SCIENTIFIC ARTICLE

Enacting deliberate practice in simulation-based surgical training: a mixed-methods study

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Abstract

Introduction

Simulation-based surgical training (SBST) is increasingly used to address reduced operative exposure and patient safety concerns. However, access to simulation alone does not ensure effective learning. Deliberate practice (DP) provides a theoretical framework for structured skill acquisition, yet its enactment within everyday surgical training environments remains poorly understood, particularly in low- and middle-income countries.

Methodology

A sequential mixed-methods design was used. The quantitative phase involved 53 participants (38 trainees, seven trainers, eight expert surgeons) who completed a structured questionnaire examining SBST access, training practices, and alignment with DP principles. The qualitative phase included 22 semi-structured interviews exploring lived experiences of simulation use, feedback, and institutional influences on practice. Quantitative data were analysed using descriptive and non-parametric statistics. Qualitative data were analysed using systematic text condensation guided by the DP framework.

Results

Expert surgeons demonstrated greater alignment with DP principles than trainees, particularly in goal setting, reflective self-monitoring, and feedback utilisation. Trainees reported more opportunistic use of simulation, limited task progression, and weaker alignment between task difficulty and competence level. Although most centres had simulation access, its use was inconsistent and rarely embedded within longitudinal curricula. Qualitative findings identified institutional barriers including limited protected training time, heavy clinical workload, absence of structured progression pathways, inconsistent faculty training in feedback delivery, and lack of scheduled simulation sessions.

Conclusion

Effective enactment of deliberate practice in SBST depends on curricular integration, structured feedback processes, and institutional support. Strengthening these elements may enhance the educational impact of simulation in resource-constrained training environments.

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Introduction

Simulation-based surgical training (SBST) has been widely adopted to address reduced operative exposure, patient safety concerns, and increasing procedural complexity. Access to simulation alone does not ensure learning. Educational effectiveness depends on how training activities are structured within learning systems.

Deliberate Practice (DP) offers a theoretical framework for understanding the development of expert performance [1]. From this perspective, expertise arises through sustained engagement in goal-directed tasks, immediate and informative feedback, opportunities for repetition with progressive refinement, and active learner self-regulation. Although DP is frequently cited within surgical education, its practical enactment within everyday training environments remains poorly understood.

Much of the existing literature on SBST emphasises technological sophistication and performance outcomes, often treating pedagogy as implicit. As a result, there is limited insight into how DP principles are operationalised in practice, or how contextual factors shape their implementation. This gap is particularly salient in low- and middle-income countries (LMICs), where institutional constraints, competing service demands, and limited faculty development may fundamentally influence learning processes. Studying DP in LMIC contexts is theoretically valuable. These contexts provide valuable insight into how educational principles operate under constraint. Insights gained from these contexts therefore have relevance beyond their immediate setting.

The aim of this study was to explore how DP is understood and enacted within SBST in Sri Lanka, and to examine how institutional conditions shape its implementation across different stages of expertise development.

Methodology

Positionality and reflexivity

The primary researcher is a Professor in Surgery at the University of Colombo, Sri Lanka. His professional position facilitated participant access but introduced potential interpretive bias. Reflexivity was addressed through explicit acknowledgement of this positioning, use of a theoretically guided analytic framework, and ongoing critical discussion within the research team.

Mixed methods approach

The research used a sequential mixed-methods design (QUAN+qual) [2]. The primary component was quantitative, with a supplemental qualitative element. A mixed-methods design was chosen to better understand the intricacies of DP and SBST through triangulation and complementarity [2].

Research site

Participants were recruited from multiple training centres in Sri Lanka. The post-graduate surgical training programme in Sri Lanka is uniform and is governed by a single institution (the Post-Graduate Institute of Medicine - PGIM).

Participants

Participants included surgical trainees (L) of all experience levels, trainers (T), and expert surgeons (ES). Colleagues of the principal investigator invited participants. ES were identified based on their surgical skills (Ericsson, 2004). The sample represented various training levels and surgical sub-specialties, providing a broad perspective on SBST and DP use.

Data collection

The quantitative phase used a self-administered questionnaire. The questions were derived from systematic reviews [3, 4] and similar tools used in previous studies [5]. Socio demographic data and prior surgical training data were also collected. The results were tested for normal distribution and parametric/non-parametric tests were used accordingly. Correlation and regression analysis were used to identify associations. The Kruskal-Wallis test was used for multi-group comparison.

A representative sample from each participant group was selected and invited for the qualitative data collection. Data were generated through semi-structured, face-to-face interviews lasting between 25 and 40 minutes, focusing on experiences of simulation use, feedback, motivation, and task design. The practices of individuals were explored, followed by a focus on similarities and differences between ES and other groups. The DP framework was used to analyse the data. Data collection followed the COREQ guidelines[6].

Data analysis and integration

Quantitative data were analysed using descriptive statistics and appropriate non-parametric tests. Systematic text condensation (STC) was employed for thematic synthesis, preserving the empirical context of the findings, with DP serving as the guiding analytic framework. Integration occurred at the interpretation stage, where qualitative findings were used to explain and elaborate quantitative patterns, generating a more comprehensive understanding of DP enactment.

Credibility of the qualitative analysis was strengthened through iterative discussion within the research team and continuous comparison between quantitative and qualitative findings during the integration stage.

Ethics approval

Ethical approval was obtained from the Ethics Review Committees of Lancaster University (EdRes-2024-4164-EdAp-2) and the National Hospital of Sri Lanka, Colombo (AAJ/ETH/COM/2024/JAN). Written informed consent was obtained from all participants.

Results

Quantitative findings

Fifty-three participants (38 trainees, seven trainers, and eight expert surgeons) completed the questionnaire. Fifty were male. The mean age was 36.0 (SD 9.8) years. Subgroup distributions are tabulated below (Table 1).

Most trainees reported nominal access to simulation facilities; however, the frequency, purpose, and manner of use varied substantially across groups (Figure 1).

Table 1: Demographics of participants

Group	Age (Mean ± SD) years	Sex (M:F)	Years as a surgeon (Mean±SD) Years
Expert surgeons	46 (±6.8) Range 40-61	8:0	12.9 (±7.1) Range 4-25
Trainers	60 (±8.1) Range 44-67	7:0	26.3 (±12.5) Range 8-40
Trainees	34 (±2.3) Range 30-39	35:3	3.7 (±1.9) Range 1-7

Expert surgeons described more frequent and intentional use of simulators for skills development, assessment, and feedback, whereas trainees reported more sporadic and opportunistic engagement. Trainers' responses generally lay between these two groups, reflecting their dual role as learners and educators. Although all three groups agreed that integrating the simulation training into the existing programme was important, this was expressed by a disproportionately higher percentage of trainers than other groups (Figure S1).

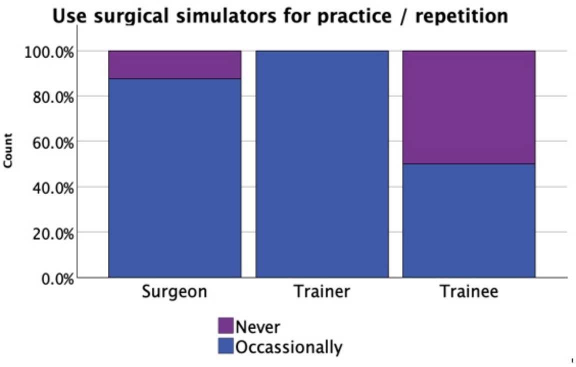

Figure 1: Use of simulation for practice

Clear differences were observed in alignment with core DP principles, including motivation (Table S1). ES reported clearer goal orientation during practice sessions, more consistent use of feedback to guide improvement, and more frequent reflective analysis of their own performance compared with trainees. Differences were particularly marked for feedback utilisation and motivation, with ES and trainers valuing feedback for learning more consistently than trainees. At the same time, both trainees and ES reported that feedback was often insufficiently specific, limiting its usefulness for targeted improvement (Figure 2).

Responses related to task design and repetition also varied across groups. While all participants endorsed the importance of practising tasks with graded difficulty (Figure 3), trainees were less likely to report that training activities were matched to their current level of competence. ES were more likely to describe deliberate repetition aimed at correcting specific errors, whereas trainees reported more general repetition without explicit performance targets (Figure S2). Taken together, these quantitative findings indicate that enactment of DP principles varied systematically with level of expertise rather than access to simulation alone.

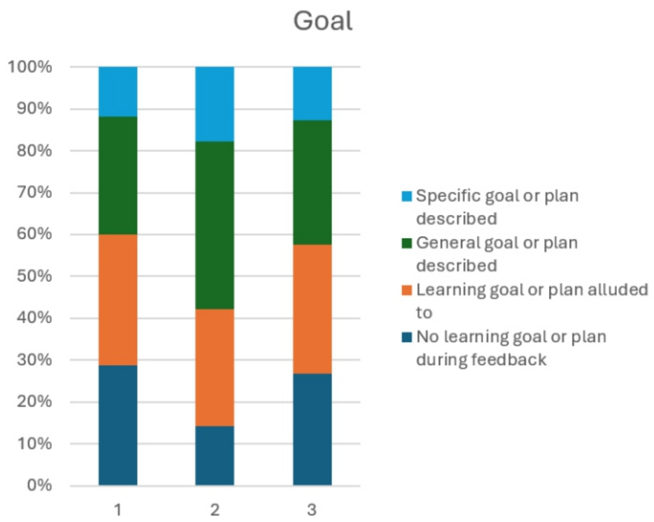

Figure 2: Feedback provided / receive

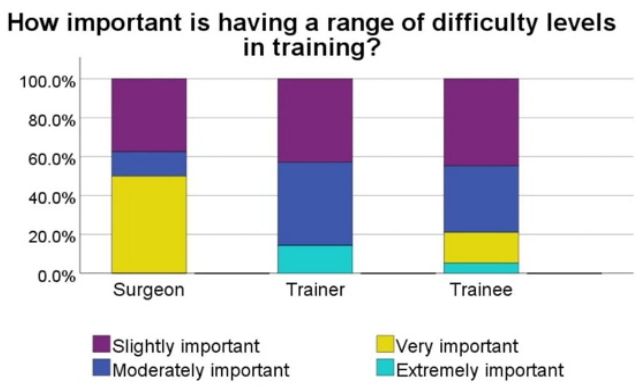

Figure 3: Importance of having a range of difficulty levels

These quantitative differences in feedback, task structuring, and goal formation were examined further through qualitative exploration of how participants experienced DP processes within everyday training systems.

Qualitative findings

Participants

Twenty-two participants (12 trainees, five trainers, and five expert surgeons) contributed to the qualitative phase. The three conceptual groups explored training from diverse perspectives, enabling a comprehensive triangulation of findings. These included ES, who successfully navigated the existing system; trainers, who served as educators within that system; and trainees, representing the learners' perspective. Analysis identified three interrelated themes that elaborated how DP was enacted within SBST and how this enactment was shaped by institutional and pedagogical conditions.

Structural constraints in deliberate practice

Participants across all groups described structural and institutional factors that constrained opportunities for DP. Simulation facilities were often limited to major training centres and typically accessible only during routine working hours, restricting use for trainees with heavy service commitments. Clinical workloads were frequently prioritised over practice, resulting in limited protected time for repeated, focused skill refinement.

"There's also a lack of dedicated time for simulation". "Surgeons and trainees are often stretched thin", making it "difficult to allocate dedicated time for simulation and deliberate practice" (Text condensate from 3 participants – T4, L11, L12).

Early skills courses and workshops were widely viewed as valuable for initial orientation, particularly for novice trainees. Participants, however, emphasised that attendance at a course did not guarantee skill acquisition. Trainers and trainees noted that learners entered such courses with differing levels of prior experience, making it difficult to accommodate individual learning needs within a short time frame. Consequently, opportunities for consolidation and progression after courses were seen as critical but inconsistently available.

"In a course, you may be there and listen, or you may not". You may have the necessary skills, or you may be too inexperienced. "sometimes it's too quick to grasp" (T2, T4, L4).

Participants also highlighted variability in trainers' preparation for teaching within simulation environments. While technical expertise and procedural volume were highly valued, pedagogical skills such as structuring tasks, setting explicit goals, and delivering actionable feedback were inconsistently developed. Several participants noted that teaching in simulation was sometimes perceived as secondary to clinical duties, shaping the depth and quality of engagement with trainees. Trainees also viewed pedagogical responsibility as distributed across organisational actors rather than individual instructors alone.

"Education is crucial - not just for trainees, but for surgeons and hospital administrators". Many trainers don't know how to train, Some see it as a distraction (ES1, ES3, T4, L2, L3, L8).

Differences in enactment across expertise levels

Clear differences emerged between ES and trainees in how DP was enacted. ES described internally generated learning goals, proactive self-monitoring, and reflective refinement of technique. These processes were often enacted implicitly, suggesting a high degree of internalisation of DP principles. ES described using simulation to focus on specific technical elements or to rehearse challenging aspects of procedures rather than to practise entire operations repeatedly. By contrast, trainees described more fragmented learning experiences. Many reported uncertainty about performance expectations and difficulty identifying what to focus on during practice sessions.

"Trainees often need to work on bigger, more obvious skills". "Experts also seem to be better at identifying their own problems to correct". Watching how different experts perform surgeries help to get a broader understanding (Text condensate from 5 participants – ES4, T3, T4, L4, L9).

Observing experienced surgeons was perceived as particularly valuable for developing mental representations of procedures. Such observations were seen as providing a reference point against which trainees could evaluate their own performance.

These accounts suggest that features of DP such as goal setting, error detection, and self-regulation become increasingly internalised with experience. For novices, however, these processes were less visible and often required explicit guidance and scaffolding from trainers.

Feedback and task structuring

Feedback practices played a central role in shaping DP. Trainees frequently described feedback as vague, delayed, or focused on overall performance rather than specific behaviours, limiting its usefulness for targeted improvement. ES emphasised the importance of immediate, task-specific feedback linked to clearly defined goals. Feedback was described not only as information provided by trainers but also as something derived from self-assessment and reflection.

Some trainees do DOPS for them. Most have no scientifically proven or objective feedback method (Text condensate from 4 participants – T4. L4, L5, L9).

Analysing the results post operative complications provide automatic feedback (Text condensate from 3 participants – ES4, L2, L11).

Task structuring emerged as a key mechanism supporting DP. Stepwise task allocation such as progressing from camera handling to selected components of procedures was described as enabling trainees to focus on discrete skills within a safe learning environment. Case selection based on complexity and trainee competence was also highlighted as an important strategy for managing cognitive and technical load.

"We started with simple cases like large renal cyst decortication, then moved to simple Nephrectomy, followed by radical nephrectomy, pyeloplasty, and then ureteric work. Final step was to get into radical prostatectomies". This was because it was self-training. Same with general surgery (Text condensate from 3 participants – ES5, T2, T5).

Across groups, self-reflection was viewed as integral to skill development. ES were perceived to engage more consistently in reflective practices, often analysing errors and modifying their approach in subsequent attempts. Trainees recognised the value of reflection but reported limited guidance on how to reflect effectively. Together, these qualitative findings contextualise the quantitative patterns by illustrating how institutional conditions and pedagogical practices shape the enactment of DP within SBST.

Discussion

This mixed-methods study evaluated how deliberate practice (DP) principles are enacted within simulation-based surgical training (SBST) in a resource-constrained national training system. The findings showed that alignment with DP principles, namely clear goals, structured progression, specific feedback, and reflective repetition, varied by level of expertise. Expert surgeons described more intentional goal setting, self-monitoring, and targeted refinement, whereas trainees reported fragmented practice experiences and limited guidance. These differences were influenced not only by individual factors but also by institutional conditions.

There are significant limitations in SBST access globally [7]. Access to simulation alone did not guarantee effective learning. Although most participants valued SBST, limited protected time, high clinical workload, and inconsistent faculty preparation restricted opportunities for structured and repeated practice. Simulation was often used opportunistically rather than within a structured curriculum. This suggests that integration into formal training pathways is essential for maximising educational impact. Incorporating simulators into training may require reducing standard training time [8].

Training centres' financial capacity determines the availability of high-fidelity simulators. Most core SBST curricula, like the Fundamentals of Laparoscopic Surgery (FLS), use box trainers [9]. The superiority of VR over box trainers for learning, however, has not been established [10]. A low-cost training program like McGill Inanimate System for Training and Evaluation of Laparoscopic Skills (MISTELS) is likely to yield the best results in resource constrained settings.

Feedback quality emerged as a key determinant of learning. Trainees frequently described feedback as general or delayed, limiting its usefulness for targeted improvement. Immediate, task-specific feedback and structured debriefing were inconsistently implemented. Introducing standardised feedback frameworks [11] and strengthening faculty development may improve training efficiency without substantial additional resources.

Task structuring and graded difficulty were recognised as important but were not consistently aligned with trainee competence. Evidence suggests a structured training program reduces the learning curve [12]. Embedding explicit progression pathways within SBST curricula may support earlier development of self-regulation and technical proficiency [13].

This study highlights that effective implementation of deliberate practice depends on curricular design, feedback systems, and institutional support rather than learner motivation alone [1, 14]. In resource-constrained settings, motivated learners may be unable to practise deliberately when structured feedback, graded task progression, and protected time are lacking. Evidence suggests that simulation achieves optimal impact when pedagogical principles are explicitly enacted [5]. Differences between expert surgeons and trainees indicate that self-regulation and reflective refinement develop progressively with experience [15]. Strengthening structured practice opportunities, feedback processes, and curriculum integration may therefore enhance the educational value of simulation without requiring substantial technological expansion.

Although this study was conducted within a single national training system, the findings have broader relevance for health professions education. Many training programmes worldwide face similar tensions between service delivery and structured learning. Understanding how institutional conditions influence the enactment of deliberate practice may therefore inform the design of simulation-based curricula in diverse educational contexts.

Limitations

This study has several strengths. The mixed-methods design enabled integration of quantitative patterns with qualitative insights, enhancing interpretive depth [2]. Use of DP as an analytic framework provided theoretical coherence across methods[1, 14], and inclusion of participants across different stages of expertise strengthened explanatory value. Reliance on self-reported data, however, may not fully reflect actual training behaviours, and future studies could incorporate observational or performance-based measures, as recommended in simulation research[5]. Additionally, findings are derived from a single national training system, which may limit generalisability; nevertheless, the mechanisms identified may inform understanding of DP enactment in other constrained educational environments.

Conclusion

This mixed-methods study examined how DP is enacted within SBST in a low-resource context. Quantitative findings showed greater alignment with DP principles among expert surgeons than trainees, especially in feedback use, task structuring, and self-regulation. Qualitative accounts explained these differences by revealing structural, cultural, and pedagogical constraints that limited opportunities for focused, goal-directed practice. Experts demonstrated implicit mastery and self-regulation, whereas trainees reported limited guidance and fragmented practice.

These findings point to a misalignment between DP principles and current training structures. They suggest that strengthening feedback processes, task progression, and access to simulation may support more equitable enactment of DP, while highlighting the need for contextually responsive approaches in resource-constrained training environments.

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Consent for publication

Not applicable

Availability of data and materials

The data used for the manuscript is available from the corresponding author upon reasonable request.

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Authors' contributions

DW – Conceptualization, data collection, data analysis, preparation of manuscript. JV – Conceptualization, supervision, data analysis, preparation of manuscript.

Clinical trial number

Not applicable

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Supplementary

1.https://drive.google.com/file/d/1w6UXf8c72JZH8NJTtmD1yKDNXpKwiXcp/view?usp=sharing

2.https://drive.google.com/file/d/1uYd_isSmIBzdtoxYUovgRQac23ft5pqX/view?usp=sharing

Practice highlights:

- Simulation alone does not ensure learning; deliberate practice requires goals, repetition, and feedback.
- Trainees use simulation opportunistically; experts use it strategically for skill refinement.
- Immediate, task-specific feedback linked to goals improves deliberate practice.
- Protected training time and faculty preparation shape effective simulation training.
- Embedding deliberate practice in curricula improves skill development in constrained settings.