Beyond STEM:

A New North Star for European Competitiveness

ASSOCIATION OF NORDIC ENGINEERS

For three decades, the STEM framework — grouping Science, Technology, Engineering, and Mathematics — has organised how we think about technical education and workforce development. This categorisation served Europe well in an era when technical competencies translated relatively directly into economic value, when value chains were more stable, and when educational investments could rely on gradual market adjustment mechanisms.

That era has ended. The STEM acronym now obscures more than it reveals. It treats fundamentally different capabilities as equivalent, masks the actual mechanisms through which technical skills create economic value, and prevents education systems from responding effectively to transformed economic realities — particularly in a lifelong learning context. Most critically, it undermines our ability to achieve three interrelated policy goals: maintaining European competitiveness in strategic sectors, building economic resilience amid geopolitical fragmentation, and sustaining the European social model that links education to inclusive prosperity.

This policy note argues that we must move beyond STEM as an organising framework. Increasing the number of STEM graduates is not sufficient on its own; categorising graduates solely by this metric may obscure our understanding of how technical skill requirements evolve within global value chains. This limitation can hinder the development of effective lifelong learning initiatives and industrial policies that are tailored to the needs of European societies.

Policy Note for the Nordic Conference of Engineers, prepared by **HANNE SHAPIRO Futures,** *for the Nordic Association of Engineers, ANE*

How Global Value Chains *Expose STEM's Inadequacy*

The Illusion of Equivalence

The STEM framework implies that a mathematics graduate, a mechanical engineer, a biologist, and a computer scientist share some fundamental commonality that makes them interchangeable contributors to "the knowledge economy." Global value chain dynamics reveal this as fiction.

Consider Europe's position across different sectors. In pharmaceutical value chains, we maintain strong positions in research and regulatory pathways. In semiconductor value chains, we excel in specific equipment domains but lack capabilities in design and advanced manufacturing. In digital platforms, we consume rather than create. These differences do not mirror generic STEM gaps, but rather the distribution of specific technical capabilities that correspond to strategic value chain positions.

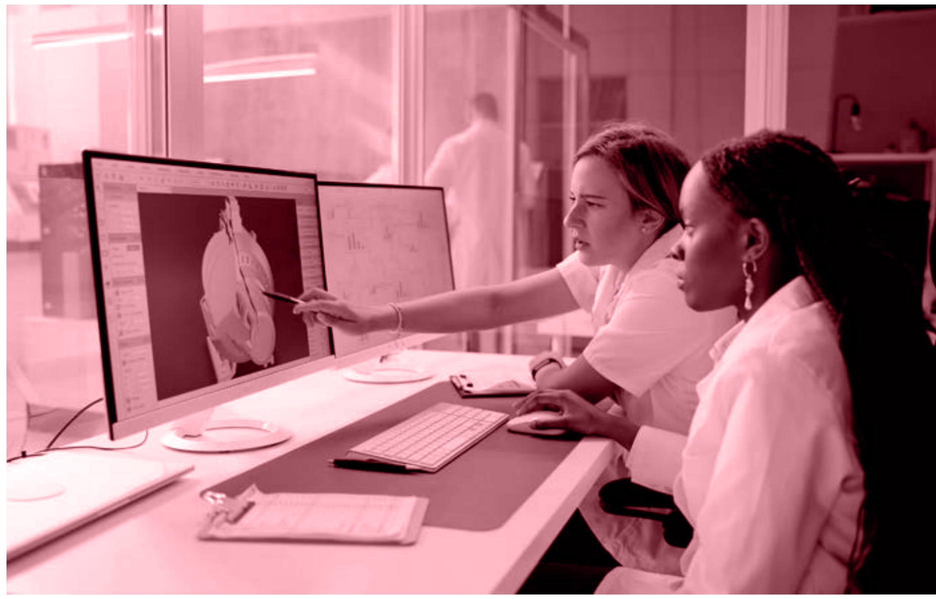
While we still struggle to improve the overall attractiveness of science, technology and engineering education, policy success should not be measured by headcount — how many STEM graduates we produce — but rather by strategic capability: What specific technical competencies enable participation in high-value chain segments? How are these distributed across our workforce? Where do capability concentrations create competitive advantage? Where do critical gaps threaten our autonomy? The STEM framework prevents us from addressing these questions because it aggregates away the granularity that strategic positioning requires — and therefore from designing appropriate, anticipatory, and data-driven policies.

Geographic Fragmentation and the Stratification of the Future of Work

Global value chains have fundamentally altered how technical capabilities create value. Lead firms in advanced economies concentrate activities like R&D, design, and system integration — requiring deep specialised expertise, interdisciplinary problem-solving, and innovation capabilities. Mass manufacturing and routine technical operations have tended to locate in cost-competitive regions, demanding different competencies focused on process optimisation, quality control, and incremental improvement.

This geographic fragmentation means that seemingly identical formal qualifications — an engineering degree — translate into radically different economic functions and value creation depending on which value chain position an economy occupies. Germany and Vietnam both train engineers, but German engineering education connects to upstream innovation activities while Vietnamese programs emphasise manufacturing operations. Both are "STEM," yet they serve entirely different economic functions and command vastly different returns.

For Europe, the critical insight is that maintaining high-value positions requires specific technical capabilities, not generic STEM capacity. The skills enabling quantum computing innovation are fundamentally different from those for battery manufacturing, which differ from those for AI model deployment. More importantly, capabilities must align with Europe's realistic competitive position within each value chain. No nation can achieve dominance across all technology segments simultaneously. Strategic positioning requires identifying domains where concentrated investment and capability development can create a genuine advantage. The STEM framework's aggregation hampers policy coordination and hence strategic clarity.



Platform Dominance

Dominant platform firms — predominantly American, increasingly Chinese — shape which technical capabilities remain valuable across entire value chains through their technology choices, standards, and tool ecosystems, as was also illustrated by Nordic Innovation in their conference presentation [1]. The rapid shift toward cloud computing, artificial intelligence, and data analytics illustrates the dynamic: established technical competencies become obsolete not because they lack rigour, but because platform firms shift the technological foundations upon which entire industries depend.

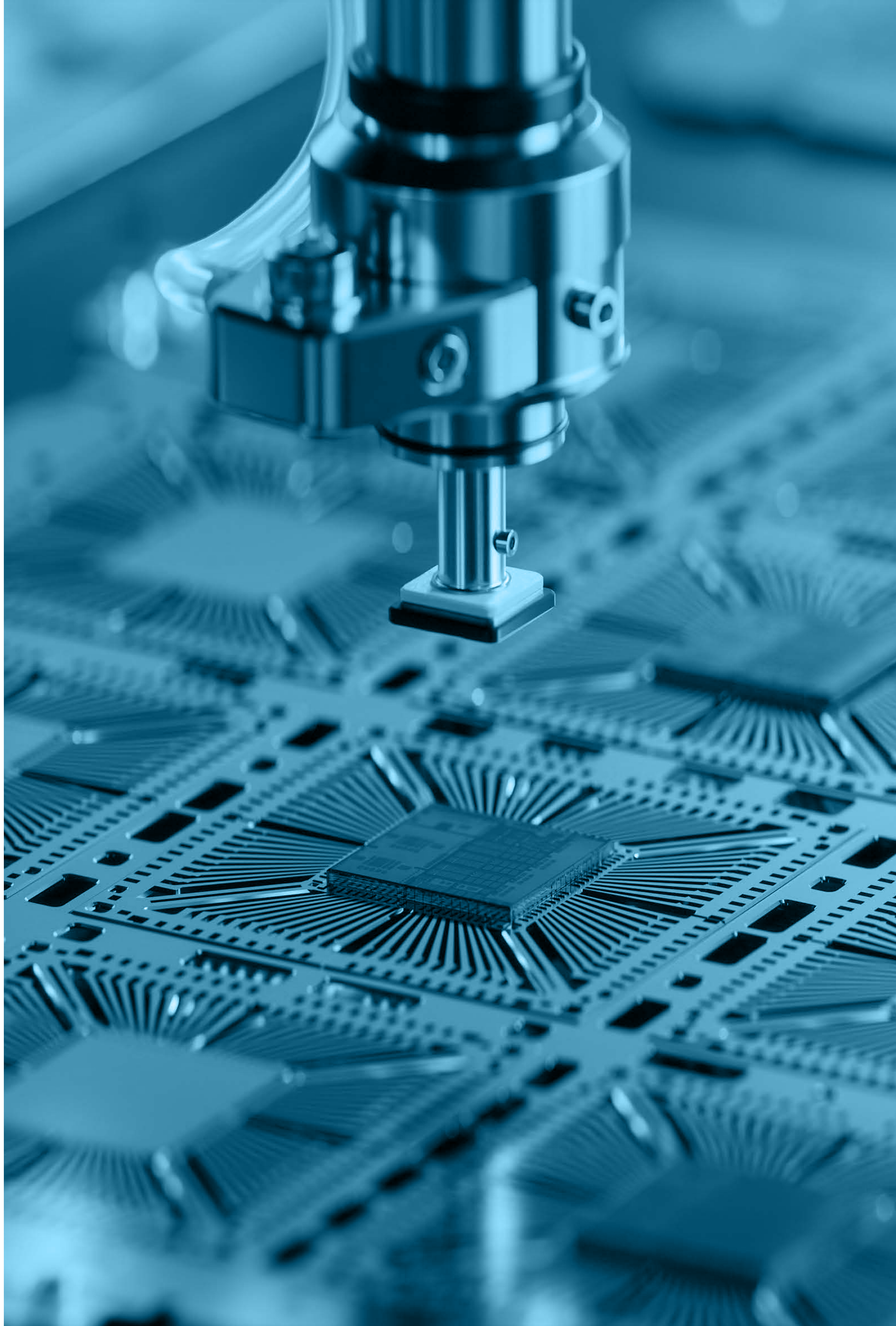
Geopolitical Fragmentation

Recent global value chain restructuring, driven by US-China tensions, pandemic disruptions, and resilience concerns, is creating parallel technical ecosystems with different standards, tools, and specialisations. China's technological self-sufficiency drive massively expands capabilities in semiconductors, AI, and advanced materials — but within technology architectures and standard systems that increasingly diverge from Western ones. American reshoring of critical technologies creates regional capability concentrations explicitly designed to exclude potential adversaries and maintain technological leadership through ecosystem control.

Europe faces a strategic choice: develop autonomous capabilities across critical value chains, accepting the costs and constraints this imposes, or accept technological dependency in key domains while hoping geopolitical tensions remain manageable. The STEM framework cannot help us think through this choice intelligently.

Moreover, this bifurcation creates competing demands on our education systems. Do we train engineers in Chinese or American technology standards and tools? When platform ecosystems diverge, which capabilities do we prioritise? These are not hypothetical questions — they already arise in domains like semiconductor design software, AI frameworks, and telecommunications infrastructure.

[1] https://nordicengineers.org/2025/10/closing-the-stem-gap-why-nordic-collaboration-is-our-superpower/



Beyond the STEM Narrative?

European education systems excel at producing graduates with strong theoretical foundations and formal qualifications. We invest heavily in ensuring educational quality and rigorous assessment. But we have no effective mechanisms at present for recognising when entire domains of technical practice are being superseded by platform-controlled alternatives, nor for redirecting capability development accordingly into responsive lifelong learning strategies.

This temporal dimension — the accelerating pace at which specific capabilities become outdated — represents perhaps the most profound challenge to traditional education and lifelong learning models. Initial qualifications that once sufficed for entire careers now require continuous renewal. Lifelong learning has been a policy priority across Europe and the Nordic region for decades, enshrined in countless strategies and action plans. Yet in practice, our education systems remain primarily structured around front-loaded credential acquisition — concentrated in early adulthood — rather than enabling continuous development opportunities for all.

Competitiveness Strategic Priority Setting

European competitiveness depends on maintaining positions in value chain segments where sophisticated technical capabilities command high returns and where our institutional advantages — strong research systems, social partnership models, regulatory capacity — create genuine competitive edges. But "STEM skills" in aggregate tell us nothing about competitive positioning in specific domains.

The capabilities required for leadership in renewable energy systems integration differ entirely from those for pharmaceutical innovation or advanced manufacturing automation. More critically, Europe's competitive position varies dramatically across these domains. We possess world-leading capabilities in offshore wind but lag in solar photovoltaics. We excel in certain pharmaceutical research but struggle with biologics manufacturing. These patterns reflect not generic STEM capacity, but the distribution of highly specific technical capabilities accumulated through decades of focused investment and institutional development.

Current policy discourse — framed around STEM promotion — cannot distinguish between technical capabilities that strengthen competitive position and those that are abundant globally. A skilled data scientist in a platform-dominated ecosystem may create less value for Europe than a specialist in power electronics for renewable integration, despite both being "STEM." Without a granular understanding of which specific technical capabilities matter for European competitive advantage in which sectors and clusters, education and lifelong learning policies risk being misaligned with wider policy objectives. We risk producing graduates qualified for globally competitive roles in capabilities that Europe cannot capture, while underinvesting in capabilities where genuine advantage is achievable.

Resilience and Anticipatory Capability

The pandemic and geopolitical tensions have elevated resilience as a policy priority alongside competitiveness. Resilience requires autonomous capability in critical domains — the technical capacity to maintain essential functions without depending on potentially unreliable external partners. But resilience differs fundamentally from competitiveness in its logic: we may need capabilities even when we lack a comparative advantage, precisely because external dependence creates unacceptable vulnerabilities.

The STEM framework cannot address resilience questions coherently. It treats all technical education as generically beneficial, whereas resilience requires specific capabilities in defined strategic domains. Can Europe design and manufacture advanced semiconductors if necessary? Do we possess the technical capabilities to develop autonomous AI systems if platform access becomes restricted or weaponised? Can we maintain pharmaceutical manufacturing without dependence on single-source active pharmaceutical ingredients?

These are questions about specific technical capabilities in defined sectors, not about aggregate STEM capacity. Addressing them requires a more granular analysis of capability requirements, current capacity gaps, development timescales, and associated costs.

The European Social Model: Inclusive, Connected Pathways

The European social model links education and lifelong learning to social mobility and inclusive prosperity. Technical education has historically served this function — providing pathways to middle-class employment for students from diverse backgrounds, regardless of social origin. Strong vocational education systems, publicly funded universities, and social partnership models that shape workplace training have made technical education a pillar of inclusive prosperity in Nordic countries and much of Europe.

But the STEM framework increasingly undermines this social function in two distinct ways. First, when platform firms and global value chain leaders demand hyper-specialised capabilities that change rapidly, generic "STEM education" may fail to provide reliable employment pathways even for STEM graduates.

Second, and more fundamentally, the STEM framework distorts understanding across all levels of technical education — not only universities but also vocational education and training (VET). The problems differ but are equally constraining. At universities, the STEM discourse considers different capabilities as equivalent and does not consider distinctions in specific areas of the value chain. At the VET level, the STEM discourse either ignores vocational pathways entirely or treats them as producing "technicians" rather than recognising the sophisticated technical capabilities that advanced manufacturing, precision crafts, and complex systems operations require.

This is where Europe — and not least the Nordic region — possesses an underappreciated strategic advantage. While the United States has allowed its vocational education infrastructure to atrophy and China builds VET capacity through rapid but fragmented expansion, Europe has sustained and continuously upgraded collaborative VET systems. Our dual education models, social partnership involvement in training governance, and coordinated investment in vocational excellence represent sophisticated institutional infrastructures that cannot be quickly replicated. These systems rest on decades of institutional development, trust-based relationships between social partners, and deep integration of workplace learning with formal education embedded in collective agreements.

Consider advanced manufacturing: the technical capabilities enabling Industry 4.0 implementation — CNC programming, robotics integration, predictive maintenance, cyber-physical systems operation — require different development pathways than university engineering degrees provide. Europe's VET systems, particularly in Germany, Switzerland, Austria, and increasingly across the Nordic region, develop these capabilities through combinations of workplace learning and formal instruction. These capabilities are neither "less than" university-level competencies nor simply practical applications of theory — they represent distinct forms of technical knowledge developed through different pedagogical approaches.

The competitive and resilience implications are substantial. When value chains require both high-level research capabilities and sophisticated technical execution skills, countries with strong VET systems can maintain more complete value chain segments domestically. The United States increasingly struggles to implement advanced manufacturing, even when it possesses design capabilities, precisely because it lacks the VET infrastructure to develop required technical skills at scale. China's rapid VET expansion produces quantity but faces persistent quality challenges due to limited workplace integration and instructor experience.

Toward Capability-Centred *Industrial Policy*

We need analytical frameworks that describe actual technical capabilities rather than formal educational categories. This requires systematic approaches across multiple dimensions:

Mapping value chain requirements: For each strategic sector, what specific technical competencies enable participation in high-value segments? This is not "engineering" or "STEM" but rather concrete capabilities like power electronics design for renewable integration, advanced packaging techniques for semiconductors, or bio-process optimisation for pharmaceutical manufacturing. Value chain mapping must identify where Europe currently possesses capabilities, where critical dependencies exist, and where capability concentration could yield a competitive advantage.

Understanding capability formation: How do specific competencies develop in practice? What mix of formal education, workplace learning, and continuous skill development creates competitive capability? Universities of vocational credentials provide the necessary foundations — but are insufficient by themselves. Critical technical capabilities increasingly require targeted interventions and regular renewal as technological change accelerates, and skill lives shorten.

Tracking capability distribution and mobility: Where do specific capabilities currently exist in Europe — both geographically and across institutions, firms, and sectors? What concentrations enable cluster effects and knowledge spillovers? What mobility patterns indicate emerging shortages or surpluses? Unlike aggregate labour market statistics, capability tracking must operate at fine granularity, identifying not "engineers" but specialists in specific domains whose movement signals shifts in industrial structure.

Anticipating capability evolution: How are required capabilities changing as technologies mature, platforms shift, and geopolitical configurations alter? What capabilities must we develop proactively rather than reactively? Opportunities afforded by real-time labour market analytics — mining job advertisements, CV data, and employment patterns — provide valuable signals about current demand and emerging skill shortages. Yet strategic positioning requires more than tracking present market signals. It demands building institutional capacity for technology foresight, scenario planning, and assessment of alternative development trajectories. Education systems take years to develop new capabilities, so we cannot wait for market signals to clarify requirements. We must anticipate which technical competencies will become strategically critical, assess how geopolitical fragmentation might create new dependencies, and evaluate which technology pathways warrant capability investment — often before clear market demand materialises.

This granular, capability-centred approach enables strategic policy alignment, as Singapore's SkillsFuture Initiative and Industry Transformation Maps illustrate by linking specific technical capabilities to economic transformation goals. While institutional designs vary, other economies are developing comparable mechanisms: South Korea through sectoral skill councils tied to industrial policy, Germany via skills anticipation integrated into Industrie 4.0, and Australia through its National Skills Commission's sector-specific analyses. Rather than generic interventions like "increase STEM enrolments", these approaches target specific capability gaps — doctoral programs in power electronics for renewable integration, industry-embedded training in advanced packaging for semiconductors, or mid-career conversion programs for software engineers moving into AI safety and governance.

Skills Intelligence at the Core of a **European Industrial Policy**

Technical capability development cannot be separated from industrial policies. They are inseparable aspects of the same challenge: maintaining European economic agency in a world of platform power and geopolitical fragmentation. Yet current institutional arrangements treat them as distinct policy domains — ministries of labour manage workforce development, ministries of education manage education policy, and industry ministries manage industrial policy, with limited coordination mechanisms and different policy logics.

This separation made sense when labour markets could coordinate capability supply with industrial demand reasonably effectively. It fails when competitive advantage requires anticipatory capabilities, when geopolitical considerations shape which capabilities matter strategically, and when platforms can rapidly render established capabilities obsolete. Policy alignment is not optional but essential for effective policy in contemporary conditions.

Integration requires several elements:

Strategic selectivity: Small European economies cannot lead in all technologies simultaneously. Strategic focus demands identifying domains where concentration of effort can achieve competitive advantage or essential autonomous capacity, then aligning education, research, and industrial policy accordingly. This means making hard choices about where to invest proactively and where to accept dependency or follower positions. The STEM framework, by suggesting that all technical education is equally valuable, prevents these difficult but necessary prioritisations.

Anticipatory development: Competitive advantage increasingly requires developing capabilities before they become economically critical, not responding to market signals reflecting yesterday's economy. This demands institutional mechanisms for technology foresight and strategic capability planning. Singapore's Centre for Strategic Futures and Industry Transformation Maps systematically link anticipatory analysis to capability development priorities. Finland integrates foresight through institutions like Sitra and strategic government programs, enabling proactive positioning in emerging technologies. Consider Finland's quantum computing investment: in 2020, the government committed €20.7 million to develop quantum computing capabilities — later increased to €70 million — building from a 5-qubit system to a planned 300-qubit computer by 2027 [2 3]. This investment occurred years before clear market demand or economic returns materialised.

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[2] https://www.vttresearch.com/en/news-and-ideas/building-finlands-first-quantum-computer-begins-vtt-partners-quantum-startup-iqm

[3] https://www.vttresearch.com/en/news-and-ideas/finland-launches-20-qubit-quantum-computer-development-towards-more-powerful-quantum

Coordinated investment: When education policy, research funding, industrial incentives, and public procurement all support capability development in strategic domains, synergies emerge that exceed the sum of individual interventions. A country investing in renewable energy research while neglecting relevant technical education, or developing technical capabilities without corresponding industrial capacity, achieves limited impact. Coordination mechanisms matter more than aggregate spending levels — a lesson that Nordic countries understand well but struggle to implement amid fragmented governance and European-level complexities.

Ecosystem thinking: Individual skilled workers matter less than concentrations of capability that enable knowledge spillovers, firm formation, and continuous innovation. Silicon Valley's advantage lies not in aggregate engineering capacity but in ecosystem effects: dense networks enabling rapid knowledge diffusion, high rates of entrepreneurship seeded by capability concentrations, and continuous attraction of global talent. Policies must support ecosystem formation, not just degree production. This demands integrated approaches linking education, research infrastructure, industrial clusters, and quality of life considerations that shape where talent chooses to locate.

Multiple Pathways to Technical Capability: Moving beyond STEM means recognising that technical capability develops through diverse, connected pathways that must function as a coherent system rather than parallel tracks:

University education remains essential for research-intensive capabilities and theoretical foundations that underpin innovation. However, it should connect more directly to specific capability requirements rather than generic categories. This approach does not equate to the vocationalisation of university education; rather, it ensures that even theoretical programmes cultivate competencies with direct relevance to economic and scientific challenges.

Vocational and apprenticeship pathways develop critical technical capabilities for advanced manufacturing, systems operation, and specialised crafts. These pathways deserve equal status with university routes in terms of investments, equal in social prestige and economic opportunity.

Continuous and modular learning enables working professionals to acquire new capabilities as technologies evolve and value chains restructure. This requires flexible credentialing systems that recognise learning regardless of provider, employer-education partnerships that integrate workplace learning with formal instruction, and financing mechanisms that support learning throughout careers. Critically, these pathways must connect to both university and VET systems and create bridges between these, allowing graduates of vocational programs to pursue university credentials if desired and university graduates to acquire practical capabilities through workplace learning.

Experience-based learning in firms develops tacit knowledge and practical problem-solving skills that formal education alone cannot provide. Recognition systems should value this learning appropriately, rather than treating only formal credentials as legitimate. The European Council Recommendation on micro credentials [4] holds potential to connect formal, non-formal, and informal learning seamlessly, but at present, we struggle with fragmentation and lack of scale.

[4] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/%3Furi%3DCELEX:32022H0627(02)

Policy Options **for Nordic Leadership**

1.

Strategic Skills Intelligence: From Fragmentation to Anticipatory Capability

Europe has launched numerous initiatives to improve skills data and labour market intelligence — from ESCO (European Classification of Skills, Competences, Qualifications and Occupations) to sectoral skills partnerships to national foresight systems. Yet these efforts remain fragmented across levels of governance, sectoral boundaries, and national systems. The Skills Data Space, developed under the DS4Skills [5] project and now part of the broader Union of Skills initiative, represents an important step toward creating a trusted European ecosystem for sharing skills data. The Union of Skills, announced in March 2025, includes plans for a European Skills Intelligence Observatory to provide data and foresight on skills shortages in critical sectors [6].

[5] https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://www.skillsdataspace.eu/
[6] https://commission.europa.eu/topics/eu-competitiveness/union-skills_en

However, these initiatives have been funded primarily as time-limited projects rather than embedded as permanent strategic infrastructure. More critically, they have not yet been fully integrated into the renewed European focus on competitiveness and resilience articulated in the September 2024 Draghi report [7], which emphasises closing innovation gaps, linking decarbonisation with competitiveness, and reducing strategic dependencies. While the Draghi report identifies "closing the skills gap" as a key horizontal policy area for EU competitiveness, the connection between skills intelligence systems and the industrial policy coordination mechanisms Draghi proposes remains underdeveloped [8].

This raises a strategic question for the Nordic region: Should Nordic nations — with their strong traditions of coordinated governance, data capabilities, and technological expertise — develop enhanced regional skills intelligence as part of their competitive positioning?

Nordic nations have the know-how to fully exploit the potential of AI technologies and advanced data analytics to build systematic capabilities that map technical competency requirements in strategic sectors and value chains, track current capability distribution and mobility patterns — including foreign talent flows—and forecast requirements given alternative technology and geopolitical scenarios.

Unlike traditional labour market information systems that operate at high aggregation levels (e.g., "engineers"), these intelligence systems must identify specific technical capabilities (e.g., "power electronics specialists with experience in renewable integration and grid stability") and track their distribution, development, and evolution. Modern machine learning approaches enable analysis of job postings, patent data, publication patterns, and professional networks to identify emerging capability requirements before they appear in labour statistics.

This intelligence could inform education policy, research priorities, and industrial strategy in integrated fashion. When capability intelligence reveals emerging shortages in critical domains, coordinated responses can align research funding, program development, and industrial incentives. When it identifies capability concentrations enabling cluster formation, policy can support ecosystem development. The goal is creating feedback loops between industrial evolution and capability development that operate at strategic rather than purely market timescales.

[7] https://commission.europa.eu/topics/eu-competitiveness/draghi-report_en
[8] https://www.daad-brussels.eu/en/2024/10/04/draghi-report-on-eu-competitiveness-education-and-research-are-key-pillars/

2.

Coordinate Strategic Capability Development Across Nordic Nations

Small Nordic economies individually face severe constraints in developing capabilities across all strategic technology domains. But collective coordination can achieve scale and scope that individual nations cannot. Across Nordic nations, leaders should identify 5-7 technology domains where coordinated effort can achieve global competitive advantage or essential autonomous capacity.

The selection criteria should encompass existing capability concentrations, shared industrial strengths, complementary research infrastructures, and strategic importance for resilience. Possibilities might include offshore renewable energy and grid integration, sustainable manufacturing and circular economy technologies, digital health systems, climate adaptation solutions, and specific segments of semiconductor equipment or battery technologies.

Once domains are identified, align education programs, research funding, industrial incentives, and public procurement to develop required capabilities proactively. This does not mean homogenisation — different Nordic countries can specialise in different segments of value chains within priority domains — but rather coordinated investment preventing duplication while ensuring comprehensive capability coverage.

Critically, strategic focus requires accepting that we cannot lead everywhere. Some domains will receive limited investment even when interesting scientifically or economically attractive, because resources must concentrate where collective Nordic effort can yield a genuine advantage. This discipline is difficult politically but essential strategically.

3.

Valorise Multiple Development Pathways with Equal Status

Modular credentialing systems: Develop frameworks allowing skill accumulation through diverse routes that connect seamlessly. VET graduates should be able to acquire university credentials through modular pathways, recognising prior learning. University graduates should be able to gain VET certifications through intensive workplace-based programs. The goal is fluidity and lifelong capability development, not rigid tracking into university or vocational lanes at age 15-16.

Recognition of work-based learning: Create mechanisms for experienced workers to gain formal recognition of capabilities developed through work, not only as credential equivalencies but as valuable contributions to continuous capability development. This matters particularly for mid-career workers whose capabilities may be extensive but whose formal credentials reflect education systems of decades past. Sweden demonstrates this approach through RISE Research Institutes' Kompetenspasset (Competency Passport) project, developed with the Swedish Public Employment Service and the Swedish National Agency for Higher Vocational Education to create a micro credentials model that documents both formal and informal learning[9]. The system makes competencies visible and portable, particularly benefiting those with shorter education periods or incomplete formal credentials, while providing transparency in validation that allows employers to assess documented capabilities.

[9] https://www.ri.se/en/how-micro-credentials-can-promote-lifelong-learning

4.

Build Adaptive Institutional Mechanisms Through Shared Digital Infrastructure

The challenge of aligning technical capability development with rapidly evolving value chain requirements cannot be solved by individual institutions acting alone. We face a paradox: Europe has seen the launch of several measures to boost lifelong learning offerings: university alliances launching micro credentials, sectoral partnerships developing specialised training, European Institutes of Technology building innovation ecosystems with integrated modular skills upgrading pathways — yet this fragmentation prevents scale and leaves learners, employers, and policymakers unable to navigate the landscape effectively.

We need a pan-European digital infrastructure for lifelong learning that provides scale while respecting institutional diversity. The Europass framework offers a foundation architecture that could evolve from a credential storage system into an active provision platform and shared services. Rather than each university, alliance, or sectoral partnership maintaining separate digital learning environments with limited course offerings, shared infrastructure could enable:

- Comprehensive catalogues of learning offerings across providers, searchable by specific technical capabilities rather than generic categories
- Seamless enrollment and credential recognition across institutional boundaries
- Modular pathways allowing learners to combine offerings from multiple providers into coherent capability development trajectories
- Integration of formal education, workplace learning, and continuous professional development within unified learner records

This infrastructure approach transforms fragmentation from liability to asset. Individual institutions contribute their specialised strengths — a Danish university's expertise in wind energy systems, a German Fraunhofer institute's advanced manufacturing capabilities, a Swedish company's AI implementation experience — while shared platforms provide discoverability and scale that no single institution can achieve.

5.

Transparent Credential Value Through *Labour Market Intelligence*

Proliferation of credentials creates a transparency crisis. Learners investing time and resources in technical education cannot assess which credentials actually lead to employment opportunities and wage premiums. Employers struggle to evaluate candidates with diverse educational backgrounds. The result: credential inflation without clarity on capability or value.

Europe needs a credential value transparency infrastructure analogous to the Burning Glass Technologies Credential Value Index developed for US labour markets [10]. This system analyses millions of job postings and employment outcomes to identify which specific credentials correlate with hiring demand and compensation levels in different sectors and regions. For technical capabilities, such intelligence could reveal that "industrial IoT implementation certification from X provider" commands wage premiums in advanced manufacturing, while "generic data science micro credential from Y university" shows limited labour market differentiation.

[10] https://www.credentialvalueindex.org/

Building European credential value intelligence requires:

- Systematic analysis of job postings to identify which specific technical capabilities employers seek, at granular rather than aggregate levels.
- Tracking of employment outcomes by credential type, provider, and capability domain, linking education data with social security records.
- Regular updates reflecting value chain evolution and technological change, operating on timescales shorter than traditional labour market statistics.
- Public accessibility, allowing learners and employers to make informed decisions before investing in education.
- Integration with shared provision infrastructure so learners see labour market value alongside course offerings when choosing learning pathways.

This transparency serves multiple functions beyond individual decision support. It signals to providers which capabilities command market value, guiding program development. It enables policymakers to identify where public investment should support capability development that markets undervalue but strategic priorities require. And it creates accountability mechanisms, making visible when education offerings fail to connect to economic opportunities.

6.

Reforming Lifelong Learning Funding Models

Current funding models — designed primarily for initial university education — create barriers to capability-centred lifelong learning. We need financing mechanisms that enable workers to acquire new capabilities throughout their careers while ensuring social partners have a voice in how resources are directed. Lessons from different approaches inform reform directions:

Personal learning accounts, piloted in France and elsewhere, provide individual entitlements for training investment. Their strength lies in portability and individual agency — workers control their learning investments and can use them across jobs and sectors. Their weakness: insufficient funding levels that limit what substantial capability development they can support, and limited guidance mechanisms, leaving individuals to navigate complex training landscapes alone without adequate labour market intelligence. Many workers lack the information and navigational capacity to make optimal investment decisions, particularly when capability requirements evolve rapidly.

Sectoral training funds and collective agreements: In Nordic countries and other strong social partnership contexts, substantial financial resources for skills development are channelled through sectoral training funds managed jointly by employer associations and unions, stipulated in collective agreements. These arrangements possess significant strengths: social partners understand industry-specific capability requirements intimately and can coordinate training with workplace practice, ensuring immediate relevance and strong employer commitment. The integration of training with collective bargaining also creates sustained funding mechanisms less vulnerable to political or budgetary cycles.

However, these systems face important limitations. Sectoral fragmentation makes it difficult to respond to cross-cutting technological changes — such as AI, data analytics, or digitalisation — that affect multiple industries simultaneously. When capability requirements transcend traditional sectoral boundaries, coordinated responses become challenging. Workers seeking to move between sectors must navigate different training systems with limited credential portability, reducing labour market flexibility precisely when technological transformation demands greater mobility.

Moreover, coverage within the private sector remains highly uneven, particularly among workers with tertiary degrees. While blue-collar workers in manufacturing or construction often benefit from robust sectoral training systems established through strong union density, many knowledge workers in professional services, technology firms, and newer industries face fragmented or non-existent collective training provisions. This creates a paradox: workers in rapidly evolving technical fields requiring continuous capability development often have the least access to collectively organised training infrastructure, relying instead on individual employer initiatives or self-funded education.

Singapore's SkillsFuture model offers instructive elements for European adaptation. It combines individual learning credits [11] with enhanced support for mid-career conversion into growth sectors. Workers over 40 receive higher subsidy rates specifically for training leading to jobs in designated growth areas — effectively a public right to career transition, provided it targets sectors with demonstrated demand. Importantly, career conversion programs include work attachments and employer partnerships, not just classroom training. The program recognises that mid-career capability development requires different support than initial education, particularly integration into new workplace contexts.

[11] https://jobsandskills.skillsfuture.gov.sg/insights/sdfe

Conclusion: *The Nordic Opportunity*

We stand at an inflexion point. The global reorganisation of value chains — driven by geopolitical fragmentation, technological disruption, and the search for greater resilience — creates a window for repositioning. But this window will close as new configurations solidify, standards emerge, and capability concentrations establish path dependencies that become difficult to reverse.

For Nordic nations, this moment presents both threat and opportunity. The threat is clear: continuation of current approaches — organising policy around STEM categories, relying on market mechanisms to align capability with need, treating technical education as separable from industrial strategy — will leave us increasingly dependent on external platforms and geopolitically fragmented ecosystems over which we exercise no control. We may produce many technically qualified graduates while losing the capability to shape our technological future.

But the opportunity is equally real and perhaps unique to our context. Unlike large countries that can afford fragmentation and policy incoherence while relying on scale, small Nordic economies have always succeeded through strategic coordination and institutional sophistication. Our social partnership traditions, our capacity for collective action through trust-based governance — these represent comparative advantages in an era requiring rapid, coordinated responses to technological change.

Our institutional infrastructure is distinguished by features that are not readily reproducible by either the United States or China. These include education systems that integrate universities and vocational pathways through modular credentials and mutual respect; social partnerships that facilitate large-scale collaboration between industry and education; and public sector entities that achieve strategic coordination without stifling innovation. These advantages matter precisely because the new competitive landscape rewards not just individual brilliance but systemic capability to develop, deploy, and continuously upgrade technical competencies aligned with strategic priorities.

Moving beyond STEM is not merely a semantic exercise but rests on the recognition that our strengths lie in the synergy between education and labour market policies in a renewed industrial strategy; the capacity to make collective choices about strategic priorities through our trust-based social partnership model, and subsequently coordinate investment accordingly.

This will require trade-offs. We cannot lead in all domains; strategic focus means accepting follower positions in some technologies to achieve advantage in others. We cannot rely only on market mechanisms; anticipatory capability development requires public investment and changes in mindsets. We cannot treat education as separable from industrial policy; integration demands new coordination mechanisms and a willingness to challenge established bureaucratic boundaries.

But if any region can navigate these challenges, it is the Nordics. We have demonstrated the capacity for strategic coordination, for evolving institutions when circumstances demand it, and for maintaining social cohesion through major transitions. The question now is whether we can extend insights gained in an era of platform power, geopolitical fragmentation, and accelerating technological change.

The stakes are not merely economic. Technical capability determines not only prosperity but agency — the capacity to shape our societies according to our values rather than accepting configurations imposed by external forces. As platform firms headquartered elsewhere shape how we work, communicate, and organise economic life, and as geopolitical competitors build parallel technological ecosystems designed to create dependencies, autonomous technical capability becomes central to democratic self-determination. The opportunity is demonstrating that small democracies with strong institutions can maintain agency and prosperity in a world of technological disruption and geopolitical competition.

The work begins with recognition that our current frameworks no longer serve us. It continues with building the analytical capabilities, coordination mechanisms, and strategic focus necessary for contemporary competition. And it succeeds when Nordic countries demonstrate that democratic societies with strong social partnerships can develop technical capabilities strategically, inclusively, and effectively, thereby providing a model for how the European social model can thrive in the 21st century.

This report builds on ANE's previous recommendations

This publication continues the work initiated in Reclaiming Europe's Edge – Competitiveness through STEM Talent, where ANE called for a comprehensive EU STEM strategy to address Europe's growing skills gap and strengthen its global competitiveness. That report highlighted the urgent need for coordinated action across education, labour markets, and innovation ecosystems to ensure Europe's strategic autonomy and sustainable growth. Download the report at **nordicengineers.org**

The Association of Nordic Engineers, ANE, consists of engineering trade union associations from the Nordic countries:

The Swedish Association of Graduate Engineers (Sveriges Ingenjörer)
The Danish Society of Engineers (IDA)
The Norwegian Society of Engineers and Technologists (NITO)
The Association of Chartered Engineers in Iceland (VFÍ)
Engineers Finland representing the Finnish organisations: the Academic Engineers and Architects in Finland (TEK), the Technical Association in Finland (TFiF), the Union of Professional Engineers in Finland (ILRY) and the Engineers in Finland (DIFF)

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