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Curriculum Reform and Competency-Based Education in the Medical Surgery Subject

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ABSTRACT

Recent advances in medical education emphasize competency-based education (CBE) as a strategic response to the limitations of traditional time-based curricula. This is particularly relevant in surgical education, where mastery of procedural skills, clinical reasoning, and intraoperative decision-making are essential for patient safety and professional competence. Curriculum reform within surgical training programs has become imperative to align learning outcomes with evolving healthcare demands and to ensure graduates are both competent and confident in real-world settings. This study investigates the integration of CBE principles into the undergraduate surgical curriculum through a mixed-methods approach involving curriculum analysis, faculty interviews, and evaluation of pilot modules incorporating simulation-based learning and structured clinical assessments. The research identifies key benefits of CBE, including learner-centered progression, improved feedback mechanisms, and enhanced readiness for clinical responsibilities. It also explores implementation challenges such as faculty resistance, variability in assessment standards, and infrastructure limitations. Using case-based data from a pilot CBE module in a surgical education setting, this paper presents strategies for curriculum alignment, competency mapping, and effective assessment tool utilization. Innovations highlighted include the use of digital portfolios, entrustable professional activities (EPAs), and real-time feedback systems supported by educational technology. Findings suggest that while CBE offers substantial pedagogical advantages, its successful adoption requires institutional commitment, continuous faculty development, and iterative evaluation. This study contributes to the growing body of evidence supporting competency-based reform in surgical education and offers practical recommendations for educators, curriculum designers, and policymakers committed to transforming medical training for future-ready healthcare professionals.

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1. Introduction

The evolution of medical education necessitates a paradigm shift from traditional time-based curricula to outcome-focused, competency-driven learning frameworks. Historically, medical and surgical education has centered on the apprenticeship model and fixed-duration clinical rotations, where progress is tied to time spent rather than the demonstration of specific skills or readiness for independent practice. However, contemporary healthcare systems require practitioners capable of delivering safe, efficient, evidence-based care in increasingly complex settings. These demands have exposed critical limitations in conventional curricula—particularly in high-stakes fields such as surgery, where critical thinking, psychomotor precision, and sound clinical judgment are indispensable.

Competency-Based Education (CBE) offers a transformative alternative, anchored in the mastery of clearly defined learning outcomes. Unlike traditional systems that advance learners based on tenure, CBE enables individualized progression contingent on meeting predefined competencies, thereby strengthening both learner accountability and patient safety[1,2]. This approach aligns with global movements to reform medical training by cultivating lifelong learning, adaptability, and reflective practice—core attributes for modern healthcare professionals[3].

In surgical education specifically, embedding CBE principles ensures trainees do not merely complete rotations, but develop the procedural expertise, intraoperative decision-making capacity, and professional conduct required for independent practice. Key advantages include tighter alignment between educational content and real-world clinical expectations, more robust formative feedback systems, and learner-centered learning pathways[1]. Institutions adopting CBE report higher learner motivation, more consistent mastery of clinical skills, and improved preparedness for residency[4,5].

Furthermore, established global frameworks such as CanMEDS and the ACGME Core Competencies provide foundational guidance for redesigning surgical and other specialty curricula[1,6]. These models emphasize explicit definition of professional roles and responsibilities, integration of Entrustable Professional Activities (EPAs), and multi-faceted assessment strategies that extend beyond cognitive knowledge to encompass communication, professionalism, and systems-based practice.

Technological advancements have also accelerated the case for reform, including the growing adoption of simulation-based training, digital assessment platforms, and electronic portfolios[7,8]. These tools not only create safer, more efficient learning environments but also enable real-time performance monitoring, targeted formative feedback, and continuous competency mapping across a learner's developmental trajectory.

Against this backdrop, curriculum reform rooted in CBE is not merely an educational innovation—it is a strategic imperative to ensure graduates are equipped to navigate evolving clinical challenges with both competence and confidence. As healthcare systems continue to advance, so too must our approach to training the next generation of surgical professionals.

Traditional surgical education typically relies on fixed rotations and end-of-course summative assessments that often fail to accurately gauge a learner's readiness for clinical responsibility. Time-bound placements prioritize completing specified durations across departments over verifying mastery of core clinical competencies. Consequently, some learners advance through the curriculum without adequate exposure to or proficiency in essential procedures. Additionally, summative evaluations conducted only at the end of rotations or academic terms provide limited opportunities for ongoing, actionable feedback to guide growth throughout the learning process.

This disconnect between time-based training and competence-based performance poses tangible risks to patient safety and undermines educational equity—especially when learners progress despite persistent gaps in proficiency. Iobst et al. note that traditional models lack mechanisms for targeted individual support, creating a mismatch between program completion and actual skill acquisition[9]. Learners also frequently describe surgical training as fragmented and

inconsistent, resulting in uneven exposure to core procedures and professional standards across institutions [10].

In contrast, CBE centers on measurable outcomes—including technical proficiency and professional behavior—to support more personalized learning journeys [2,3]. Progression is no longer tied to rotation length, but to demonstrated mastery of defined competencies. This model not only deepens clinical skill acquisition but also fosters greater ownership of learning and engagement. It allows advanced learners to progress efficiently while allocating additional time and support to those who require it.

Accumulating evidence confirms that CBE yields more consistent graduate performance across both technical and non-technical surgical competencies. Studies link structured feedback and continuous assessment in CBE to higher learner satisfaction, improved readiness for clinical duties, and closer alignment with residency requirements [11,12]. Integrating EPAs and longitudinal competency mapping further empowers learners to track their progress, actively shape their development, and build intrinsic motivation alongside reflective practice [13].

Curriculum reform must integrate evidence-based instructional approaches—such as simulation-based learning, flipped classrooms, and formative assessments—all aligned with defined competencies [1]. Simulation training builds procedural confidence and eliminates patient risk by allowing repeated practice in a controlled, standardized setting. Flipped classrooms promote active analysis of clinical cases and surgical scenarios prior to hands-on sessions, maximizing the value of in-person teaching time. Formative assessments, meanwhile, deliver ongoing insight into learner progress and enable timely intervention—all essential for fostering competency development in surgical education.

Crucially, reform must also respond to shifts in healthcare delivery. Growing emphasis on teamwork, interprofessional communication, and systems-based practice requires these domains to be embedded formally within competency frameworks [14]. Interprofessional education and collaborative simulation exercises have been shown to strengthen learners' ability to function effectively in team environments—a skill set now vital in modern operating rooms and perioperative care [15].

Regulatory and accreditation bodies are increasingly aligning standards with competency-based principles, further driving institutional adoption. In countries including Canada and the Netherlands, national surgical training authorities have mandated EPA implementation and milestone-based progression, accelerating the global shift toward outcome-oriented education [16]. These policy developments reflect broader institutional commitment to CBE, underscoring the importance of local curriculum redesign that adheres to internationally recognized best practices.

Implementing CBE demands far-reaching structural change—not only revising content but transforming the philosophy and practice of teaching, learning, and assessment across institutions. This is particularly critical in surgical education, where the stakes of clinical decision-making and procedural skill require deliberate, structured development. Successful rollout requires cross-departmental collaboration, institutional leadership, sufficient resource allocation, and sustained investment in faculty development.

1.1. Defining Competency Frameworks

The foundation of Competency-Based Education (CBE) rests on clearly articulated competencies that integrate knowledge, psychomotor skills, and professional behaviors. These competencies are not merely instructional objectives, but dynamic capabilities that graduates must consistently demonstrate in complex and unpredictable clinical settings. Consequently, their development must be grounded in humanistic principles, encompassing empathy, ethical integrity, and dedication to societal well-being.

Such frameworks must be systematically aligned with population health needs, institutional educational goals, and specialty-specific practice requirements. This alignment ensures that graduates are not only clinically proficient but also responsive to the distinct cultural, epidemiological, and socioeconomic contexts in which they deliver care. In this way, CBE fosters not only technical excellence but also the ethical and civic preparedness of future health professionals to serve vulnerable groups and address systemic health inequities.

Established examples include the National Competency-Based Learning Objectives for Medical Education (NKLM) in Germany and the Competency-Based Undergraduate Curriculum (CBME) initiative in India, both of which provide explicit learning outcomes and developmental milestones for medical graduates [17,18]. These national frameworks illustrate how structured competency mapping

can guide curriculum reform, strengthen interprofessional collaboration, and enhance assessment consistency. In particular, detailed milestones enable clear differentiation of learner progress across stages, supporting a growth-oriented approach to medical training.

Mapping existing curricula to these reference frameworks is not an administrative task, but a pedagogical and ethical obligation. This process ensures vertical and horizontal integration of content, where each learning activity builds logically on prior knowledge and prepares learners for subsequent stages of training. This is especially critical in surgical education, where competencies must closely mirror real clinical workflows, intraoperative decision-making, and adherence to professional standards. In these high-stakes environments, logical coherence and progressive development are essential to shaping practitioners who are not only skilled technicians but also reflective, compassionate, and accountable professionals.

Ultimately, successful CBE implementation requires active engagement from faculty, learners, policymakers, and communities in co-designing inclusive, adaptable curricula centered on holistic patient care. It demands a fundamental shift from time-bound training to outcome-based progression, prioritizing demonstrated mastery over mere exposure. In doing so, CBE transforms not only how health professionals are educated, but also how their roles in care delivery, advocacy, and leadership across diverse healthcare systems are conceptualized[17,18].

1.2. Competency-Aligned Assessment Tools

In CBE, assessment fulfils both summative and formative purposes, with primary emphasis on continuous feedback and developmental progress. This dual function reflects a humanistic approach that views learners not merely as subjects of evaluation, but as evolving professionals whose competence grows through repeated cycles of performance, reflection, and targeted input. Validated tools such as the Objective Structured Assessment of Technical Skills (OSATS), mini-Clinical Evaluation Exercise (mini-CEX), Direct Observation of Procedural Skills (DOPS), and Entrustable Professional Activities (EPAs) are widely established as robust, reliable instruments for measuring competency across multiple domains[19].

Each tool, while structured and evidence-based, also supports individualised learner development. For instance, OSATS not only quantifies technical accuracy but also fosters self-awareness through standardised, criterion-referenced feedback. Similarly, mini-CEX enables real-time appraisal during authentic clinical encounters, reinforcing ethical reasoning, communication effectiveness, and adaptability under pressure—attributes central to compassionate and safe clinical practice.

Integrating workplace-based assessments (WBAs) with simulation-enhanced evaluation allows for contextualised measurement of clinical judgment, teamwork, and procedural proficiency. WBAs nurture longitudinal mentorship and shift assessment culture from scrutiny to supportive supervision, consistent with the view that assessment is a collaborative dialogue rather than a final judgment. Simulations, meanwhile, provide a low-risk, controlled environment for practising high-stakes tasks, building resilience and reflective practice without compromising patient safety.

Technology-enabled assessment—including virtual reality simulators and mobile-based evaluation applications—further enhances scalability and consistency in tracking performance across settings and time points[20]. These tools improve objectivity and inter-rater reliability while broadening access to timely feedback. Combined with digital portfolios and cloud-based performance dashboards, they enable learners and educators to identify strengths, gaps, and progress trajectories dynamically, reducing administrative burden while upholding the authenticity of clinical evaluation.

Fundamentally, the evolution of assessment within CBE represents a paradigm shift from punitive grading to developmental partnership. Educators are thus challenged to redefine their roles: not solely as assessors of competence, but as facilitators of professional identity formation. When assessment is grounded in humanistic principles, supported by valid tools, and aligned with clinical reality, it becomes an ethical imperative for nurturing safe, skilled, and patient-centred healthcare professionals.

1.3. Faculty Development and Engagement

A critical determinant of successful CBE implementation is the capacity of faculty to adopt new roles as facilitators, coaches, and assessors of learning. Many educators trained within traditional systems may be unfamiliar or uneasy with

the principles and practices of CBE. This pedagogical shift requires more than surface-level adaptation—it demands a fundamental transformation in professional identity, instructional philosophy, and day-to-day academic practice. Accordingly, structured faculty development programmes incorporating workshops, mentorship schemes, and peer observation are essential to build proficiency in competency-based instruction and assessment [21]. These initiatives must extend beyond technical training to integrate critical reflection, ethical reasoning, and transformative learning theory, enabling educators to internalise the core values that underpin CBE.

From a humanistic standpoint, educators are not merely disseminators of knowledge but co-constructors of understanding in partnership with learners. This collaborative model calls for emotional intelligence, cultural humility, and sustained commitment to learner-centredness—especially when assessing competencies that encompass attitudinal and interpersonal dimensions. Faculty development must therefore acknowledge the relational dynamics and emotional investment inherent in transitioning from an authoritative stance to a facilitative role.

Furthermore, establishing a community of practice among educators nurtures reflective teaching, consistent assessment standards, and ongoing pedagogical improvement. Such networks provide a platform for shared inquiry, peer feedback, and the collaborative development of assessment rubrics that are locally relevant yet aligned with international benchmarks. Within these communities, collective expertise mitigates individual uncertainty and fosters resilience in educational practice.

For CBE to be widely and sustainably adopted, institutions must invest in these developmental frameworks while recognising that faculty transformation is a longitudinal, iterative process. Leadership should foster psychological safety, encourage pedagogical innovation, and recognise teaching excellence alongside research achievements. Ultimately, the success of CBE rests not only on revised curricula but on reimagining educational practice to empower both educators and learners within a shared ethical and academic mission [21].

1.4. Educational Technology and Data-Driven Feedback

Modern implementation of Competency-Based Education (CBE) is substantially strengthened by digital tools that enable real-time progress monitoring, systematic documentation of formative feedback, and clear visualization of developmental trajectories. Electronic portfolios, learning management systems, and performance analytics dashboards support educators in efficiently tracking competency attainment and identifying learning gaps [22]. These digital infrastructures are not merely functional utilities; they embody a fundamental pedagogical shift toward learner agency and transparent accountability. When learners receive timely insights through interactive dashboards or adaptive simulation platforms, they are better positioned to take ownership of their development and cultivate the metacognitive skills essential for sound clinical judgment and lifelong learning.

Furthermore, emerging artificial intelligence-enabled systems offer promising avenues to personalize learning pathways and generate targeted feedback based on learner performance in simulated or authentic clinical settings [23]. Such technologies complement rather than replace educational guidance: they extend human oversight by identifying performance patterns across contexts and over time. For example, intelligent tutoring systems can detect subtle errors in clinical reasoning or procedural technique and provide individualized corrective input, reducing the delays in feedback that often hinder consistent skill acquisition.

These technological advances not only ease administrative workload but also enhance assessment precision and enable more responsive educational interventions. By leveraging machine learning capabilities, digital platforms can identify potential learning challenges before they manifest in clinical practice, facilitating early remediation and tailored mentorship. This proactive approach aligns with the ethical imperative in health professions education to uphold patient safety through rigorous, evidence-informed training. Aggregate learning analytics also support evidence-based curriculum refinement while upholding individual learner privacy and diversity.

From a humanistic perspective, digital tools should enrich rather than diminish the relational dimension of education. When deployed thoughtfully, they reduce time spent on repetitive documentation, freeing educators to focus on meaningful, dialogic mentorship and professional identity formation. Ultimately, technology-enhanced CBE reaffirms the educator's central role as a facilitator of holistic growth—intellectual, ethical, and professional—while empowering

learners to navigate complex healthcare systems with competence, confidence, and compassion [22,23].

1.5. Institutional Policy and Governance

Institutional readiness and policy support form the foundational backbone of sustainable Competency-Based Education (CBE), extending beyond administrative frameworks to embody an institution's core commitment to learner-centered, outcome-driven education. Transitioning toward CBE requires moving away from rigid, time-bound conventions toward more humanistic structures that respect diverse learning paces, individual circumstances, and professional relevance. Policies that enable flexible academic pathways are not merely operational adjustments—they represent an ethical commitment to inclusivity and lifelong learning [24].

Furthermore, outcome-aligned accreditation standards act as both quality benchmarks and ethical anchors, ensuring educational practice remains responsive to societal health needs. This approach demands that institutions demonstrate not only knowledge acquisition but also authentic clinical performance, calling for governance structures that are adaptive, transparent, and evidence-based. Establishing dedicated bodies for competency oversight, quality assurance, and curriculum renewal is therefore essential. These bodies should function as collaborative communities—bringing together educators, clinicians, policymakers, and ethicists—to ensure reforms are grounded in current evidence, sociocultural appropriateness, and professional standards [24].

Integrating CBE into institutional culture requires transformative leadership that fosters shared values of adaptability, empathy, and continuous improvement. Faculty development initiatives should be reimagined not only to build technical skills in CBE delivery but also to empower educators as co-designers of innovation, strengthening a sense of shared ownership. Recognizing and rewarding contributions to curriculum development, mentorship, and interprofessional practice is vital—affirming that educational excellence stands alongside research achievement as a core institutional priority [24].

Ultimately, effective governance for CBE operates as both strategic infrastructure and cultural foundation. Its impact is measured not only by formal policies but by how deeply these principles shape the experiences of learners, educators, and healthcare systems. By embedding CBE into institutional policy and practice, institutions affirm their role as stewards of professional competence, ethical integrity, and public trust.

1.6. Inter-Institutional Collaboration and Global Benchmarks

Cross-institutional knowledge exchange and alignment with international standards are vital for advancing and sustaining Competency-Based Education (CBE). Sharing evidence-based practices through academic partnerships and benchmarking against established global models accelerates curriculum reform and minimizes duplication of effort. Participation in regional and international bodies such as the World Federation for Medical Education (WFME) and the Association for Medical Education in Europe (AMEE) facilitates structured curriculum comparison, faculty development exchanges, and joint resource development [25]. These collaborative networks strengthen the relevance of local programmes, enable thoughtful adaptation of global frameworks to national and institutional contexts, and promote greater equity in training quality across diverse settings.

Case Example: A Pilot CBE Module in Undergraduate Surgery

A pilot implementation at a teaching hospital introduced a CBE module focused on appendectomy procedures, designed to integrate theoretical knowledge and practical skills within a structured, outcome-oriented framework. Students engaged in supervised clinical sessions, simulation-based workshops, and interactive case discussions centered on core surgical competencies. Proficiency was assessed using a tailored Objective Structured Assessment of Technical Skills (OSATS) tool alongside direct observation by experienced faculty, with formative feedback provided at every stage of the learning process.

Learners were evaluated not only on technical aspects such as anatomical identification and operative technique but also on essential professional capabilities: obtaining informed consent, communicating clearly with patients and team members, and making sound clinical judgments under pressure. Competency milestones were explicitly defined, with progression determined by demonstrated mastery rather than fixed rotation duration.

Evaluation outcomes showed measurable improvements in learner confidence related to appendectomy procedures, alongside higher supervisor ratings of student preparedness and active clinical engagement. Faculty observed greater learner accountability and motivation, while students reported clearer learning expectations and more meaningful, actionable feedback throughout the module [11].

2. Materials and Methods

This study employed a mixed-methods research design to examine the implementation and impact of a Competency-Based Education (CBE) module integrated into the undergraduate surgical curriculum at a teaching hospital. The intervention focused on a pilot instructional programme centered on appendectomy procedures, with the aim of aligning surgical training with predefined competencies in technical proficiency, communication, and clinical decision-making.

Participants comprised 12 final-year medical students undertaking a clinical surgical rotation during the academic year, together with 4 consultant surgeons who directly supervised delivery, mentorship, and assessment. Purposive sampling was used to select participants, ensuring inclusion of learners actively engaged in surgical training and faculty with established experience in competency-based assessment. This sampling strategy aligns with best practice in qualitative health education research, which prioritises information-rich cases to illuminate complex educational phenomena [26].

Prior to implementation, the curriculum team completed a systematic mapping exercise based on institutional competency frameworks. Specific learning outcomes were developed to reflect core surgical competencies, including aseptic technique, anatomical identification, patient safety protocols, and effective intraoperative communication. The instructional design combined multiple evidence-based approaches: simulation workshops using synthetic tissue models, supervised bedside teaching during ward rounds, and guided participation in live appendectomy procedures under direct faculty oversight. This multimodal approach is consistent with accepted standards in surgical education, where hands-on practice, simulation, and structured feedback collectively enhance skill acquisition and learner confidence [27,28].

Assessment instruments included a tailored version of the Objective Structured Assessment of Technical Skills (OSATS), adapted specifically for appendectomy procedures, alongside structured observation forms to evaluate competencies in informed consent and intraoperative decision-making. All tools were validated internally through expert consensus among surgical educators and pilot-tested for feasibility and clarity. Learners were assessed at three key stages: baseline (pre-module), midpoint (during clinical attachment), and post-module endpoint. Assessments were documented using standardised rubrics and audio-recorded post-encounter debriefings.

To support formative development, each student received individualised feedback following every observed activity, either through immediate post-procedure discussion or scheduled mentorship sessions. Learners also maintained reflective journals to document personal insights, progress, and learning needs throughout the module. Structured reflection was integrated as a metacognitive strategy to foster self-directed improvement and deeper engagement with clinical practice [29].

Data were triangulated across multiple complementary sources to strengthen credibility, dependability, and trustworthiness: field notes recorded during simulation and operative sessions capturing procedural, communicative, and ethical dimensions; faculty assessments grounded in clinical and educational expertise; student self-evaluations reflecting metacognitive awareness and professional growth; and semi-structured interviews conducted upon completion of the module. The interview guide was developed from key literature in competency-based surgical education and pilot-tested to ensure clarity and alignment with study objectives.

Interview topics included perceived fairness and transparency of assessment, cognitive and emotional aspects of skill development, and comparative perspectives on CBE versus traditional training models. These discussions captured experiential and motivational insights not readily apparent through observation alone.

Qualitative data analysis followed the six-phase thematic framework described by Braun and Clarke, enabling systematic identification and interpretation of recurring patterns across participants' accounts [30]. Coding was performed independently by two researchers trained in qualitative methodology, with regular consensus meetings to resolve discrepancies and refine thematic structure, thereby

enhancing analytical rigour and interpretive consistency.

Ethical approval was obtained from the Institutional Review Board of Makassar Health Polytechnic prior to recruitment (approval number UL/I/378/2025). All participants provided written informed consent, confirming voluntary participation and the right to withdraw without prejudice. All data were anonymised and stored securely in compliance with ethical standards governing research involving human subjects, upholding principles of autonomy, beneficence, non-maleficence, and transparency [31].

This methodological approach enabled comprehensive examination of how competency-based instruction, assessment, and reflective practice interact within a surgical training setting, yielding empirically grounded insights to inform future curriculum development.

3. Results

Implementation of the Competency-Based Education (CBE) module in undergraduate surgical training yielded substantial improvements in both learner confidence and faculty-rated performance across all assessed competency domains. Analysis of observational assessments and self-report data revealed clear patterns of progressive improvement, while post-module interviews provided complementary qualitative insights into participants' experiences and perspectives.

3.1. Improvement in Technical and Non-Technical Competencies

Table 1 summarises learner performance across three assessment points: baseline (pre-module), midpoint, and endpoint (post-module). Evaluations were conducted using the Objective Structured Assessment of Technical Skills (OSATS) rubric and structured observation forms covering technical proficiency, communication, and clinical decision-making.

As shown in **Table 1**, statistically significant improvements were observed across all five competency domains from baseline to post-module assessment (all $p < 0.01$), indicating consistent and meaningful gains following the intervention.

Table 1. Progression of Student Competency Scores across the CBE Module.

Competency Domain	Baseline (Mean ± SD)	Midpoint (Mean ± SD)	Endpoint (Mean ± SD)	*p*-Value
Aseptic Technique	2.3 ± 0.7	3.4 ± 0.6	4.5 ± 0.5	<0.01
Procedural Accuracy	2.0 ± 0.5	3.2 ± 0.6	4.3 ± 0.6	<0.01
Informed Consent Discussion	2.1 ± 0.8	3.5 ± 0.7	4.6 ± 0.4	<0.01
Intraoperative Communication	2.4 ± 0.6	3.6 ± 0.5	4.7 ± 0.3	<0.01
Clinical Decision-Making	2.2 ± 0.7	3.3 ± 0.6	4.4 ± 0.5	<0.01

Note: Scoring based on a 5-point rubric: 1 = poor, 5 = excellent.

For Aseptic Technique, mean scores rose from 2.3 (± 0.7) at baseline to 3.4 (± 0.6) at midpoint, and further to 4.5 (± 0.5) upon completion. This upward trajectory reflects improved adherence to infection control protocols and greater procedural mindfulness, likely reinforced by repeated simulation cycles and targeted feedback.

Procedural Accuracy showed a comparable trend, increasing from 2.0 (± 0.5) to 3.2 (± 0.6) and reaching 4.3 (± 0.6) at endpoint. This demonstrates that psychomotor skills were not only acquired but refined with greater precision and consistency over the course of the module.

Informed Consent Discussion—a competency integrating communication, ethical reasoning, and legal awareness—improved from 2.1 (± 0.8) to 3.5 (± 0.7), and ultimately to 4.6 (± 0.4). The narrowing standard deviation signals both higher overall performance and greater uniformity among participants.

Intraoperative Communication advanced from 2.4 (± 0.6) to 3.6 (± 0.5), attaining a mean of 4.7 (± 0.3) at endpoint. These findings indicate enhanced clarity, assertiveness, and collaborative interaction within surgical teams under pressure.

Finally, Clinical Decision-Making improved from 2.2 (± 0.7) to 3.3 (± 0.6), concluding at 4.4 (± 0.5), reflecting strengthened critical reasoning, situational judgment, and ability to apply theoretical knowledge in real time.

Collectively, these results confirm that the structured CBE approach effectively fosters multidimensional competence. Reduced score variability over time further suggests convergence toward higher and more uniform standards of

performance, attributed to iterative feedback, repeated simulation practice, and tight alignment between learning objectives and assessment tasks[32].

3.2. Student Perception and Reflective Feedback

Qualitative analysis of reflective journals and post-module interviews yielded three dominant themes: enhanced self-awareness, appreciation for structured formative feedback, and increased confidence in surgical practice (**Table 2**).

The first theme, Enhanced Self-Awareness, was reported by 11 of 12 participants. Learners described gaining clearer insight into personal strengths and developmental needs—particularly in domains often underemphasised in traditional training, such as interpersonal communication. This demonstrates the module's effectiveness in fostering metacognitive awareness alongside technical skill acquisition.

The second theme, Valued Formative Feedback, was universally cited by all 12 students. Participants consistently highlighted that immediate, specific feedback following simulations and clinical encounters enabled timely correction of errors and reinforced positive practice. This underscores the central role of ongoing, actionable guidance in shaping competence and self-efficacy.

The third theme, Confidence in Surgical Practice, appeared in accounts from 10 students. Learners reported feeling better prepared and more assured when transitioning from simulated environments to actual clinical settings, confirming that the CBE model successfully bridges theoretical knowledge and practical readiness.

Faculty accounts aligned closely with student perspectives, noting higher levels of learner engagement, more purposeful mentoring interactions, and clearer identification of learning needs. Supervisors specifically emphasised that real-time observation tools captured subtle but critical indicators of professional development that are often overlooked in conventional assessment systems[33].

Overall, combined quantitative and qualitative findings indicate that structured CBE implementation—supported by simulation, continuous feedback, and reflective practice—improves both measurable performance outcomes and learner attitudes toward surgical training[34]. Integrating assessments of both technical and non-technical competencies was essential to obtaining a holistic view of trainee preparedness[35].

Table 2. Emergent Themes from Student Feedback and Reflective Journals.

Theme	Representative Student Quote	Frequency of Theme Appearance
Enhanced Self-Awareness	"I realized how much I needed to work on my patient communication early on."	11 of 12 students
Valued Formative Feedback	"The feedback after each simulation helped me fix mistakes right away."	12 of 12 students
Confidence in Surgical Practice	"By the end of the module, I felt ready to assist in a real appendectomy."	10 of 12 students

4. Discussion

The study findings confirm that Competency-Based Education (CBE) represents an effective, human-centered approach to undergraduate surgical training. The appendectomy module's design—integrating simulation, supervised clinical practice, and continuous formative assessment—went beyond technical instruction to foster holistic development of clinical expertise and professional identity. Statistically significant improvements across all measured domains affirm a core principle of CBE: competence is not accrued passively through exposure or time spent, but is actively demonstrated through attainment of predefined, observable outcomes[36].

The consistent gains observed across all competency domains provide robust evidence that clear learning outcomes, transparent assessment criteria, and ongoing feedback empower learners to take greater ownership of their development. This shift aligns with established adult learning frameworks, positioning learners as autonomous agents rather than passive recipients of instruction. The structured, predictable nature of competency benchmarks also fosters psychological safety, encouraging learners to progress confidently within defined expectations while reducing uncertainty associated with inconsistent or subjective evaluation[37].

Formative feedback emerged as a cornerstone of effective learning in this study. Participants consistently reported that timely, specific, and actionable input following practice

enabled immediate correction of errors and reinforcement of positive practice. Unlike summative assessments that judge performance retrospectively, ongoing feedback functioned as an iterative dialogue that strengthened both technical precision and non-technical capabilities—including communication, teamwork, emotional regulation, and situational awareness—attributes often undervalued in traditional curricula yet essential to safe, ethical surgical care [38].

Simulation-based practice fulfilled a dual role as both an equalizer and accelerator of learning. It offered a standardised, low-risk environment where all learners encountered equivalent challenges, minimising variability inherent to real-world clinical settings. The transfer of skills from simulation to live operative contexts—reflected in improved performance and learner confidence—validates simulation as a vital preparatory tool in surgical education [39,40].

Structured reflection further deepened learners' metacognitive awareness, enabling them to identify strengths, acknowledge gaps, and formulate targeted learning strategies. This capacity for self-regulation is central to both CBE and lifelong learning, consistent with adult learning principles that emphasise autonomy, relevance, and internal motivation as drivers of sustained professional growth [41].

Faculty also reported meaningful benefits from the CBE framework. Standardised rubrics, milestone tracking, and Entrustable Professional Activities (EPAs) enhanced assessment consistency, reduced subjectivity, and enabled more precise identification of learning needs. Real-time observation tools further allowed educators to capture nuanced indicators of clinical reasoning and professional conduct that are often overlooked in logbook-based or end-of-rotation evaluations [42]. These improvements not only enhanced educational quality but also increased faculty satisfaction and engagement.

Nonetheless, several limitations must be acknowledged. The small sample size and single-institution setting may limit generalisability to other contexts. The intervention also required substantial resources—including simulation facilities, faculty development, and dedicated assessment time—which may pose barriers to adoption in resource-constrained environments. Additionally, while short-term skill acquisition was clearly demonstrated, further research is needed to evaluate long-term competency retention and transfer to other procedures or clinical domains. These considerations highlight the value of larger-scale, multi-site studies and longitudinal follow-up.

Despite these constraints, the successful pilot demonstrates that CBE can be integrated effectively into existing surgical curricula with appropriate planning, institutional support, and educator development. The positive response from both learners and faculty reinforces that thoughtfully implemented competency-based reform is not only feasible but necessary to cultivate future practitioners who are technically skilled, ethically grounded, and fully prepared to meet evolving healthcare needs.

5. Conclusions

The implementation of a competency-based education (CBE) module within undergraduate surgical training yielded meaningful improvements in learner performance, engagement, and preparedness for clinical practice. By shifting from traditional time-based rotations to an outcomes-driven model, this study demonstrated that students can achieve higher levels of technical proficiency, clinical reasoning, and professional communication when guided by clearly defined competencies and supported by structured, formative feedback mechanisms.

The use of simulation, real-time assessment tools, and reflective practices proved essential in promoting deliberate learning and accelerating skill acquisition. Students not only developed confidence in performing appendectomy procedures but also gained a deeper understanding of their professional roles, responsibilities, and areas for growth. These findings underscore the value of learner-centered approaches in medical education that prioritize mastery over time served.

Faculty perspectives further highlighted the benefits of a competency-based framework in fostering more objective and consistent evaluation practices. The ability to track student progression using standardized tools allowed educators to provide more targeted mentorship and contribute meaningfully to the learner's development. This shift also supported a culture of accountability and excellence, reinforcing the institution's commitment to patient safety and clinical quality.

Despite resource and scalability challenges, this pilot project demonstrated that with adequate institutional planning, faculty development, and curricular alignment, CBE

can be successfully embedded into existing medical education structures. The positive outcomes observed in this study suggest that CBE not only enhances immediate learning outcomes but also lays the foundation for producing competent, reflective, and adaptable healthcare professionals.

As healthcare environments continue to evolve and demand greater levels of clinical competence, adaptability, and interprofessional collaboration, medical schools must embrace transformative educational models like CBE. Future research should focus on broader implementation across multiple institutions, evaluation of long-term learner outcomes, and integration with national accreditation standards. Ultimately, sustained investment in competency-based surgical education will be crucial for preparing future physicians who are not only technically capable but also professionally resilient and ready to meet the challenges of modern medicine.

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Institutional Review Board Statement

This study was reviewed and approved by the Institutional Review Board of the Makassar Health Polytechnic, Ministry of Health of the Republic of Indonesia (Poltekkes Kemenkes Makassar) in January 2025 with approval number UL/I/378/2025.

Informed Consent Statement

Informed consent was obtained from all participants involved in the study. Participants were informed about the study's purpose, procedures, and their right to withdraw at any time without any academic or clinical consequences. Confidentiality and anonymity were ensured throughout the research process.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request. Due to ethical and privacy considerations, individual participant data are not publicly available.

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Conflicts of Interest

The author declares no conflict of interest related to the conduct, analysis, or publication of this study.

AI Use Statement

The author used ChatGPT (OpenAI) solely for linguistic and grammatical refinement of the manuscript, including improvements in clarity, coherence, and readability. The use of this tool did not influence the study design, data collection, data analysis, interpretation of results, or scientific conclusions. The author retains full responsibility for the accuracy, originality, and integrity of all content presented in this manuscript.

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