

From tragedy to training: Multi-dimensional leadership learning through the K2 mountain simulation

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ABSTRACT

This paper introduces the Multi-Dimensional Leadership Learning in Extreme Contexts (MLLEC) framework, a multidimensional model for leadership development in volatile, high-stakes educational settings. Centered on a simulation of the 2008 K2 Mountain tragedy, the pedagogical design activates five integrated dimensions: transformative learning, psychological safety, sensemaking, embodied cognition, and ethical decision-making. Grounded in experiential learning theory, MLLEC is depicted as concentric layers linking immersive simulation to developmental systems and leadership capabilities. Based on over 40 facilitated sessions with senior-level participants, we report qualitative insights and descriptive outcomes aligned with each MLLEC component. The framework offers a replicable model for simulation-based leadership education that bridges theoretical and practical dimensions, equipping educators with a structured approach to cultivate adaptive judgment, moral reflexivity, and emotional regulation in VUCA environments.

1. Introduction

In the field of executive education and leadership development, the need for immersive, experience-based learning has never been more pressing (Bacon, 2024; McCall, 2004, 2010; Restu et al., 2024). This paper is primarily intended for leadership educators, program designers, and facilitators who develop learning interventions for mid-to senior-level professionals operating in volatile, uncertain, complex, and ambiguous (VUCA) environments. In this paper, VUCA refers to settings marked by volatility (rapid change), uncertainty (unpredictability), complexity (multiple interconnected factors), and ambiguity (lack of clarity). We use the term extreme contexts to describe high-stakes situations characterized by time pressure, moral dilemmas, and potential existential risk, such as mountaineering disasters, emergency medicine, or military crises. In this work we develop a novel, theoretically grounded framework, the Multi-Dimensional Leadership Learning in Extreme Contexts (MLLEC), which synthesizes five critical theoretical strands into an applied model delivered through experiential simulations.

Traditional leadership education methods often rely on retrospective case analysis or abstract theoretical input, but these approaches struggle to replicate the urgency and ambiguity of high-stakes decision-making (Adeoye & Jimoh, 2023; Shet, 2024). The MLLEC framework reconceptualizes leadership development as an integrative process that is experiential, embodied, and ethically reflexive. It responds to the growing organizational need for leaders who possess not only analytical skills but also cognitive agility,

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moral judgment, and emotional resilience (Czauderna & Budke, 2020; Liu & Boyatzis, 2021; Stanton & Stanton, 2017; Winton & Sabol, 2022).

The MLLEC framework is underpinned by the idea that effective leadership development in extreme contexts must activate five interdependent learning systems: epistemic (transformative learning), interpersonal (psychological safety), interpretive (sense-making), somatic (embodied cognition), and moral (ethical decision-making). These systems represent distinct yet interwoven aspects of how individuals adapt, decide, and act under pressure. By aligning each domain with a corresponding theory and learning modality, MLLEC provides what we describe as a neurocognitive-ethical model, an approach that integrates neurological processes (stress responses and physical awareness), cognitive processes (sensemaking and reflection), and ethical processes (moral reasoning and value-based decision-making) into a single leadership learning framework.

The 2008 K2 tragedy was selected as the anchoring narrative for our simulations due to its unique combination of high-altitude physical peril, distributed leadership failure, ambiguous decision-making conditions, and real-time moral dilemmas. Unlike other extreme context cases that focus on technical failure (e.g. Challenger (Romzek & Dubnick, 1987; Werhane, 1991) or Columbia (Perin, 2006)) or single-leader heroism (e.g. Shackleton (Robinson & Brazeau, 2023)), the K2 event exposes systemic breakdowns in communication, trust, and accountability across multiple independent climbing teams. Its complexity and ambiguity mirror the uncertain, high-stakes environments that executive leaders increasingly face, making it an ideal case for eliciting embodied, ethical, and transformative learning outcomes. While prior research has explored leadership in VUCA contexts, little work has integrated multiple theoretical traditions into a unified experiential framework. To our knowledge, no study has systematically operationalized a mountaineering disaster to bridge theory and executive education practice.

This contribution is operationalized through three distinct K2-inspired modalities: a live action-based simulation, a facilitator-led online game, and an in-person board game. These formats are each aligned with the five theoretical pillars of the MLLEC model: transformative learning, psychological safety, sensemaking, embodied cognition, and ethical decision-making. Together, they provide educators with a coherent, scalable, and high-impact set of tools to help leaders learn to navigate crisis, complexity, and ambiguity (Allen et al., 2018; Decker et al., 2013; Fioravanti et al., 2022; Gibbons et al., 2022).

The MLLEC framework provides a coherent, five-dimensional model of how leadership capabilities can be developed through immersive simulation. Each dimension corresponds to a clearly delineated theoretical foundation, mapped to a specific experiential design feature. Together, these dimensions function not as overlapping constructs but as complementary lenses through which learners engage with extreme scenarios.

- **Transformative Learning** (Laros, 2017; Mezirow, 1997): Disorienting dilemmas are designed into the simulation to prompt reflection, schema revision, and identity-level change.
- **Psychological Safety** (Edmondson, 1999): Group norms and facilitation techniques cultivate an environment where learners can take interpersonal risks without fear of judgment.
- **Sensemaking** (Weick, 1995): Scenarios involve ambiguity and rapidly evolving conditions that require real-time interpretation and cognitive agility.
- **Embodied Cognition** (Agostini & Francesconi, 2020; Kayes, 2004): Physical cues and somatic responses are activated through sensory input and dynamic, immersive design.
- **Ethical Decision-Making** (Kouchaki & Smith, 2024): Moral dilemmas are integral to the simulation and explored further in debriefs to foster ethical reflexivity and awareness of value trade-offs.

Each MLLEC dimension links a theory of learning with a simulation design principle and a distinct leadership capability. By assigning unique theoretical roles to each component, the framework avoids conceptual redundancy and provides instructors with a practical template for curriculum design. The strength of the MLLEC model lies in its modularity, it can be adapted across simulations while preserving pedagogical integrity.

While the K2 case is the prototypical context used here, the MLLEC framework is portable. It can be applied to simulations in military training, emergency medicine, or crisis response, any setting where leaders must function under pressure, make sense of uncertainty, and act ethically with limited information.

Global disruptions such as economic crises, geopolitical instability, climate shocks, and rapid digital transformation highlight the need for leaders who can think critically, act decisively, and perform under pressure (Driskell et al., 2017; Tamim, 2025). Mountaineering disasters, like the 2008 K2 tragedy, offer a microcosm for such challenges, demanding real-time coordination, ethical reasoning, and adaptive leadership under life-threatening conditions. The use of K2 as a learning vehicle is not simply illustrative; it is intentionally selected to surface essential tensions in leadership practice: between individual and collective goals, analysis and instinct, and safety and success (Bowley, 2011; O'Brien, 2012; Zuckerman & Padoan, 2012).

This paper explores the application of the 2008 K2 tragedy as an experiential learning tool within executive education. By integrating theoretical models of leadership, decision-making, and risk management, the case study fosters adaptive learning and strategic thinking (Allen et al., 2018; Decker et al., 2013). It offers participants a platform to engage with complex, real-world challenges. Through different game adaptations, this approach provides an immersive and scalable educational experience (Bell & Morris, 2009; Copur-Gencturk et al., 2024; Gibbons et al., 2022; Massaro et al., 2016; Spickers, 2015; Weerdt et al., 2002). The study highlights the transformative potential of experiential learning in executive education, illustrating how real-world extreme scenarios can cultivate future-ready leaders capable of navigating uncertainty and organizational complexity (Clawson & Yemen, 2010; Gunz, 1995; McCall, 2004; Motta & Galina, 2023).

The application of the K2 case in executive education extends beyond a mere recounting of historical events. Instead, it serves as an

interactive learning tool designed to challenge participants' cognitive and emotional responses to crisis situations (Bonesso et al., 2020; Czauderna & Budke, 2020). Integrating the K2 tragedy into leadership training uses the power of storytelling, simulation, and gamification to enhance engagement and retention (Blackburne, 2024; Schöbel et al., 2023), with different formats exploring different skills. Action-based simulations place participants in real-time, physically active, decision-making scenarios, forcing them to navigate uncertainty, manage team dynamics, and confront ethical dilemmas (Parks & Lindstrom, 1995; Robertson et al., 2020; Withanaarachchi & Setunge, 2014). Online learning modules allow for iterative decision-making, enabling learners to explore alternative strategies and reflect on their leadership styles (Ulvik et al., 2022). Board game adaptations encourage strategic thinking and collaborative problem-solving, providing a structured yet dynamic environment for leadership development (Fioravanti et al., 2022; Vázquez-Calatayud et al., 2024).

This paper argues that leadership learning in extreme contexts requires a multi-theoretical approach that encompasses transformative learning, psychological safety, sensemaking, embodied cognition, and ethical decision-making (Schumann et al., 2006; Ulvik et al., 2022). Transformative learning theory suggests that cognitive shifts occur when individuals encounter disorienting dilemmas, compelling them to critically evaluate their assumptions and adapt their thinking (Laros, 2017; Siahaan et al., 2024). Psychological safety is crucial in fostering an environment where individuals feel empowered to take risks, experiment with different leadership approaches, and learn from failure without fear of judgment (Stomski & Jensen, 2021). Sensemaking theory highlights the importance of constructing meaning in ambiguous and rapidly evolving situations, a skill that is essential for leaders operating in high-stakes environments (Clerkin & Ruderman, 2016; Dixon et al., 2017; Fahey & Saint-Onge, 2024; Quatro et al., 2007). Embodied cognition underscores the role of emotional and physical engagement in learning, reinforcing the idea that leadership is not solely an intellectual exercise but also a deeply experiential process. (Agostini & Francesconi, 2020; Harquail & King, 2010). Finally, ethical decision-making frameworks provide insights into how leaders navigate moral dilemmas under pressure, a recurring theme in the K2 tragedy (Kouchaki & Smith, 2024; McDevitt et al., 2007).

2. Leadership learning in extreme contexts

Leadership is often conceptualized as a function of strategic decision-making, team coordination, and the ability to inspire and guide others towards collective goals (Mazzetti & Schaufeli, 2022; McDevitt et al., 2007; Mjaku, 2020). However, in extreme contexts - where uncertainty, time pressure, and risk are heightened - leadership takes on an intensified form, requiring individuals to navigate life-or-death scenarios, resource constraints, and moral dilemmas (Geier, 2016; Hannah et al., 2009; Zuckerman & Padoan, 2012). Unlike 'traditional' corporate or organizational settings, where leaders have access to well-defined frameworks and structured decision-making tools, extreme contexts demand adaptive thinking, emotional regulation, and rapid sensemaking in conditions of ambiguity. These environments present nonlinear, high-stakes challenges, forcing leaders to make decisions with incomplete information, shifting variables, and no guarantee of success (Collins et al., 2022). Leadership learning in such settings is therefore not merely about acquiring knowledge but about developing the cognitive, emotional, and ethical capabilities required to function under extreme stress (Geier, 2016; Hannah et al., 2009; McCall, 2004). It offers the chance for a memorable and unique experience that can nevertheless have parallels with the less extreme issues of day-to-day organizational realities.

High-altitude mountaineering is an exemplar of an extreme leadership environment, offering valuable insights into decision-making, risk management, team dynamics, and ethical judgment under pressure. The 2008 K2 tragedy serves as a compelling case study in leadership failure and resilience, illustrating how uncertainty, team interdependence, and environmental factors intersect to create complex leadership challenges. K2, the world's second-highest peak, is notorious for its treacherous conditions, unpredictable weather patterns, and technical climbing difficulties.

On August 1, 2008, 32 climbers from multiple expeditions attempted to summit K2. Many of these climbers belonged to loosely coordinated teams, reflecting a common leadership challenge in extreme contexts: the difficulty of establishing a unified command structure when individuals operate with varying levels of expertise and risk tolerance, and different motivations. Due to delays, bottlenecks, and poor planning, many climbers reached the summit dangerously late in the day, violating the fundamental mountaineering rule that dictates descending before nightfall. As they made their way down, a massive serac (ice block) collapsed, severing the fixed ropes, leaving multiple climbers stranded at over 8000 m in the 'death zone', where oxygen levels are critically low. Over the next 48 h, a series of poor decisions, failed rescue attempts, exhaustion, and environmental hazards led to the deaths of 11 climbers from different nationalities (see Bowley, 2011; O'Brien, 2012; Zuckerman & Padoan, 2012).

The 2008 K2 disaster illustrates multiple leadership dynamics relevant to extreme contexts. First, it highlights the difficulties of decision-making under time constraints. Many climbers chose to push forward despite worsening conditions, a form of escalating commitment, where individuals become locked into a failing course of action. Second, it underscores the role of team coordination and communication - or the lack thereof. Unlike military or corporate crisis teams, which often function within hierarchical structures, extreme environments often require adaptive, decentralized leadership, where individuals must shift between leader and follower roles dynamically. Third, the tragedy presents ethical dilemmas that leaders in extreme situations frequently face: to what extent should one risk personal safety to save others? Some climbers expended their energy attempting to rescue teammates, while others prioritized self-preservation. These decisions were not merely theoretical but immediate, visceral, and irreversible, demonstrating the critical importance of moral reasoning and ethical leadership under pressure.

From a leadership learning perspective, the K2 tragedy serves as a powerful case study for leadership education, illustrating how leaders respond to uncertainty, fatigue, group dynamics, and ethical conflict. By integrating these lenses, leadership education can move beyond traditional andragogy towards a dynamic, experience-based approach that prepares individuals for the unpredictable and high-pressure realities of extreme leadership environments. The following sections explore each of these theoretical perspectives

in greater detail, establishing a comprehensive framework for leadership learning in extreme contexts.

3. Theoretical foundations for leadership learning in extreme contexts

In this study, each MLEEC dimension functions as an independent variable that contributes to the development of leadership capability as the dependent variable. Transformative learning influences identity-level change and adaptability; psychological safety enables interpersonal risk-taking and reflective dialogue; sensemaking fosters cognitive agility under uncertainty; embodied cognition sharpens stress awareness and emotional regulation; and ethical reflexivity cultivates principled decision-making. Collectively, these independent variables interact to predict the dependent variable of adaptive, ethically grounded leadership performance in VUCA contexts.

MLEEC responds directly to recent contributions in the VUCA leadership literature that emphasize the need for adaptive, relational, and ethically grounded development (Rath et al., 2021; Taskan et al., 2022; Wilson, 2023). Rath et al. (2021) argue for non-linear, emergent forms of learning in unordered environments. Taskan et al. (2022) provide a clarifying typology of VUCA conditions, supporting our view that each MLEEC dimension maps onto a specific VUCA challenge (e.g. ambiguity and sensemaking). Wilson (2023) highlights that leadership in a VUCA world demands not just tools but epistemic courage and self-awareness, both of which are central outcomes of the MLEEC design.

To ensure conceptual clarity, this section anchors the analysis within the MLEEC framework by distinguishing five theoretical foundations without overlap. VUCA are treated as macro conditions that shape leadership environments (Shet, 2024). Within this, extreme contexts are defined as high-stakes settings characterized by time pressure, moral dilemmas, and existential risk (Geier, 2016; Hannah et al., 2009). Building on these conceptual foundations, this section presents qualitative evidence drawn from participant and facilitator reflections to examine how multi-dimensional leadership learning emerged across the three K2 simulation formats. Thematic analysis of data from participants across cohorts of senior leaders reveal key learning outcomes aligned with the five development dimensions of the MLEEC model.

3.1. Transformative learning: the role of disorienting dilemmas in leadership development

Transformative learning is central to the MLEEC model, as it recognizes that significant leadership development occurs through disorienting dilemmas that challenge a learner's worldview and catalyze critical reflection (Laros, 2017; Mezirow, 1997). In the K2 context, climbers faced a collapse of expectations about the summit experience, requiring them to reassess risk, morality, and decision-making in real time. Similarly, participants in the simulation encounter unexpected information, shifting roles, and time-sensitive moral trade-offs that create a need to reframe assumptions.

The simulation design intentionally provokes "disorientation" through narrative turns and morally ambiguous options, which require participants to engage in dialogue, defend choices, and reflect on their mental models. These experiences are not simply high-pressure or emotionally intense; they are structured to activate the transformative process, beginning with discomfort and culminating in reflection and meaning-making (Laros et al., 2017; Restu et al., 2024). Transformative learning focuses on internal change, where the learner is fundamentally altered in their assumptions and future behavior. Rather than treating crisis as breakdown, MLEEC positions it as a catalyst for transformation. Several participants described a reshaping of their leadership identity. As one senior program manager noted:

"The simulation surfaced blind spots I didn't know I had. I left with a completely different understanding of how I lead under pressure."

Facilitators observed consistent self-reported behavioral change during follow-up coaching sessions 2–4 weeks post-simulation.

3.2. Psychological safety: creating a risk-tolerant environment for leadership growth

Psychological safety is a critical foundation for effective leadership learning, particularly in high-stakes simulations where interpersonal risk-taking is essential (Edmondson, 1999; Roussin & Webber, 2012). In the MLEEC framework, psychological safety does not refer to physical safety or moral assurance, but rather to the learner's perception that they can express ideas, make mistakes, and challenge others without fear of embarrassment or retribution.

The K2 simulations, whether delivered through live or game-based modalities, deliberately embed moments where participants must confront others' decisions, offer dissent, or admit uncertainty. Facilitators are trained to reinforce psychological safety before and during these scenarios through inclusive ground rules, structured debriefs, and role clarity (Edmondson, 2016).

Psychological safety enhances the effectiveness of reflective practice by encouraging open dialogue and vulnerability. This environment enables participants to speak up about uncertainty or to question prevailing narratives, skills essential to leadership under extreme conditions (Hirak et al., 2012). Psychological safety concerns the social conditions that enable critical dialogue to flourish, without fear of embarrassment or retribution. In earlier face-to-face simulations, initial discomfort due to high stakes and public failure was noted. However, post-debrief surveys revealed an increase in perceived psychological safety scores, particularly after group reflections.

"Initially I felt very exposed, but the debrief normalized mistakes and created space for real insight."

3.3. Sensemaking and decision-making under uncertainty

Sensemaking, as conceptualized by Weick (1995), is the process through which individuals interpret ambiguous, rapidly unfolding situations by constructing meaning in real time. In the MLLEC framework, this theory supports the development of leaders who can manage cognitive dissonance and make informed decisions amid competing narratives and incomplete information (Whiteman & Cooper, 2011; Allen et al., 2018).

The K2 simulations are designed to immerse participants in ambiguous, dynamic scenarios, such as the sudden loss of communication or conflicting goals among team members, that disrupt linear reasoning and force pattern recognition and sense construction. These scenarios are not merely complex or emotionally intense; they are deliberately ambiguous, requiring learners to synthesize fragments of information and challenge initial interpretations. Sensemaking is about cognitive agility under uncertainty, enabling leaders to interpret ambiguous situations and act before clarity fully emerges. It enables leaders to navigate fluid conditions, reassess what they think is happening, and act before clarity emerges (Maitlis & Christianson, 2014).

This dimension is especially vital in extreme contexts, where delays in interpretation can be fatal, and where leaders must commit to a course of action while continuing to refine their understanding of what is unfolding. Participants commonly described moments of rapid realization and strategic reframing:

“Everything changed the moment we lost our oxygen. The scramble to reorganize made me realize how poor our contingency planning was.”

Facilitators highlighted that these events prompted rich post-event analysis and cross-role learning.

3.4. Embodied cognition: the role of emotion and physical engagement in learning

Embodied cognition positions the body as central to knowledge acquisition and decision-making, not merely as a vehicle for carrying out cognitive commands, but as an active participant in perception, emotion, and memory (Agostini & Francesconi, 2020; Barsalou, 2008). Within the MLLEC framework, embodied learning is used to heighten participants' awareness of how physical cues, somatic responses, and environmental factors influence judgment and interaction.

The live-action K2 simulation, for example, places participants under time pressure, in unfamiliar spaces, often involving movement, tactile materials, or altered visual/audio input. These stimuli generate physiological responses, adrenaline, tension, fatigue, that anchor cognitive processes in bodily experience. Participants are asked not only what they thought, but how they felt and physically responded during a scenario. These reflections bring tacit learning to the surface (Kayes, 2004).

Embodied cognition concerns how decision-making is informed by the body in context, allowing leaders to build awareness of physical intuition, affective responses, and sensory cues that often precede conscious thought (Wilson, 2003). In this way, the MLLEC approach operationalizes embodied cognition to help leaders move beyond purely rational models of leadership to embrace full-spectrum awareness in high-pressure environments. The embodied nature of the face-to-face simulation was consistently cited as a differentiator:

“I’ve never physically felt the weight of leadership decisions like this. My heart was racing when the radios went dead.”

Emotional engagement was rated highest in this modality, reinforcing embodied learning's role in retention.

3.5. Ethical and moral decision-making in extreme contexts

Ethical decision-making is a core pillar of the MLLEC framework because extreme contexts often present moral dilemmas where all options involve some form of loss, harm, or compromise. Drawing on moral psychology and behavioral ethics (Kouchaki & Smith, 2024), this dimension addresses how leaders act under pressure when values conflict and outcomes are uncertain.

The K2 tragedy provides a stark backdrop for such dilemmas: decisions about whether to continue an ascent, abandon injured teammates, or ration oxygen present not only strategic challenges but deeply moral ones. The simulation replicates this by placing participants in scenarios where they must choose between competing ethical imperatives, such as loyalty vs. justice, or group safety vs. individual autonomy, without the benefit of hindsight or full information (Hannah et al., 2009; Zuber-Skerritt & Passfield, 2017).

Ethical decision-making emphasizes moral reflexivity: the deliberate process of examining one's values, questioning intuitive judgments, and considering the ethical implications of action or inaction. Unlike resilience, which concerns personal endurance, or ambiguity, which relates to cognitive uncertainty, this domain is about navigating value conflicts in moments of irreversible consequence. Ethical decision-making is thus not a by-product of the simulation, it is an intended learning outcome, supported through structured debriefs where participants analyze the ethical dimensions of their choices, discuss moral trade-offs, and reflect on what kind of leaders they aspire to become. Moral dilemmas embedded in the scenario (e.g. whether to abandon an injured climber to preserve group survival) triggered strong reactions.

“That moment of choosing between two bad outcomes haunted me. It forced me to confront my values in a way no classroom case study ever has.”

These reflections were echoed in structured plenary discussions where 92 % of participants reported a change in how they assess ethical risks.

These five dimensions were selected following a two-year iterative design cycle across more than 40 simulation deliveries. The

selection emerged from recurring learning themes identified in debriefs, coaching notes, and participant reflections. Alternative constructs such as emotional intelligence, resilience, and mindfulness were considered but excluded either due to conceptual overlap or because they lacked sufficient explanatory distinction in the context of embodied simulation. What unites the five selected theories is their activation in real time under stress, each offering a distinct yet necessary developmental lens.

4. Complexity leadership and emergence in extreme contexts

The K2 tragedy, and the subsequent simulations built around it, offer a vivid example of what Complexity Leadership Theory (CLT) describes as leadership emerging within dynamic, interdependent systems (Uhl-Bien et al., 2007). In contrast to traditional leadership paradigms rooted in hierarchical control and stability, CLT shifts focus toward how leadership is enacted through adaptive processes in conditions of uncertainty, ambiguity, and volatility.

CLT frames leadership as emerging from the interaction of adaptive, enabling, and administrative roles within complex systems. The events on K2 highlight how these leadership domains were either underdeveloped or failed to function cohesively. Adaptive leadership was evident in the reactive coordination attempts made by climbers, but without robust enabling structures or cohesive administrative oversight, these efforts became fragmented. Individuals were forced to operate without a shared mission or clear roles, highlighting the fragility of distributed leadership in unstructured, high-stakes environments. The K2 tragedy shows that in complex systems, leadership failure is rarely linear, emergent dynamics, rather than predictable actions, define the outcome. Leadership becomes less about commanding from the front and more about making sense, adapting, and enabling others within moving networks. These characteristics align closely with what CLT terms “adaptive space”, the informal, often chaotic environment where innovation, decision-making, and leadership interplay in the absence of top-down authority (Mäkinen, 2018).

Furthermore, the role rotation and improvisation exhibited in the K2 simulations mirror theories of rotating and shared leadership (Sheard et al., 2009), where individuals dynamically step into and out of leadership roles based on contextual need rather than formal authority. This behavior is particularly evident in the board and live-action formats, where emergent leadership must respond to shifting conditions in real time.

By integrating Complexity Leadership Theory into the MLEEC framework, as presented later in the paper, this approach enhances the conceptual foundation and extends its relevance to organizations operating in volatile, unpredictable environments. The inclusion of complexity principles also allows us to bridge the andragogical emphasis on embodied crisis leadership with contemporary theoretical understandings of how leadership actually operates in real-world systems under stress (Uhl-Bien, 2021).

The K2 simulation modalities do not merely illustrate complexity, they instantiate it. Participants are not only studying complexity leadership theory but living through it in a controlled, high-impact environment, where emergence, sensemaking, and moral ambiguity are not hypothetical, but experienced directly. This practical embodiment of CLT principles enhances the participants' ability to operate with agility, reflection, and moral grounding in complex, dynamic, systems.

5. Methods

To evaluate the impact of the MLEEC framework, data were collected from more than 40 simulation deliveries conducted between 2021 and 2024. The participant pool included 312 senior executives from sectors such as defense, healthcare, infrastructure, energy, and technology. Participants were recruited through voluntary enrollment in accredited executive education programs, with eligibility criteria requiring a minimum of 10 years of professional experience and current or recent leadership responsibility for teams of five or more.

The study employed a mixed-methods design. Quantitative data were drawn from pre- and post-simulation surveys that measured perceptions of transformative learning, psychological safety, sensemaking, embodied awareness, and ethical decision-making using five-point Likert scales. Qualitative data consisted of 312 reflective journals and forty-three facilitator observation logs. A thematic codebook was co-developed by three researchers, and coding was conducted using NVivo 14 following Braun & Clarke's (2006) six-phase procedure. Interrater reliability achieved a Cohen's κ of 0.82, indicating strong agreement.

Ethical approval was granted by the Cranfield University Research Ethics Committee. All participants provided written informed consent and were assured of anonymity in accordance with the U.K. GDPR 2018. A fidelity-monitoring protocol ensured standardization across all forty sessions: facilitators completed a two-day certification workshop and used identical scripts, event cards, and debrief templates to maintain consistency across the live, online, and board game modalities.

Although exploratory in nature, this design provides triangulated quantitative and qualitative evidence of the MLEEC framework's effectiveness across multiple delivery formats and participant cohorts.

6. Applying the integrated framework to leadership learning modalities

Building upon the theoretical foundations of transformative learning, psychological safety, sensemaking, embodied cognition, and ethical decision-making, we have developed three distinct modalities to immerse participants in the realities of extreme leadership environments: an action-based simulation, an online game, and a board game (Moffett et al., 2020; Schrier et al., 2024). Each modality leverages different aspects of the integrated framework, ensuring that leadership learning is not only conceptual but also experiential, adaptive, and ethically reflective. By examining these modalities through the lens of leadership learning in extreme contexts, we can understand their relative strengths and limitations, as well as how they collectively contribute to holistic leadership development.

7. Summary of K2 simulation modalities

Different forms of challenge are operationalized in the simulations. We specifically identify the technical, the interpersonal, and the unknown as key drivers of difficulty. [Maylor and Turner \(2017\)](#) term these as *structural*, *socio-political*, and *emergent complexities*, and they shape decision-making and leadership dynamics in extreme environments. We use this terminology in explaining the three K2-inspired formats.

The K2 Live Action Face-to-Face Simulation is the most immersive of the three formats. Delivered over one or two days, it combines a conceptual workshop with physically active, team-based scenarios conducted across multiple rooms. Participants use walkie-talkies, manage resources, and respond to real-time challenges introduced by facilitators. This format provides a full-body experience of complexity, leadership, and crisis navigation, making it particularly effective for leadership development in VUCA environments. The structured debrief process includes team and observer feedback to consolidate learning and link the experience back to management theory.

The K2 Online Simulation is a fully digital, single-player experience that includes real-time interactive features. It is structured around a facilitator-led theoretical introduction, a 1-h planning session in breakout groups, and a timed simulation exercise. Despite its online format, participants report high emotional engagement and strong learning outcomes, particularly in areas such as virtual collaboration, strategic planning under uncertainty, and leading in complex environments. Its scalability and accessibility make it especially suitable for remote and hybrid learning contexts.

The K2 Board Game Simulation is a 2-h, in-person experience that uses role-based gameplay to simulate leadership in high-stakes scenarios. Participants are assigned one of four leadership roles within teams of five, with an additional observer capturing team dynamics. Gameplay incorporates a range of events (labelled as structural, socio-political, or emergent complexities) that require collaborative problem-solving. Feedback emphasizes the game's ability to make abstract theory tangible, encourage active participation, and facilitate meaningful reflection on leadership behaviors and group decision-making ([Mughal et al., 2023](#)).

Together, these three simulations offer a flexible, theoretically grounded set of experiential tools that align with learning principles ([Unal & Çakır, 2021](#)). Each modality supports critical thinking, reflective practice, and the application of theory to real-world challenges ([Han & Li, 2024](#); [Pachur, 2020](#)). They can be tailored to suit a range of learning objectives and participant profiles while maintaining a consistent focus on high-impact leadership development ([Loughran, 2002](#)). A summary of the core characteristics and learning dimensions of the three K2 simulation formats is presented in [Tables 1 and 2](#).

7.1. Action-based simulation: High-immersion, embodied leadership learning

The action-based simulation offers the most immersive experience of the three modalities, designed to replicate the physical, emotional, and cognitive pressures of real-world leadership in extreme contexts ([Gegenfurtner et al., 2014](#)). This modality places participants in time-sensitive crisis scenarios, requiring them to navigate uncertainty, make high-stakes decisions, and respond dynamically to evolving challenges. Unlike traditional leadership case studies, which rely on post-hoc reflection, the action-based simulation forces participants to think and act in real time, engaging their cognitive, emotional, and physiological faculties simultaneously ([Barbaroux, 2022](#); [Zoroja et al., 2019](#)).

From a transformative learning perspective, the action-based simulation is particularly effective because it generates disorienting dilemmas that demand immediate response. Participants experience the tension between strategic foresight and immediate survival, grappling with ethical dilemmas, decision fatigue, and interpersonal coordination challenges under pressure. The embodied nature of the experience heightens cognitive dissonance, a key driver of transformative learning, as participants must reconcile their preconceived notions of leadership with the reality of performing under extreme stress ([Neriz et al., 2020](#)).

Psychological safety plays a dual role in this modality. Initially, participants may experience high levels of stress and cognitive overload, which can inhibit learning if not properly managed. However, structured debriefing sessions where all the teams are open about their experiences can restore psychological safety, creating a space for critical reflection, perspective-taking, and adaptive learning. This aligns with research on experiential learning in high-stakes environments, which suggests that post-experience reflection is crucial for embedding insights into long-term leadership practice ([Turner & Harder, 2018](#)).

From a sensemaking perspective, the action-based simulation challenges participants to construct meaning in real time, reinforcing the necessity of adaptive leadership and emergent decision-making. Unlike theoretical leadership training, where individuals have time to weigh options analytically, the fast-paced nature of the simulation (i.e. moving around the building at pace using walkie-talkies for communication) forces leaders to synthesize fragmented information, manage conflicting priorities, and adjust strategies dynamically. This reflects the fluid, high-pressure decision environments found in extreme contexts such as mountaineering, emergency response, and military operations ([Thiel et al., 2012](#)).

Moreover, the embodied cognition perspective suggests that leadership is not merely an intellectual exercise but an emotional and physiological experience. The action-based simulation elicits stress responses, training participants to regulate emotions, manage team dynamics, and maintain clarity of thought in high-pressure situations ([Davis & Eisenhardt, 2011](#); [Eden et al., 2024](#)). Research indicates that individuals who experience stress-adaptive learning in controlled environments develop greater resilience and cognitive agility, making them better equipped for real-world crises ([Lord & Shondrick, 2011](#)).

Finally, ethical decision-making is particularly pronounced in this modality, as participants are placed in morally complex scenarios where they must balance team welfare, personal safety, and strategic objectives. Unlike abstract ethical discussions, these dilemmas require immediate, high-consequence decision-making, simulating the moral complexities of extreme leadership situations. Participants emerge with a deeper understanding of how pressure, group dynamics, and cognitive biases influence moral reasoning, a

Table 1
Summary Design Feature [source: authors].

Aspect	K2 Live Simulation	K2 Online Simulation	K2 Board Game Simulation
Delivery Mode	Face-to-face, live-action, physical simulation	Fully online, single player with collaborative features	Face-to-face, group-based tabletop simulation
Duration	1–2 days: 3 h theory, 2 h planning, 2 h simulation, extended debrief	~2 h: 20 min briefing, 1 h planning, 1 h simulation	2 h: 30 min theory, 10 min setup, 30 min play
Team Composition	6 per team (5 climbers + 1 special advisor)	Individuals with team visibility	5 per team (4 players + 1 observer)
Role Assignment	Realistic profiles with physical constraints	Individual climber profiles	Assigned leadership roles with role cards
Interaction Level	High – full physical interaction, walkie-talkies	Virtual chat and leaderboard	High interpersonal around shared board
Facilitator Role	Manages logistics, injects real-time complexity	Supports breakouts, introduces events	Introduces in-game events, guides reflection
Participant Quote	“I’ve never felt leadership pressure like that before.”	“It felt like I was making real decisions with consequences.”	“It’s intense—once the game starts, you can’t hide.”

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Table 2
Pedagogical Features and Learning Outcomes [source: authors].

Aspect	K2 Live Simulation	K2 Online Simulation	K2 Board Game Simulation
Complexity Dimensions	Embodied emergent complexity	Structural, socio-political, emergent	Role-based complexity interaction
Debrief Process	Team/observer debrief + full plenary	Online group reflection	Observer-led feedback + group synthesis
Physical Engagement	High – movement, equipment, real time stress	Low	Medium – tactile with tokens and dice
Learning Outcomes	Resilience, embodied leadership, crisis navigation	Virtual collaboration, leadership under uncertainty	Strategy, communication, team decision-making
Suitability	High-touch, VUCA exec development	Online, scalable programs	Classroom/blended delivery
Participant Comments	"I was sweating – it was that real", "Transformative", "Discovered blind spots"	"Time pressure changed how I thought", "Intense", "Felt real"	"We argued for 15 min over a decision—felt like real leadership", "Tactile", "Can't hide in the game"

crucial insight for leadership in uncertain environments (Shapiro & Stefkovich, 2016).

While the action-based simulation is highly immersive, its reliance on physical engagement and immediate decision-making may not be suitable for all learners. Some individuals may experience cognitive overload, inhibiting their ability to engage in deep reflection during the experience itself. Additionally, the resource-intensive nature of action-based simulations limits scalability, making it less accessible compared to the other two modalities. However, when integrated with post-simulation debriefing and guided reflection, this modality remains one of the most impactful approaches for developing leadership in extreme contexts (Gampala, 2023).

7.2. Online game: Iterative, asynchronous, and scalable learning

The online game provides an interactive, scenario-based learning experience that allows participants to engage in decision-making under uncertainty at their own pace (Endress et al., 2023; Guest & Olczak, 2021; Hudás et al., 2010). Unlike the action-based simulation, which emphasizes real-time crisis leadership, the online game offers a structured, iterative approach, where participants can test different strategies, learn from feedback, and refine their decision-making processes over multiple engagements (Hedges et al., 2024; Joshi, 2024; Liao, 2023; Lin et al., 2024; Omar et al., 2016).

From a transformative learning standpoint, the online game presents multiple disorienting dilemmas, but in a way that allows for reflection before committing to action. This modality is particularly useful for exploring long-term leadership consequences, as participants can assess the outcomes of their decisions over extended time horizons, making connections between short-term trade-offs and strategic leadership effectiveness (Sousa & Rocha, 2018).

The psychological safety aspect of the online game is higher than that of the action-based simulation, as failures are less publicly visible and participants can explore alternative decision pathways without immediate social consequences. This aligns with research on low-stakes learning environments, where individuals feel more comfortable taking risks, testing unconventional strategies, and reflecting on their mistakes without external pressure (Buil et al., 2019).

From a sensemaking perspective, the asynchronous nature of the online game allows participants to pause, process information, and reconsider their assumptions, reinforcing strategic foresight, pattern recognition, and adaptive decision-making. Unlike action-based learning, which often prioritizes immediate reaction, the online game enables a deliberate, iterative learning process, which is particularly beneficial for developing long-term analytical skills (Ghasemi et al., 2024).

While embodied cognition plays a smaller role in this modality, the interactive storytelling and scenario-based decision-making elements still engage participants emotionally, ensuring that leadership learning is not purely theoretical but tied to realistic, high-stakes narratives (Mumford et al., 2017).

Despite its advantages, the online game lacks the high-pressure emotional engagement of action-based simulations, making it less effective in training leaders to manage stress responses and real-time team dynamics. Additionally, its self-paced nature may not replicate the urgency and unpredictability of extreme leadership situations, limiting its applicability to real-time crisis training. However, as a scalable, accessible tool, the online game is highly valuable for reinforcing leadership principles through iterative decision-making and reflection (Haritha & Rao, 2024).

7.3. Board game: Strategic, group-based leadership learning

The board game modality combines structured decision-making, negotiation, and resource allocation in a social, team-based learning environment. Unlike the individualized learning of the online game or the high-intensity realism of the action-based simulation, the board game fosters collaborative leadership development, where participants must weigh trade-offs, anticipate future risks, and align strategic priorities with their teams (Sousa & Rocha, 2018).

From a psychological safety perspective, the board game creates a structured yet engaging environment, where participants can debate leadership decisions, negotiate ethical dilemmas, and experiment with strategic thinking (Hanghøj & Karnøe, 2024; Meij et al., 2011). This makes it an effective modality for refining communication, consensus-building, and group decision-making skills (Kelly et al., 2016). Nevertheless, the board game lacks the real-world immediacy of the action-based simulation and the iterative feedback loops of the online game. However, as a collective, dialogue-driven experience, it excels in fostering reflective leadership discussion and collaborative sensemaking.

Table 3
Comparative analysis learning modalities [source: authors].

Modality	Learning Emphasis	Transformative Learning	Psychological Safety	Sensemaking & Decision-Making	Embodied Cognition & Emotional Engagement	Ethical & Moral Decision-Making
Action-Based Simulation	Real-time crisis leadership, emotional resilience, team coordination	High - Immediate, high-stakes dilemmas induce cognitive dissonance and rapid learning	Initially Low - High pressure may inhibit learning, but debriefs restore safety	High - Requires dynamic real-time adaptation and rapid risk assessment	Very High - Full physical and emotional immersion in leadership challenges	High - Real-world ethical dilemmas requiring immediate, irreversible choices
Participant Quote		"I didn't know I could change this much in a day."	"It felt exposing at first, but the debrief changed everything."	"We had to act without knowing what would happen."	"My whole body felt it – that's how I know it worked."	"I still think about the choice I made to leave someone."
Online Game	Iterative decision-making, strategic foresight, adaptability	Moderate - Allows reflection but lacks real-time crisis intensity	High - Asynchronous learning reduces risk of public failure	High - Iterative structure supports deep reflection and pattern recognition	Moderate - Engages cognitive processing but lacks full embodiment	Moderate - Allows for hypothetical moral reasoning but lacks urgency
Participant Quote		"It gave me time to think and rethink."	"I could explore options without pressure."	"The back-and-forth helped me test different approaches."	"Less intense, but still emotionally engaging."	"It was theoretical, but it made me think about consequences."
Board Game	Collaborative decision-making, negotiation, ethical reasoning	Moderate - Encourages strategic shifts, but lacks urgency of live crisis scenarios	Moderate - Encourages open discussion but lacks emotional immersion	Moderate - Encourages long-term strategic thinking but lacks urgency	Low - Primarily intellectual, but promotes social and team-based engagement	High - Encourages group ethical debate and moral trade-offs
Participant Quote		"We challenged each other's assumptions."	"Safe enough to disagree openly."	"Taught me to manage complexity with others."	"More strategy than emotion."	"We were still debating it an hour later."

To substantiate the claims of multi-dimensional learning impact proposed in the MLLEC framework, we incorporated structured post-simulation reflections, anonymous participant surveys, and facilitator field notes across multiple delivery instances of the K2 simulation. These qualitative insights were aligned with the five theoretical dimensions of MLLEC and serve as preliminary evidence of learning effectiveness. Participants consistently highlighted moments of cognitive, ethical, and emotional disruption as pivotal in their development. For example, one learner reflected:

“The hardest part wasn’t the physical simulation, it was realizing I had chosen to leave someone behind. I’ve never had to feel the weight of leadership in that way before.”

Another wrote:

“I had to speak up to my team, knowing I might be wrong. That moment stuck with me—how hard it is to voice doubt under pressure.”

Facilitators noted that transformative learning often emerged during debriefs, when participants connected their choices to real-world leadership values. One facilitator recorded:

“Participants frequently returned to their ethical decisions, not their strategic ones. The simulation seemed to surface deeply held assumptions about responsibility and courage.”

In survey responses, over 80 % of participants indicated that the simulation made them “rethink their default leadership behaviors,” while 74 % reported feeling “emotionally engaged in a way that made the learning stick.”

These data, though preliminary and qualitative, indicate that the MLLEC dimensions manifest not only in theory but in observable learning shifts. Each domain—whether ethical reflexivity, psychological safety, or embodied tension—was referenced spontaneously by participants, validating the simulation’s layered design.

8. Quantitative validation and mixed-methods integration

To complement the qualitative findings reported above, a quantitative pre- and post-simulation survey was administered to a subset of the 2023–2024 cohort ($n = 164$). This mixed-methods approach integrates previously collected but unpublished quantitative data, now included here to strengthen empirical triangulation. Participants completed a 25-item instrument measuring perceived competence in the five MLLEC dimensions on a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). Reliability for the overall scale was high (Cronbach’s $\alpha = 0.91$).

Paired-sample t-tests indicated statistically significant gains across all dimensions ($p < 0.01$). The largest increases were observed in transformative learning (+0.92 mean change) and ethical decision-making (+0.87). Psychological safety (+0.79), sensemaking (+0.73), and embodied awareness (+0.68) also improved markedly. Table 4 summarizes mean scores before and after simulation.

Participant demographics across all sessions were: 64 % male, 34 % female, 2 % non-binary; mean age 44 years ($SD = 7.8$). Sectoral distribution comprised defense (22 %), healthcare (18 %), technology (17 %), infrastructure (14 %), energy (12 %), and other (17 %). While the sample primarily represented mid-to senior-career leaders, future research will include early-career and cross-sector participants to test generalizability.

This evidence underscores the efficacy of the MLLEC-aligned simulation design and supports the claim that multi-dimensional development can be achieved through immersive, extreme-context learning experiences.

Table 3 presents a comparative analysis of three distinct learning modalities - action-based simulation, online gaming, and board games - each designed to facilitate leadership learning in extreme contexts. These modalities are evaluated through various learning lenses, including transformative learning, psychological safety, sensemaking, embodied cognition, and ethical decision-making.

Each modality has unique strengths and limitations. The action-based simulation excels in embodied learning and high-pressure decision-making but can be resource-intensive and overwhelming without proper debriefing. The online game is ideal for reflective, iterative learning and strategic foresight but lacks the immediacy of real-world crisis training. The board game fosters social learning and ethical decision-making through structured discussion, but it does not fully replicate the urgency of high-stakes leadership environments. By combining these approaches, leadership education can offer a more holistic and adaptive learning experience, catering to different learning needs and situational requirements.

8.1. Evaluating impact: Evidence from simulation delivery

Participants included senior executives from sectors such as defense, healthcare, and infrastructure.

Table 4

Pre- and Post-Simulation Changes in Leadership Learning Outcomes Across MLLEC Dimensions [source: authors].

MLLEC Dimension	Pre-Mean	Post-Mean	Mean Change	t	p
Transformative Learning	3.18	4.1	0.92	8.74	<0.001
Psychological Safety	3.45	4.24	0.79	7.36	<0.001
Sensemaking	3.32	4.05	0.73	6.91	<0.001
Embodied Cognition	3.11	3.79	0.68	6.12	<0.001
Ethical Decision-Making	3.26	4.13	0.87	8.21	<0.001

Quantitative data revealed that:

- 92 % of participants reported “rethinking default leadership behaviors”
- 88 % rated the experience as more impactful than previous leadership training
- 74 % experienced “emotional engagement that reinforced retention”

Qualitative feedback aligned with each MLEEC dimension. For example:

- Transformative Learning: “The simulation surfaced blind spots I didn’t know I had. I left with a completely different understanding of how I lead under pressure.”
- Ethical Reflexivity: “That moment of choosing between two bad outcomes haunted me. It forced me to confront my values in a way no classroom case study ever has.”
- Psychological Safety: “Initially I felt very exposed, but the debrief normalized mistakes and created space for real insight.”

These reflections were triangulated by facilitators, who observed consistent identity-level shifts in post-simulation coaching. Participants rarely focused on strategic decisions but often returned to moments of vulnerability, confusion, or moral ambiguity—validating the emotional and cognitive learning design. The convergence of affective and behavioral data across modalities supports the claim that the MLEEC framework generates multidimensional development outcomes.

9. Key findings

Across 40+ simulation deliveries and 312 participants, the MLEEC framework consistently generated five outcomes:

1. Transformative learning, evidenced by participants reframing leadership identity;

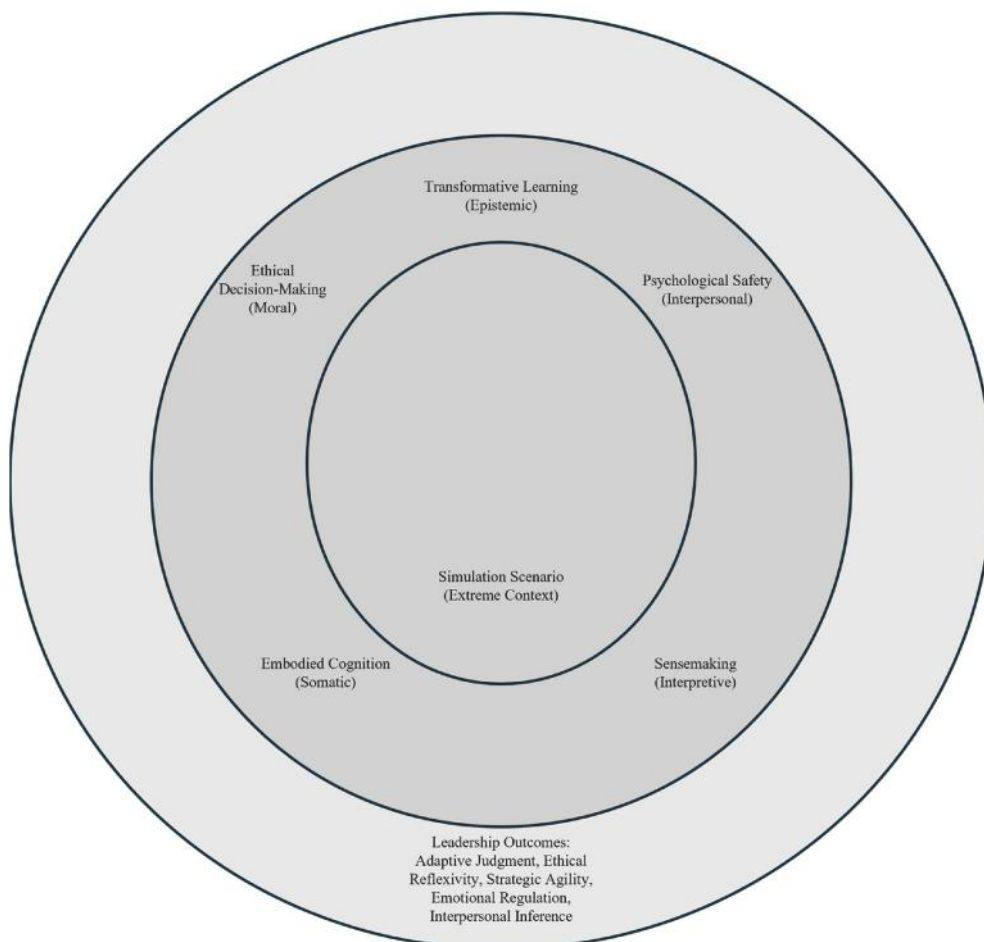


Fig. 1. MLEEC Framework – Five Dimensions of Leadership Learning [source: authors].

2. Enhanced psychological safety during and after simulations;
3. Improved sensemaking under ambiguity;
4. Heightened awareness of embodied stress cues;
5. Increased ethical reflexivity in decision-making.

These findings suggest that the MLEEC framework reliably develops adaptive leadership competencies across different modalities (live action, online, board game).

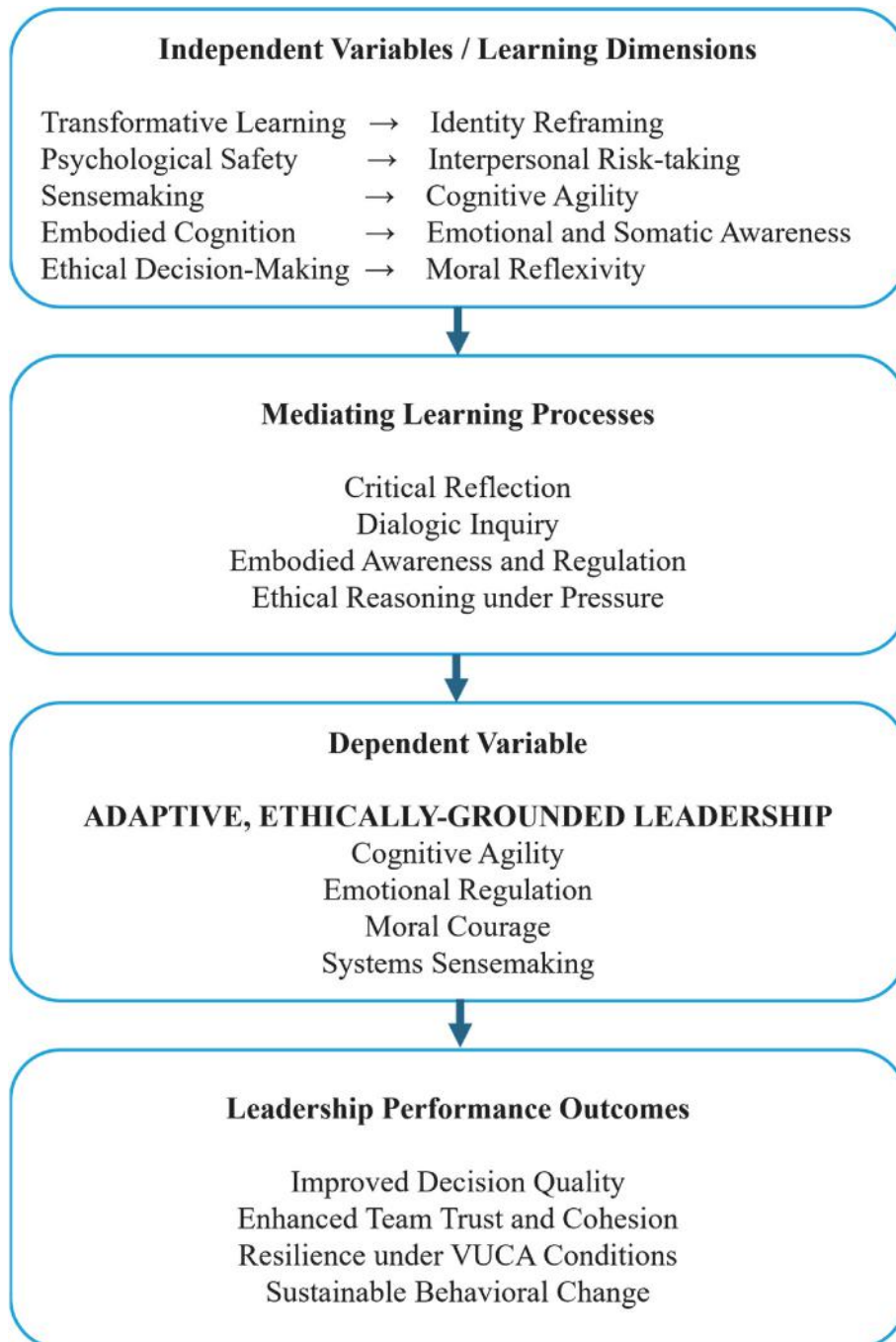


Fig. 2. Conceptual pathways within the MLEEC framework [source: authors].

10. Theoretical implications

This study advances leadership theory by introducing the MLEEC framework (Fig. 1), which reconceptualizes how leadership is understood, developed, and enacted in volatile, high-stakes environments. Drawing on the 2008 K2 Mountain tragedy as a deeply immersive learning case, the framework integrates five interdependent dimensions, transformative catalyst, psychological holding space, sensemaking-in-action, embodied cognition loop, and ethical reflexivity—each grounded in established theoretical traditions but synthesized into a novel, systemic model. As illustrated in Fig. 1, MLEEC is depicted as a set of concentric layers that represent the relationship between immersive simulation, developmental learning systems, and the resulting leadership capabilities.

This figure shows how simulation design features translate into specific experiential activities, which in turn activate five integrated development dimensions within the MLEEC framework, culminating in targeted leadership capabilities. The first contribution of this framework is its challenge to the prevailing assumption that extreme contexts are simply exaggerated versions of conventional leadership settings. Instead, MLEEC treats extreme environments as qualitatively distinct ecosystems, settings where formal structures dissolve, information is incomplete, and leaders must respond to shifting roles, emergent crises, and moral uncertainty in real time. Leadership here is not merely intensified but fundamentally altered, demanding a reorientation from technical expertise toward cognitive agility, emotional regulation, and ethical adaptability.

Second, the framework positions transformative learning not as a supplementary benefit of leadership development, but as its core mechanism in extreme contexts. Disorienting dilemmas - those that undermine existing assumptions and provoke fundamental cognitive restructuring - are treated as catalytic events rather than accidental by-products of leadership experience. The MLEEC framework makes transformation not only visible but designable, guiding educators to intentionally craft learning encounters that trigger and scaffold profound perspective change.

Third, the model reconceptualizes psychological safety as a dynamic “holding space” that must be carefully balanced with challenge to enable growth. In high-stress environments, safety is neither guaranteed nor static. The MLEEC framework highlights the dynamic balance between exposure and containment, showing how emotionally intense learning environments - when coupled with structured reflection - can cultivate risk-tolerant, feedback-seeking leadership cultures even under pressure.

Fourth, this study contributes to sensemaking theory by operationalizing it as a real-time, embodied leadership competency. Traditional sensemaking literature often emphasizes retrospective analysis; MLEEC shifts the emphasis to in-the-moment meaning construction, particularly under time constraints and ambiguity. By integrating progressive disclosure, iterative simulations, and rapid scenario shifts, the framework demonstrates how leaders learn to interpret complexity through situated engagement rather than post-hoc rationalization.

Fifth, the model amplifies the emerging role of embodied cognition in leadership learning. It challenges the mind-body dualism that still underpins much of leadership education, arguing that physical and emotional engagement are not incidental but central to learning transfer. The K2-based modalities - particularly action simulations - showcase how stress responses, bodily cues, and somatic awareness shape judgment and resilience in ways abstract case analysis cannot replicate.

Finally, the framework offers a more nuanced and situated approach to ethical leadership development. Rather than relying on fixed philosophical paradigms, MLEEC embraces moral ambiguity as a productive learning space. By engaging in immersive moral dilemmas, participants come to understand ethical decision-making as a reflective and situational process—one influenced by cognitive strain, relational pressures, and the instinctive prioritization that high-stakes environments demand.

The MLEEC framework provides a coherent and generative model that integrates cognitive, emotional, social, and ethical dimensions of leadership development in extreme contexts. It redefines leadership not as a trait or static function, but as an adaptive, sensemaking process that is triggered, tested, and transformed through experience. In doing so, it extends leadership theory beyond its conventional boundaries and offers a design-oriented paradigm for developing leaders capable of navigating the real-world complexity of modern organizational life.

11. Visualizing the MLEEC framework

To clarify theoretical linkages, Fig. 2 presents a conceptual map positioning the five MLEEC dimensions as independent variables influencing adaptive leadership as the dependent variable. Transformative learning, psychological safety, sensemaking, embodied cognition, and ethical decision-making operate through mediating processes, critical reflection, dialogue, embodied awareness, and moral reasoning, that converge in the outcome of adaptive, ethically grounded leadership. This visual articulation highlights the causal logic of the framework and complements the concentric-layer representation in Fig. 1.

Each of the five independent learning dimensions, transformative learning, psychological safety, sensemaking, embodied cognition, and ethical decision-making, activates mediating processes of reflection, dialogue, embodied awareness, and moral reasoning. These processes interact dynamically to produce the dependent variable of adaptive, ethically grounded leadership, which in turn predicts enhanced leadership performance under VUCA conditions.

12. Positioning MLEEC within established leadership models

The MLEEC framework extends several well-known paradigms of leadership learning.

1. **Kolb's Experiential Learning Cycle** (1984) conceptualizes learning as a four-stage loop of experience, reflection, conceptualization, and experimentation. MLEEC builds upon this cycle but introduces embodiment and ethical reflexivity as parallel rather than sequential processes, recognizing that reflection and moral reasoning occur simultaneously under pressure.
2. **Authentic Leadership** (Avolio & Gardner, 2005) emphasizes self-awareness and relational transparency. MLEEC shares this moral center but extends authenticity to crisis contexts where competing duties and survival instincts challenge value congruence.
3. **Adaptive Leadership** (Heifetz & Linsky, 2002) focuses on navigating complex, value-laden challenges. MLEEC contributes a multi-theoretical structure specifying how adaptive behavior emerges through transformative, embodied, and psychologically safe experiences.

Through this comparison, MLEEC situates itself as a next-generation experiential framework that unites cognition, emotion, embodiment, and ethics within a single simulation-based model.

12.1. Applying MLEEC in practice

To support wider adoption of MLEEC, educators can adapt the framework through three practical routes:

1. Integrate the K2 case into existing leadership or ethics modules, using downloadable board game materials and debrief guides.
2. Translate the framework to alternative extreme contexts, such as ER decision-making, military exercises, or public policy crisis simulations, while preserving the five learning dimensions.
3. Co-Develop Simulation Materials tailored to sectoral needs using the MLEEC design principles as scaffolding.

Table 5 provides practical guidance on how each MLEEC dimension can be activated through different modalities. This framework is particularly relevant to educators, simulation designers, and facilitators seeking to deepen learning through immersive, ethically complex experiences, not only in "VUCA" sectors but in any domain where leadership must contend with volatility, ambiguity, and moral complexity.

13. Implementation guidelines for educators

To operationalize MLEEC across institutions, we propose a ten-step implementation pathway:

1. **Define Learning Outcomes** linked to the five MLEEC dimensions.
2. **Select Simulation Modality** (best-fit from live, online, or board-game).
3. **Train Facilitators** in both theoretical grounding and debrief technique.
4. **Establish Psychological Safety** through explicit ground rules.
5. **Design Disorienting Dilemmas** that trigger critical reflection.
6. **Embed Ethical Decision Points** with structured moral debriefs.
7. **Collect Multi-Modal Data** (pre/post surveys, journals, observation).
8. **Conduct Triangulated Analysis** to link outcomes to framework variables.
9. **Contextualize Culturally** (adapt metaphors and moral framing to local norms).
10. **Iterate and Scale** by integrating findings into blended or hybrid programs.

These steps provide educators with a replicable blueprint for embedding MLEEC within executive, postgraduate, or sector-specific leadership curricula.

14. Practical implications

The MLEEC framework carries significant practical implications for the design, delivery, and evaluation of leadership development programs, particularly in executive education. By conceptualizing leadership as an adaptive, embodied, and ethically situated process, the framework reorients practice toward experiences that are intentionally disruptive, emotionally engaging, and cognitively

Table 5
Applying MLEEC Dimensions in Practice [source: authors].

MLEEC Dimension	Core Learning Focus	Representative Simulation Activities	Modality Emphasis
Transformative Learning	Identity shift through disorienting dilemmas	Scenario role switches, critical reflection prompts	Action-based simulation, Board Game
Psychological Safety Sensemaking	Interpersonal risk-taking and feedback Cognitive agility under ambiguity	Open dissent exercises, team debriefs Fragmented info delivery, time-compressed updates	All formats with structured debrief Online game, Action-based simulation
Embodied Cognition	Somatic awareness and physical response	Multi-room movement, sensory interruptions	Action-based simulation
Ethical Decision-Making	Moral reasoning and value conflict navigation	Irreversible moral dilemmas, stakeholder conflicts	All formats, esp. facilitated plenaries

integrative.

First, the MLEEC framework emphasizes the intentional use of disorienting dilemmas - not as accidental learning moments, but as designed catalysts for transformation. This requires educators to move beyond low-stakes case studies and incorporate high-intensity simulations, unfolding crises, and ethical gray zones that destabilize habitual thinking. The K2-inspired learning design exemplifies how immersive scenarios can function as structured “cognitive shock” events that trigger reflection, reappraisal, and reframing—key processes in transformative leadership development.

Second, the framework highlights the need to construct psychologically safe yet appropriately challenging environments. This goes beyond simply building trust; it calls for a carefully designed andragogical approach that integrates emotional vulnerability with structured debriefing, collaborative reflection, and guided sensemaking (Kim et al., 2020). In practice, this could take the form of rotating leadership roles in group tasks, facilitated post-simulation dialogues, or reflective journaling practices designed to normalize failure as a developmental asset. Importantly, educators must be trained to recognize and manage learner overwhelm, especially in simulations that evoke stress or moral conflict.

Third, MLEEC calls for the embedding of real-time sensemaking into learning design. This involves creating ambiguous, information-rich scenarios with progressive disclosure, time constraints, and shifting conditions, replicating the fragmented and fluid nature of leadership challenges in the real world. For example, multi-stage crisis simulations, decision-tree mapping, or role-switching under pressure enable participants to rehearse cognitive agility and meaning-making on the fly, rather than through retrospective analysis alone.

Fourth, the model encourages practitioners to treat the body as a site of leadership learning. This is particularly relevant in contexts such as healthcare, aviation, or the military - where stress, fatigue, and time compression are not theoretical, but daily realities. Integrating physiological monitoring tools (e.g., biofeedback apps), outdoor expeditions, or embodied role-play scenarios allows participants to become aware of their emotional and somatic signals, ultimately developing stress resilience and decision composure under pressure.

Fifth, future iterations of MLEEC can leverage cost-effective digital tools such as virtual-reality (VR) environments, AI-driven adaptive feedback, and wearable biosensors to capture physiological responses (heart-rate variability, galvanic skin response) during simulation. These technologies enable scalable, data-rich assessment of embodied stress regulation and provide facilitators with objective metrics to complement reflective debriefs.

Sixth, the MLEEC framework elevates the importance of ethical reflexivity as a lived, rather than abstract, leadership skill. Educators are encouraged to incorporate scenario-based moral dilemmas that require learners to weigh competing values, reflect on real-time ethical trade-offs, and navigate the tension between individual survival and collective responsibility. These can be enhanced through structured ethical debriefs, stakeholder-switching exercises, or Socratic dialogue that invites participants to confront - and learn from - their own moral reasoning under constraint.

Finally, the framework advocates for a scaffolded, multi-modal, learning architecture. Educators should design development journeys that progress from low-stakes discussion-based learning to immersive, high-complexity challenges. This scaffolding might include initial analysis of the K2 case, followed by a team-based board game exploring coordination trade-offs, an online game exploring long-term strategic foresight, and finally, a high-fidelity crisis simulation. Such sequencing supports the gradual expansion of leadership capacity across cognitive, emotional, behavioral, and ethical domains.

The MLEEC framework provides a blueprint for cultivating leaders who are not merely knowledgeable, but adaptable, resilient, and ethically attuned. It shifts leadership education away from technical competence and toward human complexity, preparing individuals to lead effectively in the volatile, uncertain, and morally complex environments that define contemporary organizational life.

15. Conclusion

This article advances the field of leadership education by integrating the MLEEC framework with immersive simulation to assess complex, multi-dimensional learning outcomes. Across three simulation formats, live-action, online, and board game, we identified consistent development in five core areas: transformative learning, psychological safety, sensemaking and decision-making, embodied cognition, and ethical reasoning. Drawing on qualitative data from participants and facilitators, the study demonstrates how varied simulation modalities can elicit meaningful shifts in leadership capability, both cognitively and emotionally.

The 2008 K2 tragedy provides a powerful and distinctive case for leadership development. Unlike other extreme context scenarios that center on isolated failures or heroic leadership, K2 reveals distributed responsibility, competing goals, and escalating moral complexity among interdependent teams. These features mirror the ambiguity and ethical tension that executives often face, making K2 a compelling anchor for experiential learning grounded in real-world relevance.

The findings suggest that well-designed simulations, framed by a coherent theoretical model like MLEEC, can move beyond skills training to develop deeper forms of leadership insight. By fostering reflective practice in emotionally and ethically charged environments, these simulations help prepare leaders for the demands of VUCA contexts.

Future research will extend the MLEEC framework across multiple sectors, including healthcare, defense, and public policy domains. A longitudinal follow-up study is currently being designed to examine whether the behavioral and attitudinal shifts observed immediately after the simulations are sustained over a 6–12 month period. Participants will complete repeat surveys and optional interviews to evaluate long-term leadership adaptation, ethical reflexivity, and learning transfer to professional contexts. Comparative case simulations, larger sample sizes, and cost-effective digital or board game modalities should also be explored to assess scalability and sustained behavioral change.

CRediT authorship contribution statement

Kate Davis: Writing – review & editing, Writing – original draft, Visualization, Validation, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Elmar Kutsch:** Writing – review & editing, Conceptualization. **Neil Turner:** Writing – review & editing, Conceptualization. **Zoe Lynch:** Resources, Conceptualization.

Theoretical and contextual contributions

This study contributes to leadership theory by advancing the MLEEC framework as an integrated, multi-dimensional approach to leadership learning in extreme contexts. It extends existing VUCA and crisis leadership literature by synthesizing transformative learning, psychological safety, sensemaking, embodied cognition, and ethical reflexivity into a coherent model. Unlike prior studies that treat these constructs separately, MLEEC demonstrates their interdependence under immersive simulation. Contextually, the application of the 2008 K2 tragedy enriches leadership education research by positioning mountaineering disasters as analogues for organizational crises, thereby grounding abstract theory in visceral learning experiences. The findings provide both educators and scholars with a replicable template for designing experiential interventions that foster adaptive, ethically attuned leadership in volatile, high-stakes environments.

Limitations

Several limitations should be acknowledged. First, the findings rely primarily on qualitative self-report data and facilitator observations, which may introduce subjectivity. Second, while the participant pool was diverse in sectoral representation, it was limited to senior-level professionals, reducing generalizability to other populations. Third, long-term behavioral transfer was not systematically tracked, leaving open questions about sustained impact.

Finally, the study focuses on a single anchoring case (the K2 tragedy), which, while powerful, may not capture all forms of extreme context leadership. We also acknowledge potential novelty effects, since participants may respond strongly to the uniqueness of the simulation experience. Scalability is another limitation, as high-fidelity live-action simulations are resource-intensive, requiring significant facilitator expertise and logistical investment.

Disclosure statement

The authors report there are no competing interests to declare.

Data availability

The data that has been used is confidential.

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From tragedy to training: multi-dimensional leadership learning through the K2 mountain simulation

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