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# Multidimensional pedagogical framework for interprofessional education: Blending classroom, high fidelity and extended reality simulation

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ABSTRACT

The growing complexity of healthcare systems and the imperative for collaborative practice underscore the pressing need to innovate interprofessional education. This paper presents a multidimensional pedagogical framework that integrates blended classroom-based learning, high-fidelity simulation (HFS), and AI-enhanced extended reality (XR) technologies to develop interprofessional competences and improve preparedness for emergency care. Grounded in socio-constructivist and student-centred educational theories, the approach combines theoretical knowledge acquisition with immersive and experiential learning environments that reflect the realities of clinical practice. HFS provides a controlled setting to cultivate critical thinking, decision-making, and collaborative skills. In parallel, AI-enhanced XR introduces adaptive, gamified scenarios that foster digital competence, emotional resilience, and situated cognition. Together, these elements form a cohesive educational strategy that prepares nursing, midwifery, and medical students for high-stakes clinical situations such as anaphylaxis and trauma care. The framework contributes to enhanced patient safety, learner engagement, and the cultivation of future-ready professionals. It also responds to international calls for digital transformation and innovation in healthcare education. By harmonising traditional teaching methods with emerging technologies, this framework offers a globally relevant, scalable solution for advancing interprofessional learning across diverse healthcare contexts.

## 1. Introduction

Across the globe, healthcare systems are struggling with increased complexity, heightened patient acuity, and critical workforce shortages. Nowhere is this more evident than in emergency and acute care settings, where healthcare professionals must act swiftly, collaboratively, and competently under pressure. However, a growing concern among nursing, midwifery, and healthcare education communities is that traditional, discipline-specific pedagogical approaches no longer equip students with the practical and interprofessional competences required to meet these demands. This educational gap poses serious implications for patient safety, healthcare team effectiveness, and the preparedness of future professionals to respond to emergent care situations.

At the heart of this issue lies the inadequacy of conventional didactic methods to develop integrated skills in critical thinking, communication, and team-based decision-making (Ropponen et al., 2025). Particularly in acute scenarios, such as anaphylaxis or trauma, learners must not only master clinical protocols but also seamlessly collaborate across disciplines (Guraya, 2024). The increasing integration of high-fidelity simulation (HFS) and extended reality (XR), including AI-enhanced

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virtual scenarios, offers an urgent and promising opportunity to modernise educational practices. Rather than a report of empirical research, this manuscript puts forward an actionable pedagogical framework with global applicability, one that responds directly to the educational shortcomings currently facing healthcare systems worldwide.

### 1.1. Rationale for multidimensional education in interprofessional education

Preparing students for high-stakes clinical settings requires more than one teaching method. A multidimensional approach, blending classroom learning, HFS, and XR, reflects the complexity of real healthcare environments and supports theoretical, practical, and interprofessional competence. Liaw et al. (2019) highlight the importance of sequencing: beginning with theory, followed by immersive and reflective simulation to support deeper learning and collaboration.

Managing anaphylactic shock illustrates this approach. Classroom sessions cover protocols and physiology; HFS enables practice in pressured settings; XR adds repeatable, adaptive scenarios to refine clinical reasoning and digital competence (Radianti et al., 2020). XR also delivers AI-driven feedback, personalising learning and supporting self-regulation (Gentry et al., 2019; Ropponen et al., 2025). Though XR incurs equipment and licensing costs, ongoing developments promise broader access and ease of use. Liaw et al. (2020) emphasise XR's value, especially where traditional simulation is limited.

Rather than proposing a radical overhaul, this framework invites educators to rebalance their curricula. The emphasis is on integration, not substitution—using each modality purposefully to engage learners in dynamic, team-oriented, and technology-enhanced contexts. It is a pragmatic step toward equipping healthcare students for the unpredictable and collaborative realities they will face.

This approach does not seek to replace clinical placements or traditional instruction but to enhance them. By merging the strengths of multiple pedagogical strategies, it aims to support deeper engagement, more confident performance, and greater preparedness for modern interprofessional practice.

### 1.2. Educational theories and methods to support student-centred learning in multidimensional pedagogical framework

#### 1.2.1. Blended classroom learning

Blended classroom-based education in the proposed multidimensional pedagogical framework emphasises a socio-constructive, interprofessional learning approach (see Table 1). Rooted in constructivist theory, this pedagogical method views learning as an active, collaborative process where students build their understanding through interaction and reflection (Vygotsky, 1978). We recognise that interdisciplinary classroom settings remain the exception rather than the norm, but in larger institutions, co-taught modules, curriculum alignment, and shared simulation or case-based learning sessions offer feasible strategies for fostering interprofessional engagement. A blended classroom combines traditional face-to-face instruction with interactive, student-centred activities such as group work, workshops, and self-directed learning, often supported by digital tools. A blended learning model maximises engagement and knowledge retention, combining traditional lectures with interactive workshops and independent study. Lectures provide a structured foundation of theoretical knowledge, while workshops encourage hands-on problem-solving and peer discussion. Independent learning allows students to explore learning material at their own pace, fostering self-regulation and more profound understanding (Zimmerman, 2002). This multifaceted approach ensures that classroom instruction incorporates interactive and knowledge-based learning, preparing learners for more complex, real-world situations.

Foundational knowledge is strengthened as students understand human physiology, clinical protocols, and the theoretical frameworks underpinning acute care practices like managing anaphylaxis. Interprofessional care is enhanced through activities that require collaboration and communication among students from diverse healthcare disciplines, mirroring the dynamics of real-world healthcare teams. Additionally, the blended learning model promotes the theoretical application of knowledge, equipping students to translate abstract concepts into practical decision-making processes. These competences collectively prepare students to excel in acute care settings, fostering self-confidence and proficiency in their roles.

#### 1.2.2. High fidelity simulation

HFS is a cornerstone of healthcare education, particularly in acute care scenarios, offering a simulation environment where students can practice and refine critical skills in a standardised setting (Liaw et al., 2024; see Table 1). This method bridges the gap between theoretical knowledge and real-world clinical application, grounded in experiential learning theory (Kolb, 1984) and the critical thinking framework (Paul and Elder, 2019). Simulation emphasises hands-on learning, reflection, and decision-making, creating a synergy between active engagement and cognitive development. Teaching strategies such as the prebriefing-scenario-debriefing model and interprofessional team-based learning operationalise these theories, ensuring that simulations are impactful and aligned with the demands of clinical practice. Kolb's experiential learning cycle—concrete experience, reflection, conceptualisation, and experimentation—aligns closely with HFS, where students apply theory in realistic scenarios and refine practice through guided debriefing (Kolb, 1984). HFSs provide a concrete experience by engaging learners in realistic scenarios to assess patient conditions, prioritise procedures, and collaborate with peers. The subsequent debriefing phase supports reflective observation, enabling students to analyse their actions, identify strengths and weaknesses, and connect their experiences to broader clinical concepts. This process encourages abstract conceptualisation, where learners extract key insights, which they then apply in future simulations or clinical practice, completing the cycle.

The critical thinking framework complements experiential learning by challenging students to engage in purposeful, evidence-based reasoning during simulations. High-fidelity scenarios replicate the

**Table 1**
Pedagogical framework to support multidimensional education.

| Component | Pedagogical theory | Teaching method | Core competences |
|---|---|---|---|
| Classroom learning | Socio-constructive, interprofessional | Blended learning (lectures, workshops, case discussions, independent tasks) | Foundational knowledge, interprofessional care, theoretical application |
| High-fidelity simulation | Experiential learning (Kolb's cycle), critical thinking framework | Prebriefing-scenario-debriefing, interprofessional team-based learning | Patient communication, clinical reasoning, problem-solving, decision-making, critical thinking, collaboration, clinical leadership, stress management, technical skills |
| XR simulation | Self-regulated learning, socially regulated learning, situated cognition, immersive learning, flexible learning | Scenario-based learning, gamification, AI-driven patients and mentors | High-fidelity core competences<br><br>In addition: digital competence, adaptive learning, self-regulation, real-time feedback |

complexity of acute care settings, requiring learners to evaluate data, prioritise decisions, and adapt to dynamic situations. Through guided reflection during debriefing, students refine their cognitive and problem-solving skills, aligning with Paul and Elder's (2019) emphasis on disciplined thinking as a foundation for effective decision-making.

Teaching methods play a pivotal role in operationalising these theoretical foundations. The prebriefing-scenario-debriefing model structures the learning experience into three distinct phases, consistent with the INACSL Healthcare Simulation Standards of Best Practice™ (INACSL, n.d.). Prebriefing includes preparation (objectives and materials) and briefing (psychological safety and orientation). The scenario phase immerses students in a realistic, high-fidelity setting that supports active skill application and decision-making under pressure. Debriefing is central to simulation-based education, supporting reflection, analysis, and learning consolidation (INACSL, n.d.).

Interprofessional team-based simulations further strengthen the learning process by replicating the collaborative dynamics of clinical practice. Acute care settings demand not only clinical reasoning but also seamless coordination across disciplines; this format provides a psychologically safe space for learners to develop and refine communication, shared decision-making, and mutual respect. By integrating experiential learning, critical thinking, and updated best practices in simulation, this approach fosters confidence, adaptability, and competence in high-stakes, team-oriented environments.

This approach enhances several key competences vital for effective performance in acute care settings. Patient communication is developed as students practice delivering clear, empathetic, and contextually appropriate information to patients and their families during high-stakes scenarios. Clinical reasoning and decision-making are sharpened through interactive engagement with complex, realistic cases, requiring students to analyse information, prioritise actions, and implement evidence-based interventions. The interprofessional format promotes understanding of team dynamics, leadership, and shared decision-making. Additionally, exposure to high-pressure environments improves stress management, equipping students with the emotional regulation skills necessary to maintain focus and perform efficiently in demanding situations.

#### *1.2.3. Extended reality (XR) simulation*

XR simulation transforms healthcare education by offering immersive, adaptive environments that integrate pedagogy with innovative methods, enhancing learner engagement and clinical decision-making (Ropponen et al., 2025). By integrating self-regulated learning theory, socially shared regulation of learning, the trigger regulation framework, situated cognition theory, immersive learning theory, and flexible learning. XR simulation creates a comprehensive and multidimensional educational experience. Teaching strategies, such as scenario-based XR learning, gamification, AI-driven virtual patients and mentors, and competence-based training, operationalise these theories, creating a synergy that enhances both technical skills and cognitive development.

At the heart of XR simulation is a self-regulated learning theory (SRL), which empowers students to take ownership of their education. XR environments enable goal-setting, progress tracking, and reflection, fostering autonomy and motivation (Zimmerman, 2002). The interactive nature of XR enables students to repeat scenarios, experiment with different approaches, and learn from mistakes, reinforcing self-directed learning behaviours. This autonomy is further supported by AI-driven virtual mentors, who provide real-time feedback and guidance, helping students refine their skills and strategies based on immediate performance insights (Gentry et al., 2019).

Furthermore, when working with a team, socially regulated learning (SSRL) emphasises the co-regulation of learning processes within collaborative settings, where individuals work together to achieve shared goals through mutual regulation of cognition, motivation, and behaviour (Järvelä et al., 2024). In the context of XR simulation, SSRL is particularly relevant as learners engage in interprofessional or team-based scenarios that mirror real-world healthcare environments. XR's immersive and interactive features allow learners to navigate complex scenarios, requiring coordination, shared decision-making, and adaptive responses to dynamic challenges. This collaborative regulation enhances critical thinking and teamwork, fostering the development of both individual and collective competences. XR environments facilitate SRL and SSRL through feedback, peer interaction, and adaptive tools that support collaborative problem-solving (Järvelä et al., 2024; Mikkonen et al., 2024). Moreover, simulating high-stakes scenarios in a psychologically safe space enables learners to experiment with different strategies, reflect on group dynamics, and develop shared regulatory practices, preparing them for the complexities of professional collaboration in acute care settings (Johnson-Glenberg, 2018). Additionally, XR simulation allows an ethically safe learning without exposing actual patients to various risks.

The trigger regulation framework (Järvelä et al., 2024) complements self-regulated learning by managing emotional and cognitive responses during challenging scenarios. This framework emphasises the importance of identifying and responding to internal and external triggers, such as emotional stress, uncertainty, or task complexity, that can either hinder or enhance learning. By recognising these triggers in real time, learners can consciously regulate their engagement, motivation, and strategies, thereby improving performance and resilience in high-stakes settings. XR simulation immerses students in realistic clinical situations that evoke emotional stress, such as managing a deteriorating patient. By repeatedly engaging with these scenarios, learners develop resilience and the ability to regulate their responses, essential traits for high-stakes clinical environments. Methods like gamification support this process by transforming these challenges into game-like tasks, where learners are rewarded for perseverance and success, fostering engagement and stress regulation (Hamari et al., 2014, see Table 2).

Situated cognition theory underscores the importance of learning in authentic contexts. XR simulation excels in this regard, placing students in lifelike clinical settings where they can apply theoretical knowledge to real-world problems. Through scenario-based XR learning, students engage in structured, interactive clinical cases that mirror the complexities of healthcare practice. This method ensures that learning is contextually relevant and immediately transferable to clinical settings, bridging the gap between classroom knowledge and practical application (Lave and Wenger, 1991).

Finally, immersive learning theory and flexible learning highlight the role of engagement and sensory immersion in enhancing retention and skill acquisition in their own time and place. XR environments provide rich, interactive experiences that captivate learners, enabling them to practice procedural and cognitive skills until mastery is

**Table 2**
Summary of key theoretical frameworks supporting XR simulation.

| Framework | Key Concept | Relevance to XR Simulation |
|---|---|---|
| Self-Regulated Learning (Zimmerman, 2002) | Learners plan, monitor, and evaluate their own learning. | Supports goal-setting, self-monitoring, and reflective practice in individual scenarios. |
| Socially Shared Regulation of Learning (Järvelä et al., 2024) | Regulation of learning as a shared, collaborative process. | Encourages co-regulation in team-based XR scenarios to build interprofessional competence. |
| Trigger Regulation Framework (Järvelä et al., 2024) | Managing responses to emotional, cognitive, or situational triggers during learning tasks. | Prepares learners to regulate stress and adapt under pressure in realistic XR simulations. |
| Immersive Learning Theory (Johnson-Glenberg, 2018) | Engagement is enhanced through multi-sensory, embodied experiences. | Enhances realism and emotional connection, reinforcing deeper learning. |
| Gamification (Hamari et al., 2014) | Game elements promote engagement, motivation, and feedback. | Encourages repetition, stress tolerance, and self-improvement through feedback loops. |

achieved repeatedly. The competence-based training approach within XR simulation reinforces this by setting clear benchmarks for student performance, ensuring learners are fully prepared for clinical challenges before advancing (Radianti et al., 2020; Liaw et al., 2022). XR enhance flexible learning by providing immersive, self-paced, and accessible training experiences that align with individual learners' personal and professional commitments.

The synergy between these theories and methods makes XR simulation a powerful tool in healthcare education. Self-regulated learning, SRL, and AI-driven mentors promote autonomy and adaptive learning while trigger regulation and gamification enhance resilience and collaborative engagement. Similarly, situated cognition and scenario-based learning ensure that knowledge and skills are developed in meaningful, context-rich environments, and immersive learning ensures deep engagement and mastery through repeated practice. Together, these elements position XR simulation as an innovative and effective approach to preparing students for the demands of modern healthcare. By integrating these pedagogical theories and teaching strategies, XR simulation builds technical competence and develops critical thinking, emotional regulation, and adaptability—key attributes for success in complex clinical settings.

This approach cultivates a range of advanced competences essential for navigating modern healthcare challenges. Digital competence is enhanced as students engage with cutting-edge XR technologies, fostering familiarity with virtual tools and adaptive learning environments. Adaptive learning is supported through exposure to dynamic scenarios that require learners to adjust their strategies in response to evolving situations. Critical thinking is developed as students analyse complex clinical cases, make evidence-based decisions, and reflect on outcomes. Self-regulation is promoted through the self-directed nature of XR simulations, allowing learners to set goals, monitor progress, refine their performance and take responsibility for learning. Real-time feedback provided by AI-driven mentors in student-friendly manner further enhances learning efficiency, enabling students to promptly identify and address gaps in their knowledge and skills. These competences prepare students to excel in increasingly technology-driven and adaptive healthcare environments.

### *1.3. Designing a curriculum using multidimensional pedagogical framework*

We propose a curriculum that blends multidimensional pedagogical methods to better prepare healthcare students for managing acute emergencies such as anaphylaxis (Höfer et al., 2024). Such a case was selected because practising such situations with real patients is not feasible, and when they occur, healthcare students may experience freeze or flight reactions (Einloft et al., 2024). It combines classroom learning, HFS, and XR simulation to bridge the theoretical knowledge and practical application gap. It provides a practical tool for educators to combine teaching methods to achieve learning outcomes and competence development of future healthcare professionals (see Table 3, Fig. 1).

The classroom component builds foundational knowledge in anatomy, physiology, emergency protocols, and team roles through lectures, interactive workshops, and independent tasks. HFS provides a controlled, realistic environment where students develop core competences such as clinical reasoning, decision-making, interprofessional collaboration, and team leadership. Finally, the XR simulation enhances learning with immersive, scenario-based experiences, emphasising digital competence, adaptive thinking, and self-regulation, allowing students to refine their skills and build confidence in high-pressure scenarios. Together, these components create a comprehensive student-centred learning pathway that aligns theoretical understanding with practical, real-world demands and technological progress in education and society. Implementing a comprehensive pedagogical framework not only prepares highly competent healthcare professionals but also enhances future patient safety.

## 2. Implications and future directions

Integrating XR and AI into healthcare education offers considerable promise—but not without complications. While immersive technologies are gaining traction as alternatives to traditional clinical training (Radianti et al., 2020; Ropponen et al., 2025), they must be applied with pedagogical intention. Human learning is inherently complex; acquiring

**Table 3**
Curriculum design for managing anaphylactic shock.

| Component | Objective to reach core competences | Content/ Scenario | Teaching Methods | Assessment | Outcome | Advantages |
|---|---|---|---|---|---|---|
| Blended classroom learning | Build foundational knowledge in an inter-professional care setting and gain theoretical knowledge for skills application | -Anatomy, physiology, and pathophysiology of anaphylaxis<br>-Steps of emergency management (ABCDE, epinephrine, patient monitoring)<br>-Team roles in acute and emergency care | - Lectures<br>- Interactive workshops<br>- Case discussions<br>-Independent tasks | - Written test or quiz on protocols and teamwork concepts (Multiple-choice questions) | Students demonstrate basic knowledge, know protocols, and recognise the significance of interprofessional teamwork. | Interactive discussions by gaining new knowledge, collaborative learning and building understanding on new concepts |
| High-fidelity simulation | Apply theoretical knowledge in a controlled environment with the development of patient communication, clinical reasoning, decision-making, collaboration and stress management | -Simulated situation of anaphylaxis in a realistic, high-pressure scenario<br>-Realistic symptoms and need for immediate intervention | - Prebriefing<br>- Simulation with a high-fidelity mannequin or actor in an inter-professional team<br>- Structured debriefing | -Performance checklist on protocols, communication, and teamwork<br>-Teacher observation, peer evaluation, self-evaluation<br>- Observed evaluation | Students demonstrate technical skills, clinical reasoning, and effective interprofessional communication under pressure. | Allows students to repeat practice of anaphylactic shock to reach proficiency |
| XR simulation | Refine and expand practical skills through immersive learning with the development of digital competence and critical thinking, and self-regulation and adaptation in stressful learning situations. | -Virtual patient experiencing anaphylaxis<br>-Branching scenarios with real-time vitals and dynamic symptoms<br>-Adaptive challenges for decision-making | - Scenario-based XR learning<br>- AI-driven feedback and gamification<br>- Opportunity for repetitive practice | - Analytics on decision-making, response times, and feedback | Students refine their skills, improve confidence in complex scenarios, and develop critical thinking, adaptability, and self-regulation. | High-fidelity advantages<br><br>In addition: adaptive evaluation, learning situation adjustment according to individual/ teams' needs. |

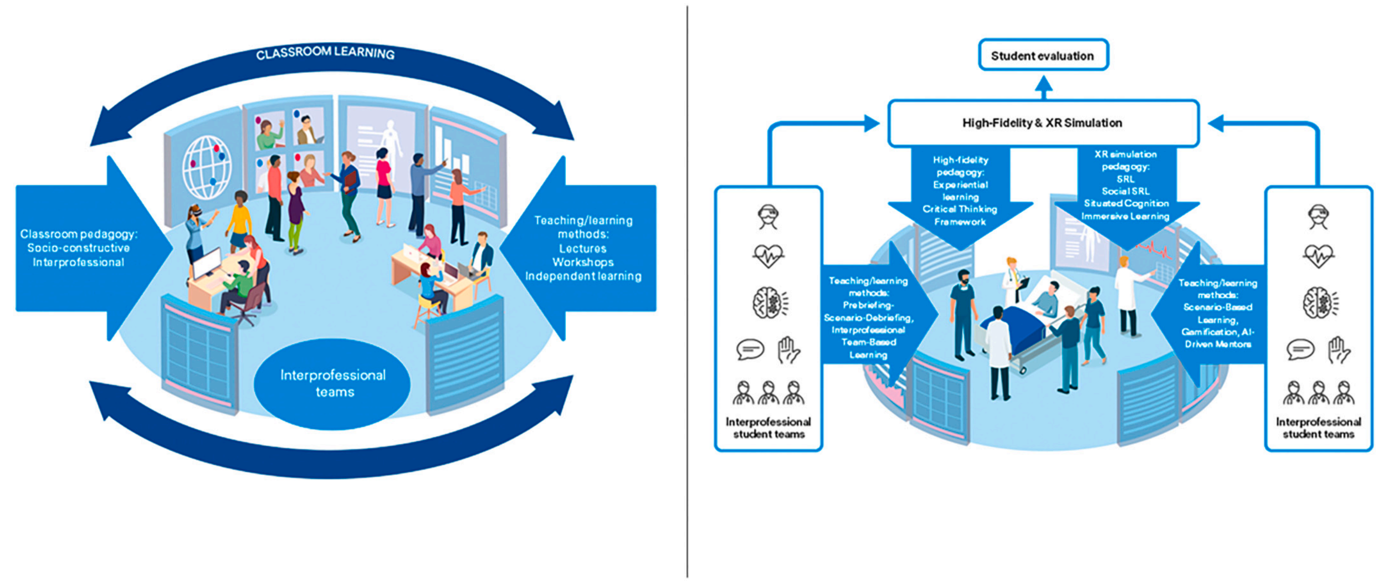


**Fig. 1.** Representation of classroom learning and High-Fidelity, XR simulation.

safe, competent practice cannot be rushed or fully outsourced to technology. Liaw et al. (2024) show that blended learning, rather than XR alone, best supports student transitions to clinical environments. Although some XR tools simulate clinical decision-making effectively, they should not be mistaken for replacements for real patient encounters. We are not suggesting the replacement of clinical experiences, but rather proposing a balanced integration where XR and HFS serve as preparatory and supplementary tools, particularly valuable when clinical placements are limited or when patient safety concerns restrict student exposure. Instead, their strength lies in complementing hands-on experience, enhancing confidence, decision-making, and readiness while safeguarding patient safety. Educators face the dual task of integrating these tools meaningfully and avoiding the burden of uncritical tech adoption. Additionally, while HFS offers substantial pedagogical value, its integration can be limited by space, staffing, and resource constraints, particularly in large student cohorts. Recognising these challenges, the proposed framework underscores the importance of a blended approach, where classroom learning, HFS, and XR can be flexibly combined to ensure equitable and scalable learning opportunities. For example, a curriculum module on emergency response could be structured with: (1) foundational theory delivered in a blended classroom format, (2) skills rehearsed through HFS in small interprofessional teams, and (3) scenario repetition, reflection, and self-regulation supported by AI-enhanced XR environments. This layered structure allows students to build confidence, competence, and teamwork progressively before engaging with real patients.

While this framework is grounded in educational theory and informed by ongoing interdisciplinary collaboration, it remains conceptual and requires further piloting and evaluation. We recognise that feasibility will vary across institutions, particularly when considering large class sizes, faculty training limitations, and infrastructure costs. Successful implementation depends on institutional readiness, including investment in educator development, technical resources, and curriculum alignment. We do not propose this model as a one-size-fits-all solution but as a flexible, scalable approach that can be adapted incrementally. Additional research, including pilot testing and outcome measurement in areas such as clinical judgement and team collaboration, will be essential to validate its long-term effectiveness.

The multidimensional framework we propose can extend beyond anaphylaxis to a range of acute care scenarios. Interprofessional education must follow this lead, integrating simulation with collaborative practice to prepare teams for urgent, real-world challenges.

Global health issues, such as climate-related emergencies, workforce shortages, and care inequities, underscore the need for interprofessional collaboration (United Nations, n.d). Multidimensional learning aligns with the broader push for sustainable, cross-disciplinary solutions to complex problems. Preparing students to work beyond disciplinary boundaries is no longer aspirational; it is essential.

Looking forward, institutions must avoid passive tech adoption and instead invest in faculty training, curriculum redesign, and student co-creation. AI and XR should be integrated into curricula where they enhance, not replace, essential elements of learning. Future research should critically evaluate long-term impacts on competence and collaboration. Feedback loops between educators and learners will be vital for adapting the model to local and evolving needs.

Ultimately, innovation in healthcare education must be balanced, inclusive, and grounded in sound pedagogy. By integrating emerging technologies within a structured, interprofessional framework, we can prepare learners not only for today's complexities but for those still to come.


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## CRediT authorship contribution statement

**Mikkonen Kristina:** Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Liaw Sok Ying:** Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Spirgienė Lina:** Visualization, Methodology, Formal analysis, Data curation, Conceptualization, Writing – review & editing. **Subočius Andrėjus:** Writing – review & editing, Visualization, Methodology, Formal analysis, Data curation, Conceptualization. **Ignatavičius Povilas:** Writing – review & editing, Visualization, Formal analysis, Data curation, Conceptualization. **Blažauskas Tomas:** Writing – review & editing, Visualization, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Riklikienė Olga:** Writing – review & editing, Visualization, Resources, Project administration, Funding acquisition, Formal analysis, Data curation, Conceptualization.

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