

Anticipating Skills For 2050: A Strategic Vision for Aviation Education and Workforce Development in Romania

Adina-Roxana MUNTEANU¹, Adina Petruta PAVEL², Alexandra Maria STANILA³

^{1,2,3}The National University of Science and Technology Politehnica Bucharest

ABSTRACT: As the aviation industry faces the combined pressures of rapid automation, mandatory decarbonization, and a shrinking labor pool, the traditional models of workforce planning are becoming obsolete. We argue that for a highly regulated and innovation-sensitive sector, a reactive approach to education is no longer viable and we propose a foresight-driven strategy for human capital development through 2050. By synthesizing European policy mandates with "on-the-ground" data from recent Erasmus+ projects, the study identifies the structural gaps currently hindering the sector, most notably the lag between industrial innovation and national training standards. We present a phased roadmap built on modular learning and institutional capacity building, designed to survive the political and administrative discontinuity that has historically stalled Romanian reform. While grounded in the specific technical and bureaucratic realities of aviation, the framework offers a transferable model for any sector navigating a high-stakes, large-scale industrial transformation.

KEYWORDS-Strategic foresight; Aviation education; Human capital development; Workforce transformation;

I. INTRODUCTION

The global workforce is navigating a period of profound transformation driven by digitalisation, the constraint of the green transition, and structural demographic change. Across all sectors, including aviation, technological advancements such as automation, artificial intelligence, and data-driven systems are reshaping job profiles and competency demands (Cedefop, 2023). Simultaneously, the European Union's climate commitments, including the Green Deal's net-zero target by 2050 (European Commission, 2019), are pushing labour markets toward greener industries and creating demand for sustainability-oriented roles (Cedefop, 2023). These developments are placed in a context of significant demographic pressures, including an ageing population and declining labour force participation, which are expected to further exacerbate skill shortages in strategic sectors (Cedefop, 2023). Together, these trends are compelling education and training systems to adapt proactively, with long-term strategic foresight becoming essential to human capital planning.

While skills gaps are a longstanding concern in EU labour markets, recent developments have intensified the problem. Employers across Europe, especially in technology-intensive and regulation-heavy sectors, are increasingly unable to find workers with the right competencies (Telling & Serapioni, 2019). In a 2023 EU-wide survey, 74% of SMEs reported difficulties in filling roles, with many pointing to critical shortages in digital and technical occupations (Santini, 2024). Notably, the same study revealed that nearly half of firms found such shortages to be an obstacle to adopting advanced technologies.

Even in the absence of major shocks in the short term, the European aviation labour market faces significant structural problems in the medium term. Projections indicate a possible shortage of around 19,000 pilots by 2032, given that training capacities are not expanded in proportion to demand (EasyEASA.com, 2025). This development is amplified by the wave of retirements of experienced staff, often described in the literature as a 'silver tsunami', which disproportionately affects high-skilled occupations. In this context, recruitment difficulties are becoming a chronic problem: more than half of SMEs in European aviation describe the recruitment process as very difficult, and a quarter consider it moderately difficult (European Commission, 2023).

These mismatches reflect deeper structural misalignments between education outputs and labour market needs. From a human resources (HR) perspective, this means increased investment in reskilling and recruitment strategies. From an education policy standpoint, it reveals an urgent need for training systems to anticipate changing industry demands. The European Commission's declaration of 2023 as the "European Year of Skills" further underscores the strategic significance of this challenge (Cedefop, 2023; Santini, 2024).

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Despite growing recognition of the need for adaptability, current policy and academic discourse often lack integration between long-term strategic foresight and workforce development frameworks. Existing education and HR strategies predominantly address short- to medium-term needs, often guided by incremental reform rather than systemic reconfiguration based on a vision. Analyses such as those by Telling and Serapioni (2019) and Cedefop (2023) have highlighted the limits of this approach: planning cycles frequently stop at 2030, failing to anticipate emerging demands of the next two or three decades. There is still no dominant framework that links scenario planning or futures literacy to the design of education systems and occupational standards. Education and training provision thus remains largely reactive, reinforcing the need for a forward-oriented model that combines strategic visioning with operational HR and policy reform.

We respond to the identified gap by developing a strategic vision for 2050 for aviation education and workforce development in Romania. The aviation sector, given its high skill intensity, global integration, and technological pace, offers a critical case through which to explore how education and human resource systems can become more anticipatory.

The paper draws conceptually from recent scholarship on strategic foresight in education policy (Abu Sitta, 2025; AlMalki & Durugbo, 2023), workforce adaptability in the context of digital and green transitions (Bianchi et al., 2024; Albertz & Pilz, 2025), and sectoral governance in training system design (Bravo et al., 2022; Pronello & Fedeli, 2025). These theoretical perspectives frame the transformation of aviation education as part of a broader shift toward anticipatory, stakeholder-driven, and equity-oriented skill ecosystems.

Drawing on futures-oriented methods, EU policy frameworks (European Commission, 2019; European Commission, 2020; Cedefop, 2023), and evidence from Erasmus+ projects (Zaharia et al., 2021; Zaharia et al., 2025), the study proposes an integrated roadmap that aligns education reform, training provision, and stakeholder coordination with long-term sectoral transformation. The aim is both conceptual and applied: to bridge foresight and education system planning, while generating a practical model for reform in Romania and potentially other national or sectoral contexts.

The contribution of this paper on one side, theoretical, as it advances the literature on human capital development by embedding long-term strategic foresight and futures literacy into education policy and HR planning and on the other side, practical, as it offers a scenario-based strategy for aligning current educational structures with the anticipated competency needs of 2035–2050.

II. METHODOLOGY

The methodology of this study is designed as a multi-dimensional synthesis, moving beyond static document analysis to integrate long-term foresight with empirical sectoral data. This journey began with a rigorous examination of the European and national policy landscapes (Strategic Research and Innovation Agenda of ACARE (2022), the European Skills Agenda (European Commission, 2020)) to identify the high-level imperatives shaping the industry through 2050. At the international level, we focused on the environmental and technological benchmarks set by Flightpath 2050 (European Commission, 2011), and the European Green Deal (European Commission, 2019), as these provide the regulatory boundaries within which any national skills strategy must operate. These were then critically aligned with Romania's domestic education priorities, specifically the România Educată [Educated Romania] strategy (Administrația Prezidențială, 2021) and the National Recovery and Resilience Plan (Ministerul Educației, 2023), to ensure that the proposed vision remains grounded in national legislative realities.

The empirical layer was added by integrating findings from the KAAT (Zaharia et al., 2021) and AVIONIC (Zaharia et al., 2025) Erasmus+ projects. Rather than treating these as isolated case studies, we utilized their granular data on emerging occupational profiles and labor shortages to "stress-test" broader industry forecasts provided by IATA (2022) and CAE (2023). This nuanced our understanding of the systemic limitations currently hindering Romanian aviation training, specifically the gap between outdated occupational classifications and the rapid rise of green and digital roles.

Finally, the design of the Vision 2050 roadmap is conceptually anchored in the literature of strategic foresight and futures literacy. We specifically adopted a backcasting approach to determine how existing educational structures must evolve to meet the "triple transition", digital, green, and skills-based, identified in contemporary human capital scholarship. By leveraging the principles of sectoral governance, the resulting strategy proposes a collaborative model where multi-stakeholder "living hubs" and the National Aviation Skills Council act as the primary engines for resilience and adaptive policy-making.

We designed the strategy to be conceptually anchored in emerging academic literature on education transformation, labour transitions, and skills governance. Contributions from foresight scholarship (Abu Sitta, 2025; AlMalki & Durugbo, 2023) highlight the role of tools such as scenario planning, Delphi studies, and futures literacy in increasing policy resilience and adaptability. Human capital development literature has further evolved toward addressing what Bianchi et al. (2024) frame as a "triple transition", encompassing digital, green, and skills transformations, that must be managed in an equitable and inclusive way. In the VET context, Albertz and Pilz (2025) identify pathways for deep sustainability integration that resonate with the needs of innovation-sensitive and environmentally regulated sectors like aviation.

Finally, literature on sectoral governance highlights the importance of collaborative structures for skills alignment. Bravo et al. (2022) document how sector skills councils, whether state- or industry-led, can coordinate curriculum design, standard-setting,

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and training investment. Similarly, Pronello and Fedeli (2025) demonstrate how participatory mechanisms, such as multi-stakeholder “living hubs,” can facilitate workforce resilience strategies in sectors undergoing technological transformation. These studies reinforce the argument that Romania’s aviation strategy should be embedded within inclusive, adaptive, and foresight-informed governance models.

Despite its analytical depth, this study is subject to several methodological limitations. Most notably, it relies primarily on secondary sources, strategic policy documents, academic literature, and Erasmus+ project outcomes, without incorporating direct stakeholder input or primary data collection. While this document-based approach is suitable for constructing a preliminary vision and reform framework, future validation should include empirical consultation methods such as Delphi studies, scenario workshops, or structured interviews with education providers, industry leaders, and regulatory bodies. These techniques would enrich the framework by capturing stakeholder perspectives, surfacing operational constraints, and testing the feasibility of proposed reforms in real institutional settings. Incorporating such participatory foresight methods would further enhance the legitimacy, precision, and adaptability of Romania’s aviation education strategy.

III. STRATEGIC DIAGNOSIS FOR ROMANIA

The Romanian aviation sector occupies a critical intersection of national economic development, international connectivity, and high-skill employment. However, the sector’s capacity to adapt to future challenges is constrained by structural weaknesses in both its educational infrastructure and workforce development systems. These weaknesses manifest as skills shortages, fragmented institutional coordination, and limited alignment with global trends in aviation technology and sustainability.

At present, the aviation industry in Romania faces mounting workforce pressure driven by global and regional trends. Post COVID-19 pandemic the industry has recovered. Moreover, the expanding demand for urban air mobility and increased international air travel, has increased the labour demand. Recent forecasts estimate the need for over 1.3 million new aviation professionals globally by 2032, including hundreds of thousands of pilots, engineers, and maintenance personnel (CAE Inc., 2023). Romania is not exempt from these pressures. However, its ability to meet projected workforce needs is limited by an ageing workforce, insufficient training capacity, and outdated occupational classifications (Zaharia et al., 2025).

A critical issue underpinning the sector’s workforce fragility is the disconnect between educational institutions and labour market demands. Romania’s aviation education is fragmented across a patchwork of providers, including vocational schools, technical colleges, universities, and private training centres, each operating with differing standards, funding mechanisms, and degrees of alignment to industry requirements. Curricula are often rigid, slow to adapt to new technologies, and disconnected from practical industry applications. This limits the sector’s ability to respond to emerging roles in drone operations, green aviation technologies, data-driven flight systems, and cybersecurity.

Moreover, the vocational and technical education pathways that should form the foundation of the aviation skills pipeline are often undervalued and under-resourced. While there are notable initiatives and individual centres of excellence, there is no nationally coordinated mechanism for ensuring quality, coherence, and strategic alignment in aviation education. As a result, employers report persistent gaps in foundational competencies (e.g., digital literacy, problem-solving, English proficiency) as well as sector-specific technical skills.

Beyond institutional fragmentation, Romania’s aviation workforce development is constrained by limited industry–education collaboration and weak stakeholder coordination. While recent Erasmus+ projects such as KAAT and AVIONIC have demonstrated the value of joint curriculum design and occupational mapping (Zaharia et al., 2021A), these initiatives remain project-based rather than systemically embedded. Strategic planning is further hampered by the absence of reliable and disaggregated data on current and future workforce needs, particularly in the context of emerging green and digital roles.

These factors point to a fragile aviation education and workforce environment one in need of structural reform, strategic visioning, and institutional capacity building. The challenges outlined above not only threaten the sector’s long-term sustainability but also reflect broader systemic gaps in Romania’s human capital development strategy. Addressing them will require coordinated, forward-looking efforts to align education systems, regulatory frameworks, and labour market dynamics around a shared strategic goal.

IV. VISION 2050

By 2050, Romania’s aviation education must transcend its current fragmented state to become a resilient and future-oriented environment. However, achieving this requires more than just adopting European mandates; it requires overcoming deep-seated structural friction, such as the persistent lag between rapid technological shifts and the rigid update cycles of national occupational standards. The Vision 2050 scenario is not a frictionless transition, but a managed evolution in how talent is cultivated and retained in a context of economic competitiveness, alignment with European Union priorities on digital transformation, sustainability, and cross-border mobility.

At the center of this 2050 vision is a shift toward modular, competency-based learning. While interoperable micro-credentials offer the flexibility needed for modern careers, their implementation in Romania faces the immediate technical challenge of

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synchronizing private training academy standards with university credit systems. The 2050 professional must be tech-savvy and sustainability-minded, yet they will likely operate in a landscape where legacy infrastructure still exists alongside cutting-edge unmanned aerial systems and green propulsion technologies. This dual reality demands an "agility of mindset" that goes beyond simple digital literacy.

Institutionally, we envision a system that finally bridges the "disconnect" between technical colleges and industry needs. This requires moving past the current project-based nature of collaboration, often seen in the temporary lifespans of Erasmus+ initiatives, toward stable, multi-annual funding for the National Aviation Skills Council. This Council should, ideally, act as a buffer against the political discontinuity that has historically disrupted Romanian educational reform. Furthermore, for Romania to truly internationalize, we must address the practical hurdle of widespread English-medium instruction and the mutual recognition of qualifications under the European Qualifications Framework (EQF), ensuring that Romanian-trained professionals are not just mobile, but globally competitive. In this vision, education functions as a strategic enabler, turning today's labor shortages into a future of sectoral resilience

This Vision 2050 scenario serves as both a destination and a reference point. It defines the desired future state against which Romania's current systems can be assessed, and from which strategic objectives and implementation pathways can be backcasted.

V. STRATEGIC OBJECTIVES

Translating a vision as broad as 2050 into reality requires a sequence of milestones that are both ambitious and grounded in the practicalities of reform. Rather than assuming a linear progression, our roadmap utilizes a backcasting methodology to identify the critical "must-haves" for each decade, recognizing that the early years will be the most intensive in terms of regulatory and cultural groundwork.

The first phase 2026–2030 will create the foundational "Heavy Lifting". The immediate priority is not technological, but institutional. This first phase is arguably the most difficult, as it requires the comprehensive audit of existing programs to align them with ESCO and EQF standards, a process that often uncovers deep-seated curriculum obsolescence. We propose the immediate standing up of the National Aviation Skills Council to act as the central "clearing house" for these reforms. The success of this phase hinges on the launch of pilot programs in dual education, specifically in high-demand areas like maintenance engineering and drone operations, to prove the concept to skeptical stakeholders.

The period between 2031–2035 will focus on scaling and technical modernization. Once the regulatory foundation is stable, the focus shifts toward the massive task of scaling. This is the period of high-capital investment. Romania must modernize its training infrastructure, moving beyond traditional classrooms toward augmented reality / virtual reality labs and high-fidelity simulators that reflect the operational reality of modern flight decks and hangars. Sustainability and digitalisation must become transversal pillars embedded throughout aviation training curricula, supported by a national competency framework and anchored in stakeholders consultations.

Crucially, this phase must tackle the "teacher gap" by prioritizing the professional development of educators, ensuring they don't just have the new tools, but the pedagogical skill to use them

The long-term phase, extending from 2036 to 2050, is oriented toward the consolidation of reforms and the integrations of Romania's aviation education into the global system. In this final phase the shifting from national reform to international leadership should be achieved. By this stage, the "innovative" practices of the previous decade must become the standard. The goal here is the full portability of Romanian credentials under ICAO and EASA standards, effectively turning Romania into a regional magnet for aviation talent. This period is less about building new structures and more about refining the research–industry–education synergies that keep the system resilient against future disruptions.

Finally, to preserve the relevance and responsiveness of the system, the strategic vision itself must be subject to periodic renewal. Embedding foresight cycles into national planning, reviewed every five to seven years, will enable the strategy to remain aligned with evolving global trends and sectoral realities.

VI. STRATEGIC DIRECTIONS AND REFORM PATHWAYS

The transition toward a resilient aviation education system in Romania is a complex matter, involving policy adoption, overcoming challenges of systemic reconfiguration across four interdependent directions: curriculum reform, institutional capacity, lifelong learning, and governance. Converting long-term objectives into actionable pathways requires us to confront a fragmented landscape where legacy systems often conflict with future-ready requirements.

A. *Overcoming the Bureaucratic Lag in Curriculum Reform*

The first strategic direction involves a fundamental redesign of curricula to match the industry's rapid pace. Curriculum reform should move decisively toward modular, competency-based structures that allow learners to build relevant skill sets in flexible formats.

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However, the real-world challenge lies in the systemic lag of national qualification frameworks, where official updates often take years to reflect the rise of green and digital roles. Moving toward modular, competency-based structures is essential, yet implementing micro-credentials in Romania requires overcoming the lack of interoperability between private flight academies and public university credit systems. Sustainability and digitalization cannot remain "add-ons"; they must be integrated into a framework that accounts for the reality that many instructors are currently teaching with tools that the industry has already phased out.

B. Moving Institutional Capacity Beyond Technology Procurement

Enhancing institutional capacity is often misunderstood as simply purchasing hardware. In reality, the "technological upgrade" of simulators and AR/VR environments is futile without a massive, parallel effort in pedagogical updates. Romania faces a "teacher gap" where educators themselves lack the technical upskilling required for high-fidelity instruction. Designating centres of excellence must serve as a strategy to concentrate limited resources and prevent the "dilution" of quality across too many under-funded institutions. Furthermore, accreditation bodies must evolve to recognize hybrid learning models without getting stuck in the rigid "attendance-based" metrics of the past.

C. Resilience and Lifelong Learning

Lifelong learning must shift from a theoretical concept to a functional reality for mid-career professionals facing automation or green transitions. The practical hurdle here is the lack of a standardized mechanism for recognising prior learning, which often forces experienced technicians to repeat basic coursework.

Furthermore, we must address the mental well-being and psychological safety of a workforce under increasing pressure. Transitioning to 'Safety II' and salutogenesis models is a cultural challenge; it requires breaking the stigma within Romanian aviation where disclosing stress is often feared as a precursor to losing a license. Additionally, the integration of evidence-based training enables personnel to identify indicators of stress in themselves and their colleagues, effectively de-stigmatizing mental health within safety-sensitive environments. Finally, as demonstrated by recent global disruptions, the inclusion of training for digital resilience has become highly relevant for a future-ready workforce (Munteanu, 2024).

D. Breaking Political Discontinuity

The final direction concerns the integration of foresight into policymaking. Effective transformation is impossible without a formal platform to end the "political discontinuity" that has historically plagued Romanian education reform. The National Aviation Skills Council must be more than an advisory group; it must act as a permanent bridge between the "clocks" of industry innovation and administrative regulation. By deploying labor market intelligence systems, Romania can finally move away from reactive planning and toward a data-informed strategy that survives shifting government priorities.

VII. RISK FACTORS AND IMPLEMENTATION CHALLENGES

While the roadmap for 2050 provides a clear trajectory, its realization is not a frictionless process. The feasibility of this transformation depends on the ability of Romanian institutions to navigate an complex landscape of vulnerabilities. While a comprehensive risk register for such a long-term strategy would include diverse factors, ranging from financial sustainability and project-based funding traps to the inherent volatility of labor market projections, we have identified three primary dimensions that present the most significant hurdles to reform.

Political and Administrative Discontinuity is assessed as the most persistent threat is the historical lack of policy consistency in Romania. Strategic initiatives in education are frequently disrupted by electoral cycles and frequent changes in ministerial leadership, which often leads to the abandonment of long-term goals in favor of short-term priorities. Without a cross-party consensus to protect the National Aviation Skills Council, the strategy risks becoming another "dormant" policy. This is compounded by fragmented governance where overlapping mandates between ministries can stall decision-making for years.

Romania's education system has experienced numerous reforms since the fall of communism, yet achieving continuity and long-term implementation has proven difficult. Scholars attribute this to the country's volatile political context, reforms are often launched "in a climate of political instability" (Rușitoru, 2016). In particular, short electoral cycles, frequent changes in government leadership, and inconsistent political commitment have repeatedly disrupted education policies before they can take root. One analysis even argues that "excessive politicization of education" has been the primary obstacle preventing policy ideas from translating into classroom practice (Nicu, 2016).

Secondly, we look at the institutional capacity constraints. Even with political will, the "on-the-ground" reality of Romanian VET and higher education institutions reveals deep resource gaps. Many providers simply lack the modern digital infrastructure or the "human capital" required to teach emerging green aviation technologies. We see a real risk of a "two-tier" system emerging, where well-connected urban centers modernize while peripheral, under-resourced regions are left behind, unable to scale the innovations proposed in this roadmap.

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Finally, the stakeholder resistance and institutional inertia is also highly relevant. We must acknowledge the "human factor" of resistance to substantive reform. Moving from rigid, traditional curricula to modular, industry-led frameworks disrupts long-standing power dynamics within academia and public administration. This resistance often manifests as passive non-compliance or "policy dilution," where the names of programs change but the underlying instructional methods do not. Overcoming this requires more than just top-down mandates; it requires building genuine coalitions of support through pilot programs that prove the value of the new model to those who feel most threatened by it.

Addressing these three core areas proactively is essential for shifting Romania's aviation sector from an aspirational vision to a sustained educational reality.

VIII. MONITORING AND EVALUATION FRAMEWORK

The implementation of a long-term strategic vision such as Romania's Vision 2050 for aviation education and workforce development requires a robust monitoring and evaluation (M&E) framework to ensure accountability, track progress, and support adaptive learning. Given the complexity and extended time horizon of the transformation process, the M&E system must combine short-term operational indicators with medium- and long-term outcome measures, while remaining responsive to emerging developments in technology, labour market dynamics, and educational practice.

A key principle supporting the M&E framework is the alignment with the phased strategic objectives outlined earlier. In the short term, monitoring efforts should focus on the establishment of foundational elements: the creation of stakeholder platforms, the launch of pilot programs, and the adoption of updated qualification frameworks. Indicators such as the number of institutions engaged in curriculum audits, the rollout of digital learning environments, or the uptake of micro-credentials can provide early signals of institutional responsiveness and policy traction.

As the strategy progresses into its medium- and long-term phases, the evaluation framework must shift toward assessing system-level impacts. Metrics should capture the integration of green and digital competencies into training provision, the extent of industry-education partnerships, and the operationalisation of dual learning pathways. At the workforce level, outcome indicators may include employment rates of aviation graduates, skill match indices, and labour market mobility patterns. International benchmarking, using EU-level tools such as CEDEFOP's skills intelligence dashboards or the European Skills Index, can also offer comparative insights and highlight areas of strength or underperformance.

To ensure credibility and effectiveness, the M&E system must be institutionally anchored and methodologically rigorous. A dedicated national observatory or independent evaluation unit should be tasked with data collection, stakeholder reporting, and the publication of periodic strategic reviews. These reviews should feed directly into policy cycles, enabling timely course correction and strategic recalibration. Moreover, the use of foresight-based approaches in monitoring—such as stress-testing current strategies against alternative scenarios—can enhance resilience and strategic agility.

Finally, transparency and stakeholder engagement are vital for a learning-oriented M&E culture. Dashboards, annual progress reports, and consultation processes should be used both as accountability tools and instruments for collective reflection and capacity building. In this way, the monitoring and evaluation framework becomes a mechanism for maintaining long-term vision while continuously improving the effectiveness of Romania's aviation education and workforce systems.

CONCLUSIONS

This study has developed a long-term strategic roadmap intended to reposition Romania's aviation education system from a reactive posture to a proactive, foresight-driven model. Our analysis suggests that the convergence of rapid digitalisation, the mandatory green transition, and shifting demographics necessitates more than just incremental changes; it demands a fundamental systemic reconfiguration. By synthesizing the high-level goals of Flightpath 2050 (European Commission, 2011) with the granular, project-based findings of KAAAT (Zaharia et al., 2021) and AVIONIC (Zaharia et al., 2025), we have illustrated that the path to a resilient workforce lies in bridging the gap between outdated training structures and the sophisticated competency needs of 2035–2050.

While the challenges identified (ranging from institutional fragmentation to the "silver tsunami" of retirements) are significant, the proposed Vision 2050 framework offers a scalable solution. The integration of modular, competency-based learning and the establishment of a National Aviation Skills Council are not merely administrative suggestions, but essential pillars for an internationalized, competitive ecosystem. Beyond the aviation sector, this research demonstrates that combining futures thinking with concrete implementation tools, such as the backcasting methodology, can effectively bridge the gap between aspirational policy rhetoric and actionable system design.

The success of the proposed strategy is contingent, however, upon a sustained commitment to institutional coordination and a cultural shift toward lifelong learning. By investing in these educational foundations today, Romania can secure its position within the global knowledge economy, ensuring that its workforce is not only technically proficient but also psychologically resilient and digitally fluent. This strategic vision serves as both a call to action and a transferable model for other sectors navigating the complexities of large-scale industrial transformation.

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