From "nice-to-have" to "core pedagogy": repositioning simulations as assessment-integrated learning environments in higher education

De "algo deseable" a "pedagogía fundamental": reposicionando las simulaciones como entornos de aprendizaje integrados con la evaluación en la educación superior

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ABSTRACT. Simulation-based learning has become an increasingly significant component of higher education, offering immersive, authentic environments that support the development of skills. Yet despite their pedagogical promise, simulations remain underutilised due to limited and inconsistently designed assessment practices. Much of the existing literature highlights strong learner engagement and perceived benefits, but also reveals a persistent assessment gap in which simulation activities are evaluated through reflective writing or self-report rather than analytics and behavioural performance data. This conceptual paper argues that simulations can only realise their full educational potential when they are reframed as assessment-integrated learning environments, rather than enrichment tools. Drawing on experiential learning theory, authentic assessment, and learning analytics, the paper introduces the Assessment-Integrated Simulation Learning Cycle (AISLC) - a holistic model that aligns simulation design with learning outcomes, embeds performance measurement, incorporates authentic artefacts and reflective integration, and connects outputs to feedback and credentialing. By synthesising insights from simulation research, competency-based education, and emerging analytics frameworks, this paper advances a new conceptualisation of simulation-integrated assessment. The paper concludes by outlining limitations and proposing a research agenda to support empirical validation, cross-disciplinary learning, and the ethical use of simulation analytics in assessment.

RESUMEN. El aprendizaje basado en simulación se ha convertido en un componente cada vez más importante de la educación superior, ofreciendo entornos inmersivos y auténticos que apoyan el desarrollo de habilidades. Sin embargo, a pesar de su potencial pedagógico, las simulaciones siguen siendo infrautilizadas debido a prácticas de evaluación limitadas y con un diseño inconsistente. Gran parte de la literatura existente destaca la sólida participación del alumnado y los beneficios percibidos, pero también revela una persistente brecha en la evaluación, ya que las actividades de simulación se evalúan mediante la escritura reflexiva o el autoinforme, en lugar de análisis y datos de rendimiento conductual.
Este documento conceptual argumenta que las simulaciones solo pueden alcanzar su máximo potencial educativo cuando se replantean como entornos de aprendizaje integrados con la evaluación, en lugar de como herramientas de enriquecimiento. Basándose en la teoría del aprendizaje experiencial, la evaluación auténtica y el análisis del aprendizaje, el documento presenta el Ciclo de Aprendizaje de Simulación Integrado con la Evaluación (AISLC), un modelo holístico que alinea el diseño de la simulación con los resultados del aprendizaje, integra la medición del rendimiento, incorpora artefactos auténticos e integración reflexiva, y conecta los resultados con la retroalimentación y la acreditación. Al sintetizar los conocimientos de la investigación en simulación, la educación basada en competencias y los marcos analíticos emergentes, este artículo propone una nueva conceptualización de la evaluación integrada en simulación. El artículo concluye describiendo las limitaciones y proponiendo una agenda de investigación para apoyar la validación empírica, el aprendizaje interdisciplinario y el uso ético del análisis de simulación en la evaluación.

1. Introduction

Simulation-based learning has become an increasingly prominent feature of higher education, particularly in domains where authentic decision-making, problem-solving, and applied skills are central. Business schools, engineering programmes, and healthcare training environments have adopted simulations to provide experiential, practice-oriented learning opportunities that mirror the complexity of real organisational and operational settings (Faria et al., 2009; Gaba, 2004; Salas et al., 2009). The rise of digital platforms and technology-enhanced learning has further accelerated this trend, enabling simulations to move beyond simple scenario exercises to sophisticated, data-rich environments capable of modelling uncertainty, collaboration, and longitudinal strategic outcomes (De Freitas & Neumann, 2009; Schwob et al., 2020; Vlachopoulos & Makri, 2017).

Recent contributions show how these developments are being operationalised in concrete course designs, ranging from restructured business game modules focused on generic and specific competences (Gandolfi Castagnola, 2024) to simulation-based leadership and AI-supported training in virtual universities (García Cuevas & Cisneros del Toro, 2024).

Despite their widespread adoption and positive reception among learners and educators, simulations often remain positioned as supplementary pedagogical tools - valued for their engagement and novelty yet rarely embedded as core components of curriculum design or assessment strategy. Numerous studies have highlighted that simulations enhance motivation, engagement, and the perceived relevance of learning (Anderson & Lawton, 2009; Arroteia, 2024a; Avramenko et al., 2021).

However, such benefits are often superficial when simulations are detached from structured evaluation. As a result, the pedagogical potential of simulations is constrained: students may approach the activity with lower levels of seriousness or strategic intent, and educators may underutilise simulation data that could serve as evidence of performance, competency development, or reflective growth (Spector et al., 2016).

A central issue underpinning this marginalisation is the gap between assessment integration within the simulation environment. Assessment is well-established as a primary driver of student learning behaviour (Biggs & Tang, 2003; Boud & Falchikov, 2006). When a learning activity is not assessed - or when assessment relies solely on reflective writing that does not capture the complexity of performance within the simulation - students are less likely to engage deeply with the decision-making process, teamwork dynamics, or analytical reasoning that simulations require. Existing research also indicates an overreliance on subjective, self-reported outcomes, such as satisfaction or perceived competence, rather than performance metrics derived from the simulation environment itself (Faria et al., 2009; Tompson & Dass, 2000).

This conceptual paper argues that simulations can only realise their full pedagogical value when they are repositioned as assessment-integrated learning environments, capable of generating authentic, data-driven evidence of learning. By leveraging the rich data generated through simulated decisions, interactions, and outcomes, educators can create assessment frameworks that evaluate both process and outcome, incorporate learning analytics, and align simulation activity with programme-level learning outcomes. Such integration represents more than an incremental improvement: it reframes simulations as central mechanisms for developing and evidencing complex competencies. The purpose of this conceptual paper is therefore fourfold:

1. To review existing literature on simulation-based learning and assessment practices across higher education.
2. To identify gaps that limit the impact of simulations, particularly the absence of structured assessment frameworks.
3. To propose a conceptual model for assessment-driven simulation-based learning that integrates performance analytics, authentic assessment methods, and reflective components; and
4. To outline implications for educators, programme leaders, and simulation providers seeking to embed

simulations more meaningfully within curricula.

By advancing this argument, the paper contributes to ongoing debates in business education, experiential learning, and technology-enhanced learning about how to move simulations from peripheral enrichment activities toward central components of evidence-based, outcome-driven pedagogy.

2. Literature review

A substantial body of empirical research demonstrates that simulations support a range of desirable educational outcomes. Early foundational work by Faria et al. (2009) and Anderson and Lawton (2009) show that business simulations enhance cognitive engagement, strategic reasoning, and student motivation. More recent systematic reviews confirm that simulations improve conceptual understanding, critical thinking, and decision-making across disciplines (Vlachopoulos & Makri, 2017). These effects are attributable in part to simulations' alignment with experiential learning theory, which emphasises learning through action, reflection, and iterative experimentation (Okoli et al., 2019; Kolb, 2014; Musteen et al., 2018). Results from several studies reinforce these conclusions, documenting positive effects of simulators on academic performance, perceived learning, and the development of generic and managerial competences in Latin American and European higher education institutions (Gandolfi Castagnola, 2024).

Simulations also have strong affective benefits. They support motivation, psychological empowerment, and perceived self-efficacy, which are important foundations for behavioural engagement. Lean et al. (2006) found that students perceive simulations as more engaging and meaningful than traditional teaching methods, while Avramenko et al. (2021) showed that business simulations increase learners' sense of agency, autonomy, and confidence in decision-making. These findings resonate with broader research in management education showing that learning is enhanced when students take active roles in complex, realistic environments (Arroteia, 2024b; Arroteia et al., 2018; Salas et al., 2009).

A significant area of interest in simulation scholarship concerns the development of soft skills - particularly teamwork, communication, leadership, and negotiation. Simulation-based teamwork activities create structured opportunities for collaboration under time pressure and uncertainty, which has been shown to influence team processes and interpersonal skills (Gosen & Washbush, 2004). In business contexts, simulations allow students to practise interdependent decision-making in ways that closely resemble real organisational settings.

2.1. Experiential Learning and Simulated Environments

The most frequently cited theoretical foundation for simulation-based learning is Kolb's Experiential Learning Theory, which conceptualises learning as a cyclical process involving four interconnected modes: concrete experience, reflective observation, abstract conceptualisation, and active experimentation (Kolb, 2014). Simulations closely align with this model by enabling learners to cycle repeatedly between experience (engaging with the simulation), reflection (examining outcomes), conceptualisation (connecting performance to theory), and experimentation (modifying strategies). Because simulations allow learners to test ideas in low-risk environments, they offer an effective mechanism for bridging theoretical understanding and practical decision-making (Gosen & Washbush, 2004; Tompson & Dass, 2000).

Experiential learning research further suggests that learners develop stronger and more durable mental models when they have opportunities to confront uncertainty, experiment with strategies, and receive feedback from consequences. Simulations operationalise these principles by providing iterative, consequence-driven experiences that mirror real-world complexity more closely than traditional instructional approaches such as lectures or case studies (Faria et al., 2009).

2.2. Constructivism, Situated Cognition, and Authentic Learning

In addition to experiential learning, simulation-based pedagogy is grounded in constructivist assumptions about how learners construct knowledge through active engagement with meaningful tasks (Jonassen, 1999).

Constructivist perspectives emphasise that learning is most effective when learners are positioned as agents who manipulate variables, test hypotheses, and build understanding through problem-solving. Simulations allow for these conditions by placing students inside dynamic environments that require them to make iterative decisions, negotiate uncertainty, and derive insights based on outcomes (De Freitas & Neumann, 2009).

The theory of situated cognition further reinforces the educational value of simulations by arguing that knowledge is inseparable from the contexts and activities in which it is acquired (Brown et al., 1989). Simulations provide learners with access to quasi-realistic environments - such as virtual firms, markets, policy frameworks - where knowledge can be applied in context. This contextual engagement supports the development of tacit knowledge, professional reasoning, and the ability to transfer learning across domains (Lave & Wenger, 1991).

Similarly, authentic learning frameworks argue that learners benefit most from engaging with tasks that approximate real-life professional challenges, requiring integration of multiple skills and knowledge domains (Herrington et al., 2010). Business simulations, for example, require students to apply financial literacy, strategic reasoning, teamwork, communication, and analytical skills in a coordinated manner.

2.3. Cognitive Apprenticeship and Decision-Making Under Uncertainty

The concept of cognitive apprenticeship offers additional insights into how simulations support skill development. Cognitive apprenticeship models emphasise learning through observation, coaching, and guided practice in environments that reveal expert thinking processes (Collins et al., 1989). Simulations - especially those with built-in analytics dashboards - make decision-making processes explicit by providing feedback, performance metrics, and visualisations of strategic outcomes. Educators can use these features to model professional reasoning, scaffold learner understanding, and gradually reduce guidance as learners gain expertise.

Moreover, simulations uniquely allow learners to practise decision-making under uncertainty, which is a core competency in business, management, healthcare, and many applied disciplines. By confronting students with ambiguous market signals, limited information, or competing objectives, simulations help cultivate skills related to risk evaluation, adaptive strategy, and complex problem-solving (Salas et al., 2009).

2.4. Current limitations about simulations and assessment

2.4.1. The Dominance of Perception-Based and Reflective Assessment

While the literature highlights substantial benefits, assessment practices remain a critical weakness in how simulations are implemented in higher education. A consistent pattern across studies is the dominance of indirect, perception-based assessment methods. For example, many empirical studies rely on self-reported gains, satisfaction surveys, or reflective essays as primary measures of student learning (Lean et al., 2006; Anderson & Lawton, 2009). Although these methods provide insights into learner experience, they do not capture how students behave or perform within the simulation environment.

Reflective assignments are commonly used as assessment artefacts because they align with experiential learning and allow students to articulate insights gained from the simulation. However, reflections often measure metacognitive awareness rather than competence in executing tasks or making sound decisions (Gosen & Washbush, 2004). As Tompson and Dass (2000) argue, reflections may demonstrate that learning occurred, but they do not necessarily demonstrate that students can transfer or apply skills effectively.

This disconnects between simulation activity and assessment means that educators often lack objective evidence of how students reason, collaborate, or execute decisions within the simulation. As a result, simulations may be assigned limited assessment weight or treated as formative exercises without significant influence on course grades.

2.4.2. Underutilisation of Simulation Data and Analytics

A striking gap in the literature is the underutilisation of performance data generated by simulation platforms. Modern digital simulations collect a wide range of analytics - including decision logs, financial indicators, team communication metrics, behavioural patterns, and strategy outcomes - yet few studies or programmes translate these data into assessment instruments. Faria et al. (2009) noted this issue more than a decade ago, and evidence suggests it persists today (Arroteia, 2024b).

There are several potential reasons for this gap. First, educators may lack confidence in interpreting simulation analytics or integrating them into grading frameworks. Second, simulation providers often design dashboards for feedback rather than formal assessment, leaving educators without validated instruments or rubrics. Third, traditional assessment regimes in universities - particularly in business schools - are not structured around performance analytics or dynamic behavioural data, making alignment difficult.

However, where simulation data has been studied, findings highlight substantial potential. Salas et al. (2009) showed that performance analytics can provide insight into how teams coordinate and adapt under pressure. These studies suggest that simulation data has significant untapped value for assessing competencies such as decision-making, collaboration, timing, and resilience.

2.4.3. Lack of Competency-Based Assessment Frameworks

Another major limitation identified across the literature is the absence of competency-based assessment frameworks tailored to simulation environments. Many simulations are designed to foster competencies such as strategic reasoning, communication, analytical thinking, teamwork, and leadership, but these competencies are rarely assessed through the simulation itself. Instead, they may be assessed indirectly through written reports or presentations, which often measure articulation rather than execution.

Competency-based education requires aligning learning outcomes, tasks, and assessment criteria in transparent, measurable ways (Biggs & Tang, 2003). Yet research indicates that curriculum alignment around simulations is often weak or inconsistent. Lean et al. (2006) and Anderson and Lawton (2009) both note that educators may adopt simulations for engagement purposes without integrating them into programme-level outcomes or accreditation frameworks.

Several studies have attempted to propose assessment frameworks, but they remain limited. For instance, Gosen and Washbush (2004) suggested using decision quality and game outcomes as proxies for competence but acknowledged challenges in differentiating skill from chance. Likewise, Tompson and Dass (2000) identified improvements in student self-efficacy but did not connect these improvements to observable competence. Work at the intersection of competency-based education and simulation assessment (Khatri et al., 2020; Vermylen et al., 2024) points to promising models, yet these approaches have not been systematically translated into business and management education. However, the field continues to lack robust, validated frameworks that systematically connect simulation performance with competency measurement.

2.4.4. Fragmentation Across Disciplines and Lack of Cross-Field Integration

The simulation literature spans diverse fields - business, medicine, engineering, public policy, and education - yet assessment approaches vary significantly between disciplines. Healthcare, for example, has more mature assessment practices such as simulation-based OSCEs, checklist methods, and behavioural scoring (Gaba, 2004). In contrast, business and management education rely heavily on reflective or written assessments, with little use of embedded performance metrics.

Conceptual contributions that situate business simulation within wider digital transformations – for example, discussions of metaverse-based learning environments (Martínez-López et al., 2023) – reinforce the need to import more rigorous assessment paradigms from other simulation-intensive fields into business education.

This disciplinary fragmentation limits opportunities to share best practices. The business simulation community has made progress in studying learner perceptions and system design; however, assessment remains underdeveloped compared to clinical or aviation simulations. As a result, research insights remain siloed and fail to converge into a unified framework that could guide assessment design across disciplines. These limitations highlight the need for new conceptual models - such as the one proposed later in this paper - that integrate simulation environments with assessment practices through performance analytics, competency mapping, and authentic evaluation.

3. A proposed conceptual model for assessment-integrated simulation-based learning

Although simulation-based learning is widely used in higher education, its pedagogical potential remains limited by weak or inconsistent assessment practices. To address this gap, this paper proposes the Assessment-Integrated Simulation Learning Cycle (AISLC) - a conceptual model that positions simulations as core assessment mechanisms rather than supplementary learning activities. The AISLC integrates principles from experiential learning, competency-based education, and learning analytics to create a structured framework through which simulation environments generate assessable evidence of student learning, performance, and skill development. In doing so, it builds directly on the calls for research to evidence competence development, leadership skills and psychological empowerment in simulation-rich curricula but pushes further by foregrounding embedded analytics and credentialing as central design elements.

The AISLC provides a structured, holistic framework for integrating assessment into simulation-based learning. Unlike conventional models that treat simulations as low-stakes or supplementary activities, AISLC positions simulations as core assessment environments capable of measuring competencies through behavioural data, authentic artefacts, reflective integration, and structured feedback. By aligning simulation design with learning outcomes, embedding measurable performance indicators, and connecting outputs to credentialing systems, AISLC addresses key gaps identified in the literature and moves simulation-based learning towards an assessment-driven, evidence-rich pedagogical paradigm. The model comprises six interrelated components:

1. Design Alignment
2. Embedded Performance Measurement
3. Authentic Assessment Artefacts
4. Reflective Integration
5. Feedback and Coaching Layer
6. Credentialing and Progression Pathways

Together, these components create a coherent system that connects simulation activity with meaningful, evidence-based assessment processes.

3.1. Design Alignment: Linking Simulations to Learning Outcomes

Simulations offer authentic performance contexts unavailable through traditional assessment methods. Whereas essays and exams evaluate theoretical knowledge or isolated cognitive skills, simulations integrate multiple domains - strategic thinking, teamwork, communication, and adaptive responsiveness - within dynamic and uncertain environments (Herrington et al., 2010; Salas et al., 2009). Authentic performance cannot be captured through static or decontextualised assessments; simulations provide the contextual complexity required to evaluate higher-order competencies (Brown et al., 1989).

Thus, simulations should not supplement lectures or case studies but instead serve as core assessment platforms where students enact and demonstrate competence under realistic conditions. In this regard, the foundation of the AISLC is the explicit alignment between simulation activities, learning outcomes, and competency frameworks. According to Biggs and Tang's (2003) model of constructive alignment, assessment tasks must be designed in relation to intended learning outcomes; without this alignment, learning activities

become peripheral and lack pedagogical coherence. Many simulation implementations fail at this initial step, treating simulations as engaging experiences rather than structured ways to demonstrate target competencies. In the AISLC model, educators begin by identifying competencies that simulations are uniquely positioned to assess, such as strategic decision-making, analytical reasoning, teamwork and collaboration, communication and negotiation, and adaptive expertise and reflection-in-action.

These competencies often involve complex, situated behaviours that are difficult to measure through traditional forms of assessment (e.g., essays, exams) but which simulations naturally elicit (Brown et al., 1989; Herrington et al., 2010). Establishing these links early ensures that simulation tasks contribute directly to programme-level goals, rather than functioning as enrichment or entertainment.

3.2. Embedded Performance Measurement: Using Simulation Data as Assessment Evidence

Digital simulations generate extensive and granular data - decision logs, resource allocations, communication patterns, financial outcomes, behavioural indicators, and time-stamped actions. Yet, as the literature shows, these data are rarely used systematically for assessment (Faria et al., 2009). The AISLC model positions simulation analytics as primary evidence of learning, allowing measurement of both process and outcomes. Embedded performance metrics may include:

- Decision quality (alignment with sound strategy or constraints)
- Responsiveness to feedback (adaptation over simulation rounds)
- Collaboration patterns (frequency, coherence, equity of contributions)
- Risk management strategies
- Financial or operational outcomes (interpreted not as scores, but as indicators of strategic coherence)

This approach recognises that simulation performance is multi-dimensional; what matters is not winning the simulation but demonstrating competence, reasoning, and adaptability. Embedded measurement echoes the logic of authentic assessment, which evaluates learners based on performance in realistic scenarios rather than artificial test conditions. It also aligns with emerging work on learning analytics in simulation-based professional learning, which argues for multi-modal, sensor-informed indicators of performance and collaboration (Herrington et al., 2010).

3.3. Authentic Assessment Artefacts: Converting Simulation Activity into Evaluable Outputs

While embedded analytics capture behavioural and performance data, the AISLC model also incorporates authentic artefacts - tangible outputs produced by learners during or after simulation cycles. These may include:

- strategic plans or rationale statements
- decision justifications
- dashboards annotated with commentary
- performance reviews
- team process reports
- data-driven reflective portfolios

Authentic artefacts ensure that assessment is not limited to quantitative metrics but integrates qualitative evidence of reasoning and communicative competence. This aligns with research showing that simulation learning is enhanced when students articulate strategic logic and interpret emerging results (Gosen & Washbush, 2004; Tompson & Dass, 2000). When these artefacts explicitly reference simulation data (e.g., key indicators, turning points, or team decisions), they create a traceable link between performance and reflection,

strengthening the validity of assessment claims (Shum & Crick, 2016). Importantly, artefacts should be grounded in simulation evidence, not abstract theorising. For example, a strategy reflection should refer to specific decisions made, data observed, and outcomes experienced in the simulation environment.

3.4. Reflective Integration: Transforming Experience into Learning

Reflective practice is a core component of experiential learning and is frequently used in simulation assessment (Kolb, 2014). However, as noted in the literature review, standalone reflections often capture attitude rather than competence. The AISLC model reframes reflection as interpretive integration - the process by which learners make sense of simulation data and connect it to theory, feedback, and future professional practice. In this model, reflections are:

- evidence-based (drawing on simulation data rather than general impressions)
- structured (guided by prompts such as "What data informed your decision?" or "How did your strategy adapt in response to feedback?")
- linked to competencies (e.g., explaining how decisions demonstrate teamwork, analysis, or leadership)

This ensures that reflection enhances - not replaces—the assessment of actual performance.

3.5. Feedback and Coaching: Using Analytics to Support Learning Cycles

Research in assessment theory shows that students direct their learning effort toward what is assessed; assessment shapes study strategies, engagement, and attention (Biggs & Tang, 2003; Boud & Falchikov, 2006). When simulations are not assessed - or assessed only superficially - students treat them as optional or recreational. This undermines the strategic reasoning, analytical experimentation, and sustained engagement that simulations are designed to promote. Thus, repositioning simulations as high-stakes assessment activities elevates their importance, ensuring students engage deeply with data, decisions, and team processes. Assessment creates perceived value; without it, simulations become pedagogically underutilised.

High-quality feedback is central to learning (Boud & Falchikov, 2006), and simulations provide unique opportunities for rich, data-informed coaching. The AISLC incorporates a feedback layer where educators (or AI-driven feedback tools) use simulation analytics to provide:

- formative feedback on decision-making
- insights into team dynamics
- personalised coaching on strategic adaptation
- comparative benchmarks or dashboards

Because simulation data are fine-grained and dynamic, feedback can be targeted and actionable - helping learners understand not only what happened but why. Studies in management and clinical simulations show that coaching during or immediately after simulations improves skill acquisition and reflective capacity (Gaba, 2004; Salas et al., 2009).

3.6. Credentialing and Progression: From Assessment to Recognition

Most business and professional programmes articulate explicit competency frameworks, yet few integrate simulation performance into competency evaluation. Competencies such as leadership, problem solving, and communication are often assessed indirectly through written reflections or presentations rather than through observation of behaviour in authentic tasks. Simulations uniquely enable competency enactment, providing observable evidence of whether learners can apply skills in context (Gosen & Washbush, 2004). Integrating simulation outputs with programme competencies strengthens curriculum coherence and creates an assessment system aligned with professional practice.

Thus, the final component of the AISLC model connects simulation-based assessment to formal recognition

structures, ensuring simulations contribute meaningfully to academic and professional progression. This may include:

- formal grading based on simulation performance and artefacts
- micro-credentials for competencies demonstrated
- digital badges linked to simulation analytics
- portfolio inclusion for employability
- evidence for professional standards or accreditation requirements

By embedding simulation outputs into credentialing systems, institutions reinforce the legitimacy and value of simulation-based learning. This step also facilitates external verification of learner capabilities, supporting employability and lifelong learning.

Bringing these components together, the core argument is that simulations must shift from (See Table 1):

Old Paradigm	New Paradigm
Simulation as enrichment	Simulation as core pedagogy
Reflection as assessment	Performance + analytics as assessment
Self-reported learning	Data-driven competence evaluation
Low-stakes engagement	High-stakes demonstration of mastery
Isolated activities	Integrated, aligned assessment cycles

Table 1. Old and New Paradigms regarding simulations for teaching and learning. Source: Own elaboration.

This paradigm shift is operationalised through the Assessment-Integrated Simulation Learning Cycle (AISLC) proposed earlier, which embeds simulations within a coherent system of measurement, reflection, feedback, and credentialing.

4. Conclusion

Simulations represent one of the most promising pedagogical innovations in contemporary higher education, yet their potential remains constrained by persistent limitations in assessment design and integration. Although the literature consistently demonstrates the value of simulations for enhancing engagement, promoting experiential learning, and cultivating higher-order competencies, these benefits remain only partially realised when assessment practices fail to capture the depth and complexity of learner performance. In the absence of structured, data-informed evaluation, simulations continue to be perceived as optional or peripheral rather than integral to the curriculum, reducing their pedagogical influence and limiting their contribution to evidence-based teaching and learning.

The Assessment-Integrated Simulation Learning Cycle proposed in this paper offers a coherent way of addressing this longstanding gap. By integrating learning outcomes, embedded analytics, authentic performance artefacts, structured reflection, feedback mechanisms, and pathways to credentialing, AISLC reframes simulations as assessment engines capable of generating meaningful evidence of learning. This shift - from simulations as enrichment tools to simulations as core assessment environments - has implications not only for simulation pedagogy but also for the broader movement toward competency-based education. When assessment is embedded into the design and execution of simulation activities, educators can more effectively evaluate how learners interpret data, make decisions under uncertainty, collaborate within teams, and adapt strategies over time. In turn, students become more deeply engaged, taking simulations seriously as spaces where their analytical, interpersonal, and strategic abilities are assessed and recognised.

The implications of this shift extend across the educational ecosystem. For educators, integrating simulations into assessment requires reconceptualising their role - not simply as facilitators of an activity, but as learning engineers who interpret behavioural data, design meaningful evaluation criteria, and support learners in understanding and acting upon feedback. For institutions, the widespread adoption of assessment-integrated

simulations demands parallel developments in policy, training, and infrastructure. This includes aligning simulations with programme-level competency frameworks, building capacity in learning analytics, ensuring quality assurance for simulation-based assessments, and integrating simulation outputs with digital learning environments. Simulation providers, too, have a vital role: designing platforms that are transparent, data-rich, and assessment-ready; offering validated scoring frameworks; and incorporating AI-driven tools that support both educators and learners. Collectively, these shifts mark a transition toward a more mature, integrated approach to simulation-based education - one in which simulations function not as pedagogical enhancements but as foundational assessment environments.

Despite its promise, the AISLC model also has limitations. While conceptually strong, its implementation requires substantial educator expertise in analytics, assessment literacy, and facilitation, which may vary across institutions and disciplines. Not all simulation platforms currently offer the depth of data or customisation required to operationalise the model fully, and some competencies - particularly socio-emotional or ethical dimensions - may remain challenging to measure reliably through simulation analytics alone. Furthermore, simulation-based assessment raises questions regarding data privacy, algorithmic transparency, and equity, all of which warrant careful attention as institutions move toward more data-intensive pedagogical practices.

These limitations open avenues for future research. Further empirical work is needed to validate which simulation metrics best correspond to specific competencies and to determine how performance in simulations predicts behaviour in authentic professional environments. Research should also explore how learners interpret simulation analytics, how they respond to AI-generated feedback, and how simulation-based assessments shape motivation, identity, and engagement over time. Comparative studies across disciplines - particularly between fields with mature simulation assessment frameworks, such as healthcare, and those in earlier stages of adoption, such as business education - could illuminate best practices and support the development of cross-disciplinary standards. Moreover, as simulation platforms increasingly incorporate AI, virtual reality, and adaptive decision environments, researchers must examine the ethical, pedagogical, and social implications of automated assessment in simulated contexts.

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