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Leveraging Simulation to Support Competency-Based Surgical Training

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CONTEXT: Simulation-enhanced education (SEE) has evolved from a supplementary activity into an evidence-supported cornerstone of medical education, yet in most surgical training programs it remains confined to formative use with little influence on high-stakes progression decisions. This disconnect limits SEE's contribution to patient safety, particularly at transition points where residents assume greater clinical autonomy.

ISSUE: High-stakes decisions about readiness for autonomy in surgery continue to rely primarily on workplace-based assessments, which are vulnerable to bias, impression management, and limited opportunities for granular technical observation. This reliance introduces variability into autonomy decisions and latent patient safety risk, despite robust evidence that simulation-based assessment can reliably differentiate performance across the training continuum, while competency frameworks such as CanMEDS offer limited guidance on mandatory assessment mechanisms at high-stakes transition points.

APPROACH: Using surgical training in the Republic of Ireland as a primary case, this article examines how national policy levers, funding arrangements, and institutional leadership can reposition SEE and simulation-based assessment as consequential components of training governance. In Ireland, service-level agreements, strategic investment by the Royal College of Surgeons in Ireland, and protected training time have enabled integration of summative simulation-based assessment into an 8-year surgical training scheme, with scores contributing directly to progression alongside established portfolio elements, illustrating design principles that are transferable across specialties and jurisdictions.

IMPLICATIONS: The article argues that the next developmental step is the introduction of specialty-specific autonomy thresholds, framed as entrustable professional activities and substantiated through simulation-based assessment at defined progression points. Such mandatory, simulation-anchored checkpoints would align assessment practice with patient safety priorities and competency-based progression, repositioning SEE from a source of isolated validity evidence to an integrated safeguard at the point where autonomy decisions carry the greatest clinical consequence. (J Surg Ed 83:103959.
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KEYWORDS: Simulation-based education, Surgical training, Competency-based medical education, Assessment, Patient safety

UNDERUSED POTENTIAL OF SIMULATION IN SURGICAL TRAINING

Simulation-enhanced education (SEE) has evolved from a supplementary activity into an evidence-supported cornerstone of medical education.[1] Yet this recognition is not consistently reflected in postgraduate surgical training. A 2024 global consensus statement highlights SEE's potential to improve outcomes and calls for coordinated integration of high-quality SEE into standardized

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programs supported by policy and sustained funding.[2] Despite widespread investment, its use for deliberate practice[3] and high-stakes assessment remains limited. Recent reviews describe a shift from subjective apprenticeship models toward structured, competency-based systems supported by simulation, motion analysis, and standardized rating frameworks, but integration into training governance and progression decisions remains inconsistent.[4] In most systems, SEE is positioned as formative and non-determinant. This undervalues SEE not only as an educational intervention but also as a system-level patient safety safeguard, particularly at transition points where residents assume increasing clinical independence.

SIMULATION, MOTIVATION, AND TRAINING WORKLOAD

Surgical residents work long hours while managing multiple mandatory requirements that determine progression. As a result, engagement with formative SEE may be deprioritized when participation is optional, limiting opportunities to identify and address performance gaps before residents assume greater autonomy. Motivation increases when SEE is incorporated into mandatory modules linked to progression and high-stakes assessment, although translation into policy depends largely on institutional leadership. This convergence of evidence and policy reform likely represents the future direction of surgical training but remains absent in many regions.

Simulation centers and technical skills laboratories are frequently established with strong educational intent and substantial capital investment; however, in the absence of mandatory curricular integration or linkage to high-stakes assessment, simulator use predictably declines over time.[5] Without formal requirements tied to progression, SEE risks becoming an optional "nice-to-have" adjunct rather than an embedded, safety-critical component of training, resulting in underutilized facilities and unrealized gains for patient safety.

STRUCTURAL LIMITS OF WORKPLACE-BASED ASSESSMENT

Competence evaluation currently relies heavily on workplace-based assessments (WBAs), often completed by supervisors working closely with the resident.[6] In principle, WBAs triangulate performance across multiple consultants and assessment episodes, including placement reports, case-based discussions, operative assessments, and annual review panels, thereby mitigating individual assessor bias and supporting holistic judgment. However, implementation challenges remain. Documenting concerns about a trainee often requires additional administrative processes, which may incentivize "tick-box" completion and passing marginal performers, particularly under service pressure. WBAs therefore tend to provide a broad indication of performance but may lack the precision required for targeted technical remediation. These limitations reflect implementation vulnerabilities rather than inherent flaws in the WBA model and highlight the value of integrating structured simulation-based assessments (SBA) as complementary sources of objective technical performance data at key progression points.

A further concern in surgical training is a cultural "failure to fail," whereby reluctance to document poor performance may arise from relational dynamics, conflict avoidance, and service pressure. This is not unique to WBAs; SBAs are similarly vulnerable if standards are implicit, assessors are not calibrated, or remediation pathways are burdensome. When embedded within a summative, competency-based assessment system supported by explicit standards, assessor training, and clear remediation processes, simulation can contribute more robustly to progression decisions, with governance implementation often more feasible in controlled educational environments. In our setting, both WBA and SBA contribute summatively to points-accrued progression decisions, creating clearer incentives to uphold agreed standards.

Longstanding work in procedural specialties, including neurosurgery and microsurgery, demonstrates that technical performance can be objectively differentiated across levels of expertise using structured bench-top and SBA, with metrics such as time, motion economy, error rates, and applied force reliably distinguishing skilled from less skilled operators.[7] By contrast, direct observation in the operating room (OR) remains subjective and resource intensive. Strong validity evidence now demonstrates that equivalent assessments can be conducted reliably through SEE.[8] The Irish Core Training Assessment System exemplifies this, integrating WBA and SBA with high composite reliability and strong correlation with operative performance.[9] SEE therefore offers a standardized, objective means of evaluating technical skills at key progression points. Reliance on WBAs alone at these points introduces variability into autonomy decisions, creating latent patient safety risk in high-stakes clinical environments. A more robust approach is to integrate two complementary assessment systems, in which WBAs provide patient-facing, holistic judgment while SBAs isolate and evaluate specific technical and non-technical skills under standardized conditions.

FROM COMPETENCY FRAMEWORKS TO CONSEQUENTIAL ASSESSMENT

High-stakes technical performance assessments conducted outside the OR, including SEE approaches, can play a meaningful role across the surgical training continuum. These assessments can be calibrated to appropriate levels of professional authenticity, from capturing inherent aptitude at selection to verifying canonical competence during early training and assuring minimum standards for less frequently encountered procedures later. Once clearly defined, realistic assessable performance variables are identified,[10] perceived authenticity deficits can be mitigated through targeted task design and structured scoring frameworks. This aligns with competency-based education principles and provides a framework for embedding SEE as a legitimate component of consequential assessment throughout surgical curricula.[11]

Competency frameworks such as CanMEDS clearly articulate the multidimensional capabilities expected of surgeons, including technical expertise, communication, leadership, and professionalism; however, they provide limited direction regarding mandatory assessment mechanisms to ensure these competencies at high-stakes transition points where patient safety risk increases. SEE and SBA offer one such mechanism but are rarely treated as essential.[12]

A NATIONAL POLICY EXEMPLAR: THE IRISH MODEL

In the Republic of Ireland, postgraduate training is funded through the Health Service Executive's National Doctors Training and Planning (NDTP) division via service-level agreements (SLA) with postgraduate training bodies. Although NDTP does not mandate SEE, it provides a single global training budget for each program, allowing providers discretion in resource allocation. Within this structure, Royal College of Surgeons in Ireland (RCSI) designates a defined proportion of funding to SEE infrastructure, faculty time, and assessment delivery alongside other curriculum costs. This demonstrates that system-level integration of SBA depends less on additional resources than on how existing funds are prioritized.

At the RCSI, educational leadership has chosen to invest in SEE, faculty development, and high-stakes assessment, illustrating what is possible when policy flexibility aligns with academic vision. Agreements with affiliated hospitals ensure protected time for residents to undertake "mandatory" SEE activity without compromising service provision. Although upfront costs of SEE and SBA can be substantial, early standardized competency assessment can reduce downstream costs by preventing avoidable errors, limiting medicolegal exposure and reducing the need for intensive remediation, positioning SEE as a long-term cost-avoidance and patient safety strategy.

SCALABILITY AND RESOURCE CONSIDERATIONS

System-level integration of deliberate practice and SBA is achievable when supportive policy structures exist, and leadership actively prioritizes them, with risk mitigation and innovation often driven by a small number of senior decision-makers who direct strategic resource allocation and embed SEE as a consequential progression criterion. Building on this policy foundation, RCSI shows how targeted investment in SEE and high-stakes assessment can drive reform by incorporating summative SBA of technical and non-technical skills into years one and two of an eight-year surgical training scheme, with SBA scores contributing to progression to year three alongside interview performance, OR logbook activity, and other portfolio metrics. In doing so, SEE is repositioned from an adjunct educational resource to a meaningful determinant of progression and readiness for higher surgical training. Although high-stakes simulation carries its own fairness risks, these are mitigated in our context by restricting summative assessment to models, instruments, and scenarios already used in mandatory teaching, and by structured examiner preparation, including pre-briefing and advance circulation of checklists to promote consistent scoring.

Infrastructure and resourcing remain important considerations. High-quality SEE depends not only on facilities but also on the educational expertise underpinning them. While well-resourced centers can support high-fidelity procedural models and complex scenario-based assessments, the principles of surgical skill acquisition do not require advanced technology. Granular technical competencies can be taught and evaluated effectively using low-cost modalities. Educational impact depends less on model fidelity than on trained educators who design structured curricula, deliver consistent teaching and feedback, and apply sound assessment principles. This is particularly relevant in low-resource settings, where financial constraints may limit technology but do not preclude systematic teaching and evaluation. Investment in faculty development and in SEE as a progression metric are likely key determinants of success. By prioritizing educator capability and curriculum design over technological sophistication, SBA becomes feasible and scalable across diverse global contexts.

STANDARDIZED PRINCIPLES OVER STANDARDIZED SIMULATORS

Aviation provides a useful, although imperfect, analogy for standardized performance assessment. Commercial pilots undergo regular performance evaluations on uniform aircraft simulators using shared criteria that ensure consistency and fairness. Surgical training cannot replicate this directly, as the profession spans numerous specialties with distinct procedural and cognitive demands, making a single universal simulator neither feasible nor equitable. Establishing standardized assessment principles can, however, address heterogeneity across the 10 established surgical specialties. These include faculty calibration, validated scoring frameworks, structured feedback processes, and common performance metrics, paired with specialty-specific procedural content that reflects authentic clinical practice. Such an approach preserves fairness while enabling assessments to capture disciplinary nuance.

FUTURE DIRECTIONS: AUTONOMY THRESHOLDS AND ENTRUSTABLE PROFESSIONAL ACTIVITIES

As the Irish model evolves, the next step should include specialty-specific autonomy thresholds framed as entrustable professional activities (EPAs), representing units of real clinical practice and requiring entrustment decisions grounded primarily in demonstrated workplace performance. SBA should therefore not be viewed as EPAs themselves nor as standalone proxies for independent clinical capability, but rather as complementary evidence supporting entrustment decisions by verifying readiness for specific technical and crisis-management competencies. Such thresholds would operationalize competency frameworks, support early targeted remediation for trainees not yet meeting expected standards, and could be supported by SBA to confirm readiness for independent emergency on-call case management. Implemented effectively, this approach could provide a scalable template for international surgical training reform, aligning assessment practice with patient safety priorities and competency-based progression at the point where autonomy decisions carry the greatest clinical consequence. Mandatory, simulation-anchored autonomy checkpoints represent a logical next step in modern surgical training. Without such integration, surgical training is likely to remain on its current trajectory, with limited progress toward objective assurance of readiness for independent practice outside the OR. In this context, SEE and SBA risk remaining sources of isolated validity evidence rather than functioning as integrated patient safety safeguards within high-stakes entrustment decisions.

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