. A PRISMA flow diagram [29] summarises the process (*see figure 1)*. The remaining 17 papers were read in full by two reviewers (MH & RP) and data independently extracted into a specifically designed charting table (*see figure 2*) based on guidance for the conduct of scoping reviews outlined by the Joanna Briggs Institute.[30] The context, design and study population were recorded and a summary created for each study with details of the deliberate practice elements employed, the reported outcomes and study limitations. Disagreements between the two reviewers (MH & RP) were discussed with a third reviewer (CM) and a consensus opinion accepted. Elements of deliberate practice were defined as;[23,31] a) explicit structured goal setting, b) objective assessment method, c) supervision by a trainer, d) feedback that was specific and individualised, e) repetitive practice. The labels for trainee surgeons vary between countries and specialties, so for clarity the term "trainee surgeon" was used universally.

Data Analysis

In anticipation of varied methodologies and reporting of results, a pragmatic approach was adopted for the synthesis of mixed qualitative and quantitative data.[30] A descriptive summary of the key findings and common themes was provided alongside an objective appraisal of each study. Methodological quality was assessed using the Medical Education Research Study Quality Instrument (MERSQI),[32] outcomes were classified using Kirkpatrick's hierarchy[33] and the strength of the evidence was graded using the BEME grading.[34]

RESULTS:

Study Context and Design

Ten of the seventeen studies were conducted in the USA,[35,36,37,38,39,40,41,42,43,44] four in Canada,[45,46,47] three in the UK[48,49,50] and one in Belgium.[51] A range of surgical procedures were examined, the most common being endoscopic[37,40,46,49,50,52], including joint arthroscopy, laparoscopy and hysteroscopy. There were a mix of study designs with six described as prospective randomised control trials (RCT).[36,44,46,47,49,50] One of six RCTs described no process for randomisation and in the same study used novice medical students as a control group for senior trainee surgeons undertaking the intervention.[44] Seven studies used a pre- & post-test design.[38,39,40,41,48,51,52] Across all seven of these studies, participants underwent baseline testing before receiving the deliberate practice based SBME intervention and then underwent repeated testing immediately afterwards to evaluate for any change in performance outcomes. Two studies compared the outcomes of trainee surgeons with expert surgeons.[37,44] Three studies did not have a control or comparison group.[4242,43,45] The evaluation of methodological quality (MERSQI) across the included studies is presented in Table 1.

Table 1. Evaluation of studies following the MERSQI, Kirkpatrick heirarchy model, and BEME grading.

MERSQI = Medical Education Research Study Quality Instrument; De=Design, S=Sampling, Da=Data; SV=Score Validity; A=Analysis; O=Outcomes.

			MERSQI								
Study	**Recruited participants**	**Design**	**Total**	De	S	Da	SV	A	O	**Kirkpatrick level**	**BEME Score**
Kloek 2014	16 PGY3&4 opthalmic surgery trainees	Observational	13.0	2.0	2.0	3	2	3	1.0	2a	2
Tan 2018	22 PGY1&2 trainees – 12 Emergency medicine & 20 Gen Surg	RCT	13.0	3.0	1.5	3	1	3	1.5	2b	3
Hakim 2018	9 PGY4 opthalmic surgery trainees	Observational	14.0	1.0	2.0	3	3	2	3.0	4b	3
Crochet 2011	26 novice trainees with no prior practical experience of procedure: 15 final year medical students and 11 PGY1/2 trainees	RCT	15.5	3.0	2.0	3	3	3	1.5	2b	4
Hashimoto 2015	20 PGY1-3 trainees with no prior practical experience of procedure	RCT	16.0	3.0	2.5	3	3	3	1.5	2b	4
Rackow 2012	37 surgical trainees; 19 PGY1/2 and 18 PGY3/4 from 3 hospital sites	Comparison	13.5	2.0	2.0	3	2	3	1.5	2b	2
Hsu 2016	9 4th year medical students with expressed interest in surgical specialty	Pre-/Post-test	12.0	1.5	2.0	3	1	3	1.5	2b	3
De Win 2013	22 final year medical students with expressed interest in surgical specialty	Pre-/Post-test	12.0	1.5	2.0	3	1	3	1.5	2b	3
Palter 2014	16 PGY1/2 trainees	RCT	15.0	3.0	2.0	3	2	3	2.0	3	3
Nesbitt 2013	10 4th year medical students compared to 11 senior gen surg trainees with >3 years experience	Comparison	13.5	2.0	2.0	3	2	3	1.5	2b	2
Pafitanis 2018	5 surgeons with no prior experience of microvascular techniques	Pre-/Post-test	12.0	1.5	2.0	3	1	3	1.5	2b	1
Price 2011	39 PGY1/2 trainees with no prior practical experience of procedure	RCT	16.0	3.0	2.0	3	3	3	2.0	3	3
Wayne 2008	40 PGY3 medicine trainees	Pre-/Post-test	13.0	1.5	2.0	3	2	3	1.5	2b	2
Teitelbaum 2014	10 senior surgical trainees; 5 PGY5, 2 PGY4 & 3 PGY3	Pre-/Post-test	14.0	1.5	2.0	3	3	3	1.5	2b	3
Yeo 2015	25 surgically naive 1st year medical students	Pre-/Post-test	10.0	1.5	2.0	3	0	2	1.5	2b	4
Feins 2017	27 PGY1 cardiothoracic trainees	Observational	13.0	1.0	2.5	3	2	3	1.5	2b	4
Rowse 2015	25 PGY1 general surgery trainees	Pre-/Post-test	9.0	1.5	2.0	1	0	3	1.5	2b	2

Elements of Deliberate Practice

Fourteen studies demonstrated evidence of explicit and structured goal setting prior to deliberate practice based SBME interventions, as well as before assessment of performance outcomes. Eight studies described whole-task demonstrations by experts with commentary and instruction, either live or via video.[39,40,41,48,49,50,51,52] Six studies described a deconstruction of the skill into procedural steps and provided participants with detailed instruction for undertaking the required technique, albeit without an accompanying visual demonstration.[36,42,43,44,45,47] One study objectively assessed participants performing a laparoscopic procedure on a live patient in the operating room and used the breakdown of these scores to highlight specific areas of performance that fell below the accepted standard. Trainers then provided individualised goals for subsequent simulation-based training.[4645]

Fifteen studies objectively measured change in performance outcomes of a practical skill. The most frequently used scoring systems were the Objective Structured Assessment of Technical Skills (OSATS) with or without a procedure-specific rating scale (PSRS) or a bespoke checklist created through a process of expert discussion. Nine studies undertook assessment prior to the deliberate practice based SBME intervention [38,39,40,41,45,46,47,48,49,50] with six measuring outcomes after the intervention only.[36,37,43,44,51,52] Twelve studies were observed by a trainer or senior surgeon.[36,37,39,40,41,43,44,45,46,49,50,52] The ratio between supervisor and trainee surgeon varied from 1:1 to 1:25, i.e. one-to-more than one trainee, across these studies. Nine studies described a process of a trained observer giving individualised feedback or coaching on the simulator directed towards improving performance.[36,39,40,43,44,45,49,50,52] Five studies defined feedback as digital outcomes generated by the simulator that were provided for participants at the end of each repetition, but this did not include any technical coaching.[38,42,46,48,51]

All studies described repetitive practice as part of the deliberate practice based SBME intervention. Five studies described a mastery-learning approach, where participants continued practising until a pre-set performance standard was achieved.[38,39,40,48,52] The remaining twelve described a traditional approach where participants received the same number of turns or duration on the simulator. [36,37,41,42,43,44,45,46,47,49,50,51] The frequency and duration of training varied between studies. Four studies provided massed practice within a single training session [36,38,41,46] whereas the other thirteen studies provided distributed practice across multiple sessions over a longer period of time.[37,39,40,42,43,44,45,47,48,49,50,51,52] A summary of the deliberate practice elements described across studies is presented in Table 2.

Table 2. Evaluation of studies following the deliberate practice criteria.

DP = Deliberate Practice; IOP = Intra-Ocular Pressure; OSATS = Objective Structured Assessment of Technical Skills; GRS = Global Rating Scale; PSRS = Procedure Specific Rating Scale.

Study & if DP specified?	Structured Goals	Objective Assessment	Observer	Specific & Individualised Feedback	Repetitive Practice	Objective Reassessment
Kloek 2014 ✓	✓ Deconstructed procedure into key steps and structured training to focus on each step individually	✗	✗	✗ Only digital feedback of sim component	✓ mean 23 (range 0-50) hrs	✗ no skills assessment
Tan 2018 ✓	✓ Checklist of key steps, no time limit, repeat until independent	✗	✓ 1:1	✓ Coaching through steps	✓ continued until competent	✓ subsequent real procedure against 15-point checklist
Hakim 2018 ✗	✓ Deconstructed procedure into key steps and structured training to focus on each step individually	✗	✓ 1:1	✓	✓ continued until competent	✓ assessment of IOP and objective positioning of implant by expert
Crochet 2011 ✓	✓ Attended a training seminar with introduction to procedure and demonstration, then specific tasks set for the individual based on performance	✓ OSATS-derived GRS & PSRS	✓ 1:1	✓ Specific feedback of marks and why each was awarded	✓ assigned to areas of poor performance	✓ OSATS-derived GRS & PSRS
Hashimoto 2015 ✓	✓ Attended a training seminar with introduction to procedure and demonstration, then specific tasks set for the individual based on performance	✓ OSATS-derived GRS & PSRS	✓ 1:1	✓ Specific feedback of marks and why each was awarded	✓ assigned to areas of poor performance	✓ OSATS-derived GRS and PSRS
Rackow 2012 ✓	✗	✗	✓ 1:1	✗ no feedback described	✓	✓ OSATS in dry lab setting
Hsu 2016 ✓	✗	✓ knot integrity and peak forces measured across 10 throws	✗	✗ digital force outcomes but no technical coaching	✓	✓ knot integrity and peak forces
De Win 2013 ✓	✓ cognitive preparation with step-by-step video, live demo, explanation of scoring and performance target	✗	✓1:6	✓Constructive feedback and correction of technique	✓	✓ Validated objective assessments of proficiency

Palter 2014 ✓	✓ broad goal = improve outcomes on LC sim. Specific tasks set for the individual based on performance	✓ OSATS GRS, modified OSATS &PSRS	✓	× digital feedback on outcomes (Real-time feedback from computer)	✓ Up to 1 hr until passing standard achieved	✓ OSATS GRS
Nesbitt 2013 ✓	✓ intentional 1:1 detailed instruction of the technique required, with goals to master basic skills before progressing to more advanced techniques	×	✓ 1:1	✓ Specific coaching of practical and technical aspects as required	✓ Repetitions across 10-14 hrs and 12+ simulated procedures	✓ Modified OSATS
Pafitanis 2018 ✓	✓ Expert demonstration of each step of the procedure prior to training	×	×	× HMA outcomes but no technical coaching	✓ Repetitions carried out until proficient (mean 8)	✓ time, hand movement & final test of patency
Price 2011 ✓	✓ didactic instruction on technique & 3 practices with expert instruction	✓ OSATS, Time & End-product evaluation	×	× Self-directed practice	✓ 10 unsupervised repetitions over 2 weeks	✓ OSATS, Time & End-product evaluation
Wayne 2008 ✓	✓ First 1hr = step-by-step expert demonstration	✓ 25 step checklist MCQ written exam	✓ 1:2 - 4	✓ Directed feedback given	✓ Up to 3 hours allowed for repetitive practice	✓ 25 step checklist & MCQ written exam
Teitelbaum 2014 ✓	✓Didactic reading of technique & instructional video of procedure	✓ Previously validated objective score of performance on simulator	✓ 1:2	✓ Immediate feedback on performance	✓ Weekly 1hr sessions until participants met mastery standard	✓ Previously validated objective score of performance on simulator
Yeo 2015 ✓	✓ Online module including step-by-step description and video followed by demo on simulator	✓ Hand motion analysis	×	× Digital feedback from HMA software; performance related to expert standard	✓ 3-4 sessions of 30-60 mins each, spaced 6 weeks apart	✓ Hand motion analysis
Feins 2017 ✓	✓ Sessions explained to participants with explicit goals and objectives	✓ 21 task assessment tool based on modified OSATS with 5-point Likert scale	✓ Variable, up to 1:4	✓ "expert coaching"	✓ 3-4 hr sessions scheduled weekly where possible.	✓ 21 task assessment tool based on modified OSATS with 5-point Likert scale
Rowse 2015 ✓	✓ Instructional video outlined step-by-step technique	×	✓1:25	× no reported feedback	✓ 2 x 3hr sessions on consecutive weeks	× no practical assessment

Outcomes

All seventeen studies demonstrated a significant change in participant-level outcomes following the deliberate practice based SBME intervention. Five studies explicitly reported a change in outcomes over more than one time point. Four of these studies demonstrated no evidence of skill decay between 1 and 7 months.[356,39,41,52] One study demonstrated a negative change in performance outcomes 27 days from baseline measurement, despite participants demonstrating skills measured against an expert standard at the end of training.[51] One study described a trend of transient decline in skills performance between sessions, spaced 1 week apart, however there was evidence of recovery and further improvement across training sessions.[45]

One study assessed patient-level outcomes.[43] In this study, a deliberate practice based SBME intervention involving part-task training on an eye model and a synthetic simulator prepared trainees to perform the final procedure under supervision with 100% success. No intraoperative complications among participants who received the intervention were noted and there was significant reduction in intraocular pressures as well. Two RCT studies demonstrated transfer of skills learned following a deliberate practice based SBME intervention into the clinical environment.[46,47] One of these studies described improved performance demonstrated during laparoscopic cholecystectomy in the operating theatre among participants who engaged in deliberate practice. In the other of these studies, improved performance on a microvascular anastomosis performed on a living porcine specimen was also demonstrated by participants receiving the deliberate practice based SBME intervention. Fourteen studies assessed outcomes at a lower Kirkpatrick level, with improvements in skills (n=12) or knowledge and confidence (n=2) as a result of the training intervention, but no evidence of transfer of these skills into the workplace environment.[36,37,38,39,40,41,42,44,45,48,49,50,51,52] A summary of study outcomes and how these relate to Kirkpatrick's hierarchy model can be seen in Table 1.

Study Quality

The strength of each paper was assessed using the BEME grading, taking into consideration the methodology and design, limitations of the study, stated conclusions and how these related to the published results. Overall quality of the published literature was middling to poor, with only two studies satisfying BEME grade 4, with results that were clear and very likely to be true. Results are summarised in Table 1 and described in more detail in the supplementary table.

DISCUSSION

This research identified that deliberate practice informed SBME interventions included in this study appeared effective for developing surgical skills amongst trainee surgeons, but that the strength of these conclusions was limited by the quality of studies. Analysis of the instructional design elements (structured goal setting, objective assessment, supervision, feedback and repetitive practice) were inconsistent within, and across the training activities. The majority of research studies used a pre- and post-test design for measuring skills change with few studies actually evaluating deliberate practice with any other specified instructional designs. There was little evidence from the review that deliberate practice operationalised as a SBME intervention across the studies led to skills retention beyond 30 days although low numbers of participants was commonplace and the quality of research studies, as demonstrated by the MERSQI scores and BEME grade, was modest.

This research was undertaken against the backdrop of the move away from the traditional Halstedian model of surgical training towards one influenced by working time regulations and less direct observation of performance or supervision in theatre. Whilst the elements of deliberate practice align with the philosophy and principles of the Halstedian model, there was insufficient evidence in this review that the effectiveness of SBME extended beyond the benefits of repeated practice. Although opportunities to repeat and refine skills is important in surgical training, expertise development in surgery also requires attention to virtues such as craftsmanship and workmanship.[52] In the absence of a skilled trainer providing direct observation on performance, training risks becoming a tick-box exercise and SBME-interventions function as a means to an end.[53] Likewise, surgical training driven by SBME risks becoming reduced to technical skills development only, whereas the development of surgical expertise requires a diversity of opportunity and experience as part of curriculum that scaffolds individual surgeon development.

Although deliberate practice is a specific type of training, supervised and guided by an expert, the underpinning principles are developed from the expertise performance approach.[23] This approach proposes that it is necessary to identify reproducibly superior performance in the real world and then to capture and reproduce this performance. The Halstedian model provided trainees opportunities for direct observation so individuals were able to witness this superior performance, and in some cases attempt to reproduce it receiving direct feedback in the process. Not all SBME interventions labelled as deliberate practice are designed so that experts observe the performance of surgical trainees on the simulator. Without opportunity to practice surgical skills in theatre, the critical steps necessary for performing surgery independently in the setting of uncertainty may not be learnt on a SBME intervention – a critical aspect of the expertise performance approach. Likewise, the opportunity to reflect over errors is necessary for improving future performance.[54] In order to satisfy requirements of deliberate practice SBME interventions must provide feedback as part of the instructional design. Adequate debriefing focusing on errors and potential strategies for improving performance in the future should involve identifying the occasions when initial problem-solving or decision-making lead to less than ideal choices or outcomes.[55]

Despite research suggesting SBME-interventions are effective, evidence of skills retention over the short-, or long-term is lacking. The maxim ‘practice makes perfect’ may be inaccurate and inappropriate for surgical skills training using SBME interventions for a number of reasons, not least because individuals without direct observation from experts may be practicing the wrong thing repeatedly. Deliberate practice attempts to encourage skill acquisition at least in part through repetition. There is evidence that this approach can lead to improved outcomes in comparison with no intervention,[56] however learners require immediate and direct feedback from an expert coach which may not always be possible in some training contexts.

Much of the research involving SBME in a surgical training context involve small participant numbers despite the significant number of potential surgical trainees available across the various sub-specialty training programmes. The quality of the research studies as evaluated by the MERSQI was low reflecting a persistent and wider issue about the conduct of educational research in healthcare.[57] The challenge with medical or healthcare professions education research is both philosophical and practical. Philosophically, the research assumptions made about knowledge and the reality of the natural world in a healthcare context is relatively consistent within the profession and across the various clinical sub-specialties.[58] However, these assumptions remain when researching educational outcomes, albeit in a healthcare professions context, despite the nature of both knowledge and reality contested to be subjective rather than objective.[57] As a consequence, research design and methodology may not necessarily be appropriate, leading to the inconsistent use of methods and over-interpretation of findings in some cases. More quality research is necessary with more consideration of the way terms are operationalized in the real world, with more consideration for the inter-subjectivity across both researchers and participants.

There are a number of implications for existing SBME practice in surgical education from this review, and recommendations can be seen in table 3. Firstly, the instructional design of SBME interventions should be made explicit by the teacher, and for the learner. The use of SBME interventions should be part of a wider programme of education where training opportunities are carefully personalised to the individual needs of the surgical trainee. In the authors’ opinion the current evidence supports the use of SBME with deliberate practice in developing technical skills by means of supervised repetition and directed feedback, however a key element remains the identification of expert performance and this is ideally suited to observing and assisting surgical cases in the operating room. A hybrid approach may be optimal, with a curriculum of SBME embedded within a clinical placement and supporting learning objectives that are tailored to individual trainees. The challenge for surgical trainers is to find the time to watch surgical trainees during SBME interventions so authentic feedback can be given about specific performance task as well as overall development as surgeons. The outcomes from

SBME interventions should focus more on skills retention and decay as well as transfer into the operating theatre given the purpose of the training is to develop independent surgical expertise. Finally, surgical trainers should underpin SBME interventions with opportunities to engage with deliberate practice since opportunities for repetition combined with regular assessment and frequent feedback is associated with improved educational outcomes.

Table 3: Educational Recommendations

Educational Recommendations
1. Ensure trainees have ample opportunity to witness expert performance in clinical environment
2. Produce a personalised learning plan for trainees based on supervised clinical practice
3. Provide opportunity for supervised deliberate practice through SBME
4. Frequently reassess clinical performance and revise learning plans

Figure 1: PRISMA flow diagram

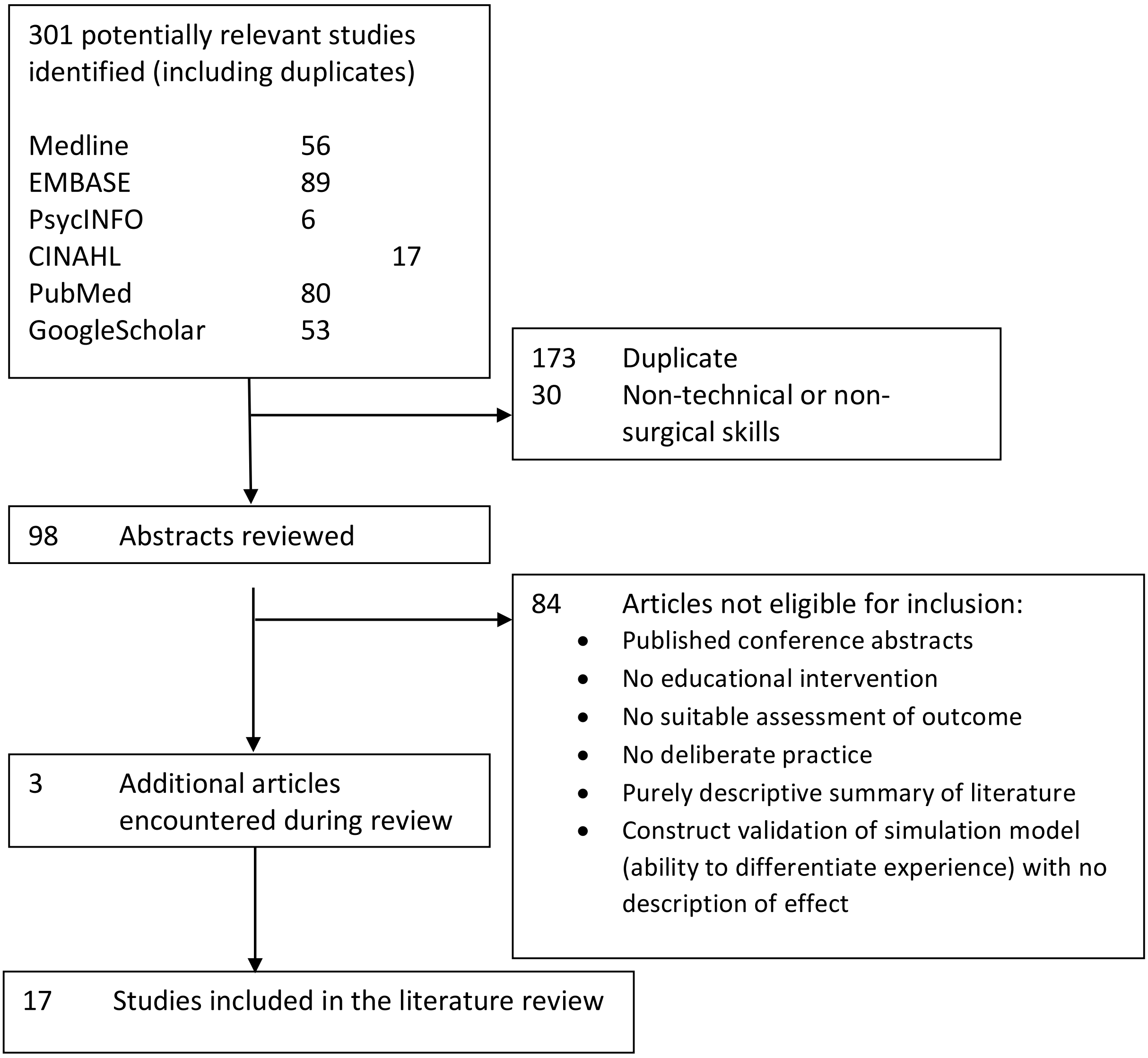

Figure 2 - Data extraction form

Study Details and Characteristics	
Citation details: Title/Authors/year/journal	
Country	
Context: Aims/purpose	
Study population specifics and sample size	
Methodology	
Duration of intervention and repetition #	
Details/Results extracted from study	
Outcomes assessment	
Key findings that relate to aims of review:	Effectiveness: Evidence of skill retention: Design of deliberate practice approach:
Modified Kirkpatrick level (1-4b)	
BEME strength (1-5)	
MERSQI scales	

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