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APPLYING IMMERSIVE AND GAMIFIED LEARNING TO CRITICAL CARE EDUCATION: A CONTINUOUS MEDICAL EDUCATION MODEL FOR EMERGENCY MEDICINE POSTGRADUATE TRAINEES

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Abstract

Emergency settings demand rapid decision-making, procedural expertise, and teamwork for critically ill patients. Recognizing the limitations of traditional CME, we developed a five-week immersive Critical Care Month for emergency medicine trainees. The program integrated didactic lectures, scenario-based procedural stations, digital quizzes, and a gamified escape-room challenge. Weekly modules covered core critical care, including domains such as ventilation, point-of-care ultrasound, critical procedures, and electrocardiography interpretation. Procedural training featured a self-constructed phantom. The final week's gamified challenge reinforced clinical reasoning under pressure. Thirty trainers completed evaluation feedback, which showed high satisfaction with the content's relevance (mean: 4.63 ± 0.81), session engagement (4.6 ± 0.81), and improvement in clinical understanding (mean: 4.51 ± 0.81). Learners endorsed program repetition, reporting increased confidence and enthusiasm. This study highlights immersive, multimodal CME's effectiveness, feasibility, and low-cost, scalable, replicable model for postgraduate training

Keywords: Active learning; Critical care; Emergency medicine; Gamified challenge; Immersive

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Abstrak

Situasi kecemasan memerlukan keputusan pantas, kepakaran prosedur, dan kerjasama pasukan dalam pengurusan pesakit kritikal. Menyedari keterbatasan CME tradisional, kami telah membangunkan program lima minggu "Critical Care Month" secara imersif untuk pelatih perubatan kecemasan. Program ini menggabungkan kuliah didaktik, stesen prosedur berasaskan senario, kuiz digital, dan cabaran bergamifikasi berbentuk 'escape room'. Modul mingguan merangkumi bidang utama penjagaan kritikal: saluran udara/ventilasi, ultrasound di tempat rawatan (POCUS), prosedur kritikal, dan interpretasi elektrokardiografi. Latihan prosedur menggunakan phantom buatan sendiri. Cabaran bergamifikasi pada minggu akhir mengukuhkan penaakulan klinikal dalam situasi tekanan. Seramai 30 pelatih melengkapkan maklum balas penilaian yang menunjukkan tahap kepuasan tinggi terhadap kerelevanan kandungan (purata: 4.63 ± 0.81), penglibatan sesi (4.6 ± 0.81), dan peningkatan pemahaman klinikal (purata: 4.51 ± 0.81). Peserta menyokong pengulangan program ini, melaporkan peningkatan keyakinan dan minat. Kajian ini menonjolkan keberkesanan CME multimodal secara imersif yang mampu dilaksanakan, berkos rendah, berskala, dan boleh diulang untuk latihan pascasiswazah.

Kata kunci: Cabaran gamifikasi; Imersif; Pembelajaran aktif; Perubatan kecemasan; Rawatan kritikal

1.0 INTRODUCTION

Medical education continually evolves to meet the changing needs of healthcare, particularly in specialty training, which requires technical competencies and critical thinking skills (Samarasekera et al., 2024). In emergency medicine (EM), traditional continuing medical education (CME) has relied heavily on didactic lectures and opportunistic bedside teaching. While these approaches remain important for foundational knowledge transfer, they may be insufficient in preparing trainees for complex, time-sensitive decision-making and procedural performance in high-acuity environments (McMahon, 2016; Cervero & Gaines, 2015). This has contributed to a persistent gap between theoretical knowledge and confident clinical application.

In response to these limitations, simulation-based education has become increasingly embedded within postgraduate EM training. Simulation and skills-based workshops have been associated with improved learner engagement, confidence, and perceived preparedness, particularly for resuscitation and procedural competencies (Gentry et al., 2019; Donoghue et al.,

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2024). However, many simulation-based programmes depend on high-fidelity equipment, dedicated simulation centres, and external facilitators, which may limit sustainability and scalability, especially in resource-constrained settings.

Educational gamification has also emerged as a complementary strategy to enhance learner motivation and engagement. Game-based learning approaches, including team challenges, competitive quizzes, and escape-room–style activities, have been reported to promote active participation and positive learner experiences in medical education (Xu et al., 2023; Quek et al., 2024). Nevertheless, much of the existing literature describes isolated or short-term gamified interventions, with limited attention to curriculum integration, instructional sequencing, or feasibility within routine postgraduate CME programmes. Emerging evidence further suggests that the acceptability and educational value of gamification depend on thoughtful instructional design, including alignment with learning outcomes and the progressive introduction of competitive elements (Kirsch & Spreckelsen, 2023; Wang et al., 2024).

The four-year EM postgraduate program integrates structured CME into clinical rotations across high-acuity departments. While comprehensive, this curriculum struggles to translate theoretical knowledge into confident, hands-on clinical performance. Clinical service demands, limited exposure to high-risk cases, and resource limitations often restrict experiential learning. Given these constraints, we identified critical care as an optimal area for educational innovation, requiring trainees to integrate clinical reasoning, procedural proficiency, and team-based decision-making. These competencies are best fostered through active learning strategies that mirror real-life emergency settings and provide psychologically safe environments for deliberate practice. Hence, the Critical Care Month (CCM) program was developed as a supplementary CME initiative designed to enhance and reinforce existing postgraduate emergency medicine curriculum learning outcomes

Building on our successful immersive trauma education, which demonstrated strong learner engagement and satisfaction (Sabardin et al., 2023), the CCM CME retained the core pedagogical principles of immersive, scenario-based, hands-on learning that underpinned the earlier intervention. Specifically, Sabardin et al. (2023) used faculty-guided procedural stations, realistic clinical scenarios, and experiential learning as the foundation of the program. In the CCM CME, this foundation was extended by systematically and progressively integrating gamification

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and digital interactive tools to enhance engagement and application of critical care concepts. To bridge the gap between theoretical knowledge and clinical application in EM, we embedded game-based learning elements like escape-room–style challenges and team-based tasks into our program design. Recent reviews have shown that game-based learning significantly improves student engagement, motivation, and learning outcomes in medical education (Xu et al., 2023). This insight, alongside a 2024 systematic review finding positive effects of gamified resuscitation training across cognitive and behavioral domains (Donoghue et al., 2024), reinforced our decision to adopt a comprehensive framework.

Our goal was to design a realistic and scalable gamified CME model that integrates foundational skill building with immersive and competitive critical care learning experiences. This study describes the development and implementation of a five-week progressive curriculum incorporating procedural training and game-based elements. By assessing learners' perceived improvements in clinical understanding, engagement, and satisfaction, we aimed to explore the feasibility and replicability of this model for other CME programs.

2.0 MATERIALS AND METHODS

2.1 Program Design and Framework

The Critical Care Month program design, initiated in May 2025, involved collaborative discussions with emergency medicine lecturers and postgraduate trainees. The development team identified five core critical care topics, aligning intended learning outcomes with higher Bloom's Taxonomy levels for both cognitive and psychomotor domains (Anderson & Krathwohl, 2001). These outcomes aligned with the postgraduate curriculum's critical care modules, which emphasized airway management, ventilatory support, and emergency resuscitation skills (Figure 1).

To support these outcomes, we adopted the Technological Pedagogical Content Knowledge (TPACK) framework, integrating content, pedagogy, and educational technology (Mishra & Koehler, 2006) (Figure 2). The program progressively builds from foundational knowledge to application and synthesis through immersive, learner-centered activities. Pedagogical strategies were selected first to align with experiential and learner-centered principles, after which digital tools were chosen iteratively to support pedagogical intent rather than determine program structure.

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Within this framework, Kahoot was used as a formative gamification tool during selected sessions to reinforce key concepts, facilitate team-based competition, and provide real-time feedback, particularly during ECG interpretation and procedural review activities.

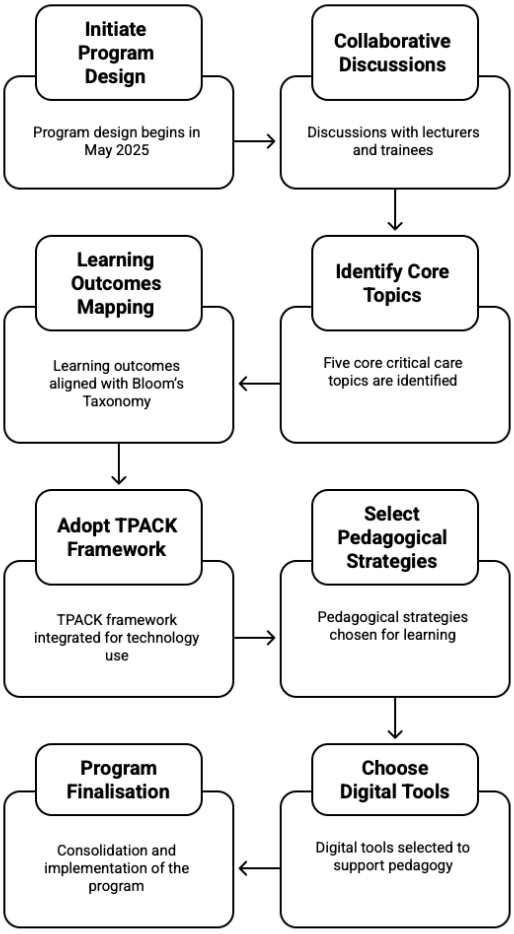

Figure 1: Critical care month program design

2.2 Weekly Modular Structure

The five-week program was conducted in July 2025, with each weekly module consisting of a four-hour face-to-face session. Each session layered learning across four components: didactic teaching, procedural skills stations, digital interactive tools, and gamified elements (Table 1). The progressive modular format aimed to scaffold knowledge and skills through increasingly complex clinical challenges.

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Structured for cost-efficiency, the program leveraged in-house expertise, reusable materials, and low-cost simulation strategies, minimizing expenditure without compromising educational quality. The five-week program cost RM1,050, significantly less than conventional immersive CME modules that often rely on commercial simulation centres and external facilitators.

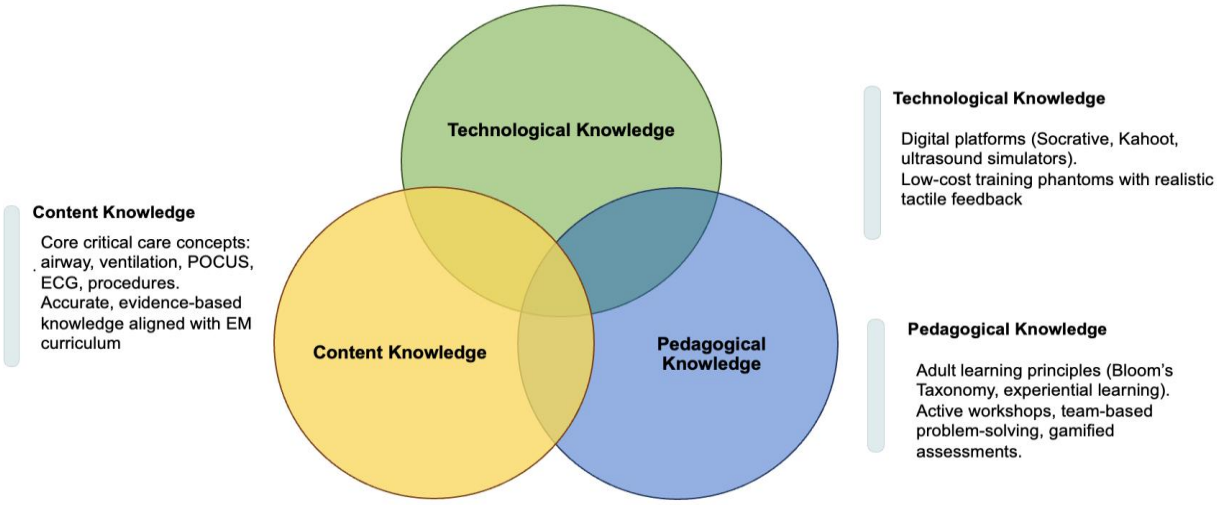

Figure 2: Technological Pedagogical Content Knowledge (TPACK) framework

2.3 Gamification Strategies and Capstone Challenge

To enhance learner engagement and create a high-impact critical care curriculum, gamification strategies were embedded across multiple weeks. These strategies motivated participants, deepened their learning, and interactively replicated the high-pressure dynamics of clinical practice.

In Weeks 3 and 4, the procedural skill workshops evolved into competitive team-based stations with quizzes and puzzles. Participants engaged in time-bound challenges, applying procedural knowledge rapidly and accurately. Points were awarded for task completion and teamwork, with live scoring and instant feedback. These elements instilled urgency and reinforced core procedural competencies (e.g., intraosseous access, central venous catheter insertion, pericardiocentesis) using low-cost, self-constructed phantoms.

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Table 1: *Critical Care Month Learning Components*

WEEK	CRITICAL CARE THEME	KEY ACTIVITIES	LEARNING OBJECTIVES	LEARNING COMPONENTS
1	Airway and Ventilation	SALAD trainers, NIV, cricothyrotomy	Apply appropriate critical airway interventions in emergency scenarios	
2	Point of care ultrasound	Bedside ultrasound scanning, image interpretation	Integrate POCUS into clinical decision-making by analyzing anatomical images and interpreting pathological findings	
3	Electrocardiogram interpretation	Competitive team challenges, hands on workshop	Interpret high-risk ECG patterns, differentiate life-threatening features,	
4	Critical care procedures	Procedural sedation, custom phantom, pericardiocentesis, central line insertion, intraosseous access	Demonstrate procedural competency in life-saving techniques by evaluating indications, contraindications, and complications.	
5	Explorace escape room style challenge	Escape room simulation requiring clinical decision making under pressure	Synthesize knowledge, prioritize clinical interventions, and collaboratively design effective strategies to manage critically ill patients in high-stress, time-constrained scenarios	

Didactic teaching Procedural skill station Gamified learning

The final week featured the most elaborate gamified experience: a team-based clinical exploration challenge, styled as an adventurous escape-room journey. This hospital quest guided teams with sequential clinical clues across various stations, each simulating an emergency scenario. This quest-like structure added a narrative layer, reinforcing motivation and engagement.

Each station featured a 20-minute escape-room style challenge. Tasks included rapidly initiating non-invasive ventilation (NIV) for a simulated patient, interpreting 30 critical ECGs within a limited time (testing speed and diagnostic accuracy), choosing the correct medication for sedation, and integrating POCUS into clinical scenarios. The POCUS challenge involved a team member acting out an ultrasound finding (e.g., right ventricular strain) for teammates to diagnose, encouraging peer-led interaction and diagnostic reasoning. The sedation stations incorporated a gamified sedation-themed puzzle, where participants had to unlock sequential boxes by correctly answering sub-questions, culminating in a Morse code challenge that reinforced clinical reasoning under pressure. The last station tested leadership and communication, requiring the team leader to guide blindfolded members through a hands-on task, reinforcing clarity and collaboration in high-stress environments.

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Gamification elements, including team selection, strategy development, time pressure, and a coin-based reward system, were embedded into every level of the challenge (Figure 3). This structure created a psychologically safe, yet stimulating, environment that promoted collaboration, problem-solving, and applied learning. The blend of procedural realism and gamified engagement allowed participants to synthesize knowledge, practice decision-making, and reinforce skills in a format mirroring real-world EM, fostering adventure and collaboration.

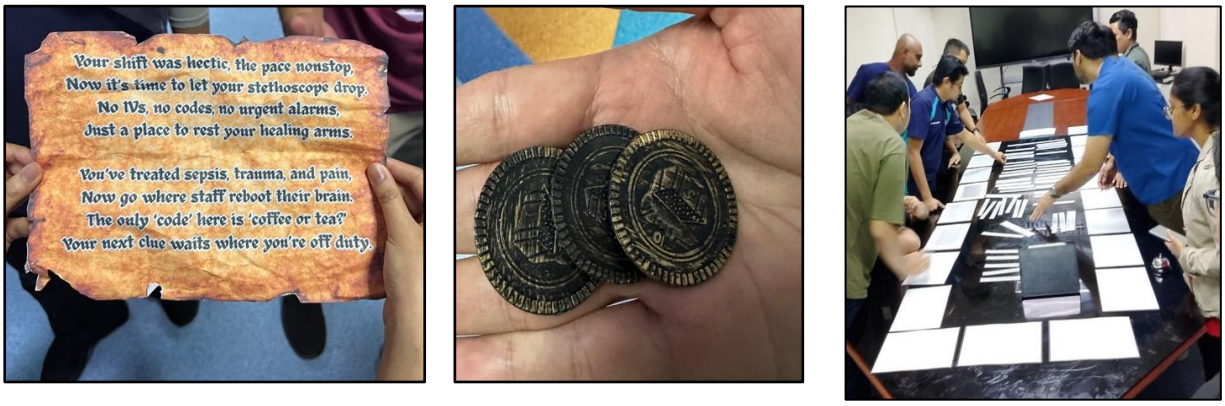

Figure 3: Gamification strategies with sequential clues, coin-based reward system, and team strategy

2.4 Evaluation

Program evaluation involved structured participant feedback through a standardized Google Form survey administered at the conclusion of the five-week CME program. The survey included both quantitative and qualitative items that comprised three main sections: participant background and attendance, session-specific evaluation, and overall program experience. The survey comprised quantitative and qualitative components. Quantitative items used a five-point Likert scale (1 = strongly disagree to 5 = strongly agree) and were structured around session-specific domains assessing perceived knowledge gain (“I gained new knowledge”), confidence improvement (“My confidence improved”), and perceived usefulness for clinical practice (“This session was useful in practice”) across all five weekly modules. Additional Likert-scale items evaluated overall programme organisation, engagement, and perceived enhancement of critical care understanding.

Open-ended questions explored perceived benefits, anticipated changes in clinical practice, and suggestions for programme improvement. Participants also indicated whether they

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would recommend the programme to colleagues and whether the CME should be repeated, providing global indicators of acceptability and perceived value.

3.0 RESULTS AND DISCUSSION

A total of 30 EM postgraduate trainees participated in the five-week Critical Care Month program. Feedback was collected using structured Google Forms with five-point Likert scale items (1 = strongly disagree to 5 = strongly agree), focusing on three domains: content relevance, session engagement, and perceived improvement in understanding of critical care.

The overall response was highly positive. Attendance rates progressively increased throughout the five-week program, rising from 55.2% in Week 2 to 89% in Week 5. Among the 30 respondents, attendance varied due to clinical service commitments. Feedback analysis included all respondents regardless of full program completion and reflects overall learner perceptions rather than differential attendance effects.

The mean rating for relevance of the content was 4.63 $\pm$ 0.81, indicating strong agreement among participants that the sessions addressed critical clinical areas. Session engagement was rated at a mean of 4.6 $\pm$ 0.81, suggesting that the interactive and multimodal delivery was well received. Likewise, the perceived improvement in clinical understanding scored a mean of 4.51 ± 0.81, reflecting the program's effectiveness in reinforcing core critical care concepts. Notably, 100% of respondents agreed that the program should be repeated and recommended its continuation for future cohorts.

Open-ended feedback further emphasized the program's practical impact. The gamified, escape-room–style team challenge assessment was cited as a highlight, offering a high-engagement opportunity to apply clinical knowledge, teamwork, and decision-making under time constraints. Trainees also reported improved competency in critical care skills procedures such as airway management, ultrasound-guided line placement, and pericardiocentesis.

These findings indicate that the critical care CME effectively met its objectives of delivering structured, multimodal learning with high perceived educational value, practical relevance, and learner satisfaction.

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3.1 Progressive Learning Implementation: What We Learned

Our experience demonstrated suggested that gradually introducing gamification elements may be more acceptable to learners than implementing them all at once. This observation is supported by increasing attendance trends and qualitative feedback, although causal conclusions cannot be established from this evaluation alone. This progressive approach aligns with recent evidence suggesting careful timing of competitive elements is crucial for gamification success, as immediate implementation may overwhelm learners (Kirsch & Spreckelsen, 2023). The immersive, structured CCM program design enriched EM trainees' educational experience by replicating real-life emergency environments and offering additional learning values. It enabled trainees to make time-sensitive decisions, collaborate under pressure, and perform life-saving procedures often underemphasized in traditional lecture-based CME.

Didactic lectures and faculty-led hands-on training in weeks 1 and 2 allowed trainees to build confidence before competitive challenges. Faculty refers to consultant emergency physicians and academic lecturers involved in teaching, facilitation, and supervision during the program. The program adopted a layered learning approach, strategically scaffolding content across five weeks. For example, ECG interpretation was first taught through short lectures, reinforced with quizzes, and finally applied in simulated team-based scenarios. This structured layering facilitated the progressive mastery and integration of skills, consistent with adult learning principles that emphasize building complexity over time (Kolb, 2014; Xu et al., 2023).

By week 5, trainees fully engaged in the high-pressure escape room scenario. This progression was reflected in attendance data, which showed increasing engagement from week 2 to the final challenge, demonstrating that strategic progression enhances participants' motivation and readiness for complex scenarios. This pattern supports emerging research indicating that the introduction of systematic gamification enhances rather than hinders educational engagement (Wang et al., 2024). The progressive engagement increase also suggests this approach can address common challenges in postgraduate medical education, where maintaining learner motivation remains a persistent concern (Prober & Heath, 2012; Koshova, Horachuk & Pishchykov, 2018).

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3.2 Creating an Immersive Learning Environment

One of the program's primary strengths was the creation of an immersive learning ecosystem. It supported multi-sensory engagement where trainees not only listened to theoretical content but also engaged visually, tactilely, and kinesthetically. For instance, the pericardiocentesis session combined demonstration, guided instruction, and hands-on practice using a self-constructed phantom heart model. Such active participation promotes greater engagement and memory retention.

Additionally, authentic clinical simulation fostered stress inoculation. In the final week, the escape-room–style challenge recreated the urgency of emergency scenarios. Teams solved clinical problems under strict time limits, reinforcing the need for rapid decision-making and adaptive teamwork. These experiences closely mimic actual emergency department dynamics, building confidence for real clinical situations. This approach aligns with recent systematic reviews demonstrating escape room formats show significant educational promise in healthcare, particularly for developing clinical reasoning skills under pressure (Quek et al., 2024).

3.3 Cost-Effective Innovation in Medical Education

A key program innovation was the use of cost-effective simulation tools. Instead of commercial simulators, the team constructed procedural phantoms using affordable materials, such as gelatin and chicken breast. These models replicated realistic tactile feedback for central line insertion and pericardiocentesis. For example, gelatin models with water pockets allowed trainees to practice pericardial fluid aspiration (Figure 4).

Using readily available materials, we provided tactile learning experiences that would otherwise require expensive commercial equipment, making this approach replicable for programs with limited budgets. This innovation made the training impactful and scalable to other institutions with limited resources. This approach demonstrates that utilizing cost-effective alternatives or innovations for educational activities does not compromise learning effectiveness and is more feasible in financially constrained settings (Irfanullah et al., 2023; Xu et al., 2023).

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Figure 4: Procedural self-made phantom models

3.4 Peer-Led Learning and Collaborative Education

Collaborative learning was also a core feature. Senior trainees leading skill stations created several unexpected benefits. In every session, teams worked together to analyse cases, set ventilators, or perform procedures. This process built clinical acumen, communication, leadership, and peer-learning skills, aligning with essential non-technical competencies essential in emergency care.

Junior trainees seemed more comfortable asking questions of their peers rather than the faculty. Senior trainees reinforced knowledge by teaching others, while lecturers' workload decreased without compromising educational quality. This peer-teaching model is easily replicable in other departments with minimal additional resources, Figure 5. These observations align with established evidence supporting peer-assisted learning in clinical education, where horizontal learning relationships often facilitate more open communication and knowledge exchange (Glynn et al., 2006; Secomb, 2008).

Figure 5: Peer-led stations

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3.5 Gamification Elements: Understanding What Motivated Learners

The competitive elements, namely team challenges, leaderboards, and time pressure, generated genuine enthusiasm among participants. However, our experience showed that timing their introduction was crucial. During the final gamified challenge, each station corresponded to progressively more complex cognitive tasks, ranging from remembering and understanding to applying, analyzing, evaluating, and creating. Participants recalled ECG findings, explained their interpretations, applied knowledge to interventions, analyzed cases, prioritized assessments, and developed strategic team responses.

Gamification introduced motivational elements that are not present in traditional CME. Team-based structures fostered peer accountability, whereby participants prepared more thoroughly to support their teammates. Time pressure simulated authentic clinical urgency, making learning immediately relevant. We also observed trainees taking intellectual ownership of the educational process. Early gamification might have overwhelmed participants, but by week 3, student teams had taken greater ownership of the sessions, collaborating with faculty to design scenarios that appropriately challenged their colleagues. This shift from passive recipients to active educational designers represents a fundamental change in learning activity.

Our systematic progression from foundational learning to complete gamification reflects emerging best practices in medical education gamification design, where key elements like progressive challenge, peer collaboration, and authentic assessment are crucial for educational success (Wang et al., 2024). Recent reviews have identified that clinical reasoning is well-suited to gamification approaches, supporting our focus on critical care scenarios that require rapid decision-making and collaborative problem-solving (Quek et al., 2024; Lee et al., 2025). The final explorace created a sense of achievement and team bonding rarely achieved by traditional CME sessions, as evidenced by peak attendance and positive student feedback.

3.6 Implementation Insights for Other Programs

Several factors contributed to program success, which other departments could consider. These factors include flexible attendance policies accommodating clinical schedules; 4-hour sessions provided sufficient time for meaningful engagement without overwhelming participants; and voluntary participation ensured intrinsic motivation. The modular design allows institutions to

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adopt individual components or the complete five-week structure based on available resources and curriculum constraints.

Our approach demonstrates that meaningful educational innovation can be achieved through creative resource utilization rather than substantial financial investment. The systematic progression provides a replicable template adaptable across medical specialties while maintaining core pedagogical principles. This framework addresses the need for accessible, scalable educational innovations in medical training (Gentry et al., 2019).

3.7 Limitations and Future Directions

While encouraging, our single-institution experience with voluntary participation limits the generalizability of our findings. The evaluation focused on satisfaction and engagement, not formal learning outcomes or long-term retention. Future implementations would benefit from pre- and post-knowledge assessments, as well as longer-term follow-up for skill retention and clinical performance transfer. Despite these limitations, the universal endorsement and increased engagement suggest that this approach addresses common challenges in postgraduate medical education. Its cost-effectiveness, high satisfaction, and practical feasibility make this model particularly valuable for resource-constrained environments seeking innovative CME.

4.0 CONCLUSION

The Critical Care Month CME demonstrated positive learner perceptions of engagement, educational value, and acceptability of an immersive and gamified approach to critical care education for EM trainees. Participants reported perceived improvements in understanding, confidence, and relevance to clinical practice across core critical care domains, including airway management, POCUS, procedural skills, ECG interpretation, and team-based decision-making.

From a teaching and learning perspective, this study highlights the potential value of integrating progressive gamification, experiential learning, and low-cost simulation within postgraduate CME. The program provides an example of how aligning learning outcomes, pedagogy, and educational technology may support learner engagement without reliance on high-cost simulation infrastructure.

As outcomes were based on learner perceptions rather than objective performance measures, conclusions regarding educational impact should be interpreted cautiously. Nevertheless, the findings indicate that learners perceived a structured, multimodal CME

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approach as relevant and engaging in a high-acuity training context. This model offers practical considerations for postgraduate educators exploring scalable and resource-conscious strategies for CME delivery, particularly in settings with competing clinical demands.

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