Building the Evidence Base For a Swedish STEM Policy: Objectives & Prevalence in Comparator Countries

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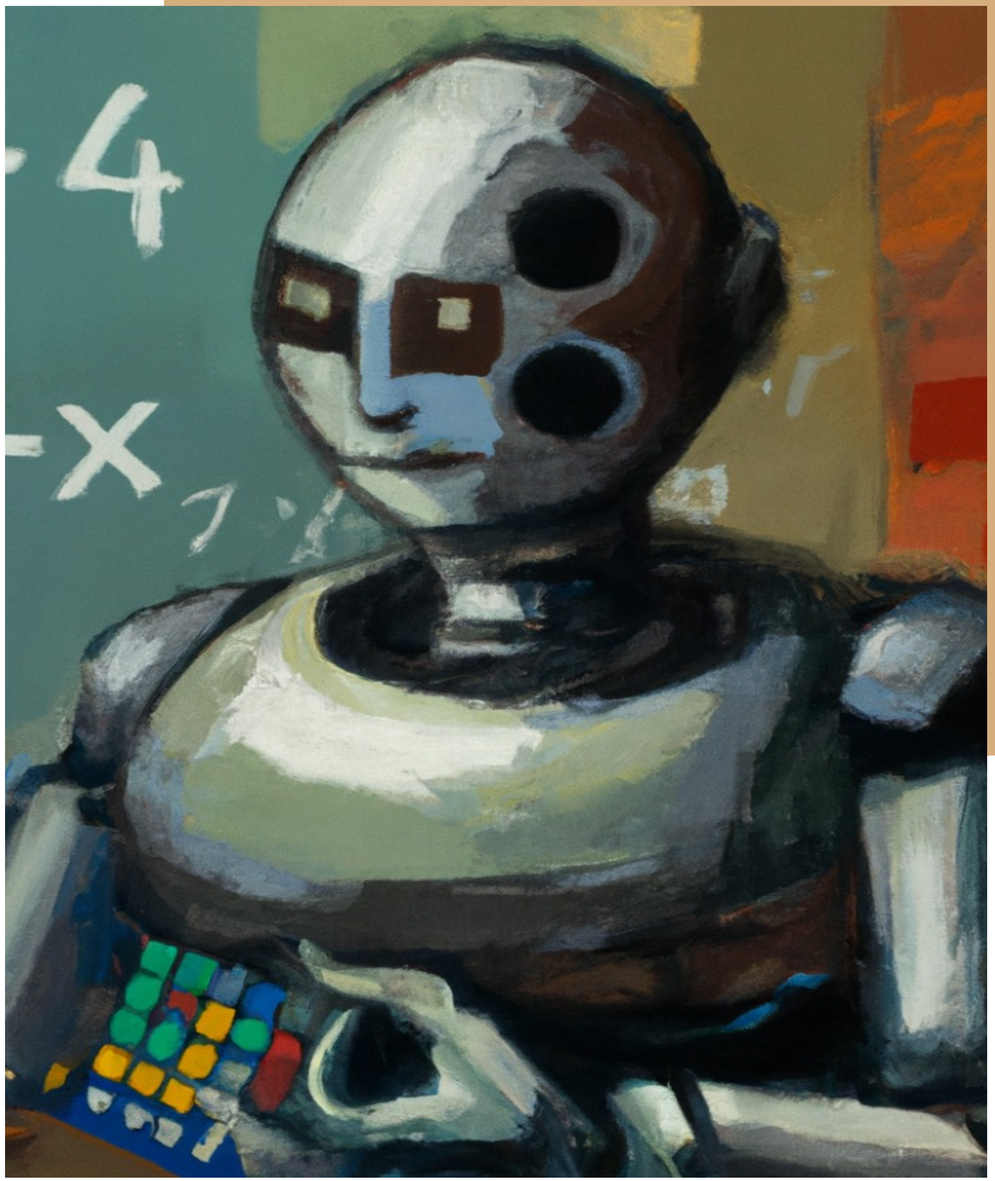
Näringslivets skolforum
SWEDISH ENTERPRISE SCHOOL FORUM

Stockholm, Sweden
24th May 2023



Comparator Countries Have STEM Policies

“We are at a crossroads of a great age. Science, technology, and innovation policies will continue to be formulated in every country for the foreseeable future in two major directions. …

[1] science and technology require wisdom to overcome global crises stemming from the explosive expansion of human activities since the late 20th century.

[2] At the same time, each country will accelerate domestic reforms and expansion of future investment in science and technology to strengthen [their] competitiveness, while competing with other countries in various international proposals and concepts for global cooperation and harmony”

(Government of Japan, 2021, p. 3)

SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS

6 POLICY PROBLEMS

POLICY PROBLEM 1

Declining participation in school mathematics and science, illustrated by surveys of school student interest, and science and mathematics enrolment data. This policy problem also extends to issues regarding curriculum, pedagogy, and subject integration.

POLICY PROBLEM 2

Declining (or suboptimal) relative national and international educational performance in school mathematics and science assessments. This includes the Programme for International Student Assessment (PISA), and Trends in International Mathematics and Science Study (TIMSS) data.

Sweden's relative performance in mathematics and science steadily deteriorated until 2012

"Sweden's performance in international assessments began to steadily deteriorate. … in the TIMSS study, Swedish average results fell by 56 points between 1995 and 2011, which was the largest decline among all participating countries.

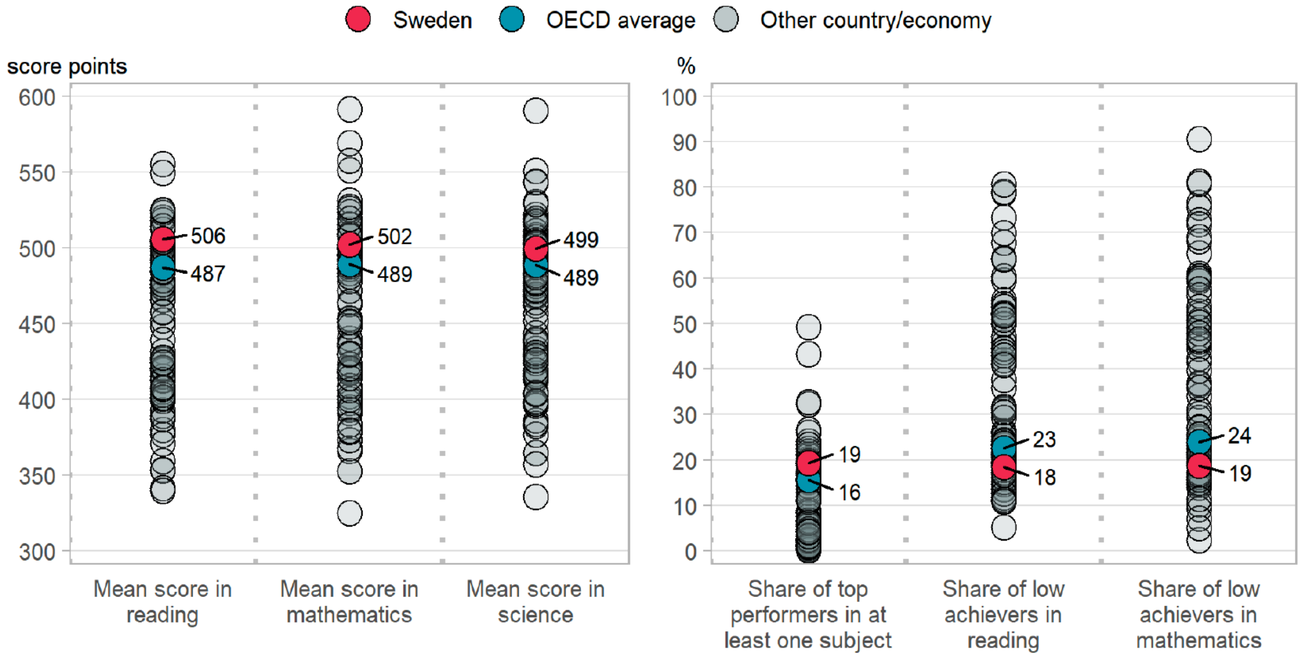
… Perhaps most alarmingly, the decline was relatively greater for students at the bottom of the ability distribution, who had previously fared comparatively well in the Swedish educational system.

Mirroring the development observed for the TIMSS, the Swedish PISA results also progressively worsened until a low point was reached in the 2012 survey. The overall score was well below the OECD average, and in each area of PISA, i.e., reading, mathematics, and science, only three OECD countries performed worse than Sweden"

(Henrekson and Wennström, 2022, p. 5)

Evidencing the Policy Problem

Snapshot of Performance in Reading, Mathematics and Science (PISA, 2018)



Note: Only countries and economies with available data are shown.
Source: OECD, PISA 2018 Database, Tables I.1 and I.10.1.

See OECD, 2019.

IN 2018, ABOVE OECD AVERAGE

After a period of decline, Sweden's PISA 2018 results corrected somewhat, with 15-year-olds performing above the OECD average for reading (506), mathematics (502) and science (499) (mean score).

TOP & BOTTOM PERFORMERS

A larger proportion of Sweden's 15-year-olds (19%) performed at the highest proficiency levels, and a larger proportion achieved the minimum proficiency level (Level 2 or higher) in one or more subjects (72%) (i.e., the proportion of low achievers – 18% - is less than the OECD average – 23% for reading).

EQUITY CONCERNS PERSIST

As with comparator countries, socio-economic status remains a strong predictor for performance in science and mathematics; however, some disadvantaged students perform in the top quarter ("indicating that disadvantage is not destiny" (OECD, 2019, p. 4).

POLICY PROBLEM 3

Declining (or inadequate) participation in STEM disciplines at higher education level, including under-representation of specific cohorts relative to industry demand for qualified, competent STEM professionals and knowledge workers for continued industry competitiveness. Particular attention is given to enrolment and graduation numbers, and particular issues associated with admission and retention of women and traditionally marginalised groups (e.g., new migrants).

STEM is Important for University Research and Industry Innovation

“The last decade has seen considerable concern regarding a shortage of science, technology, engineering, and mathematics (STEM) workers to meet the demands of the labor market. At the same time, many experts have presented evidence of a STEM worker surplus.

A … review … reveals a significant heterogeneity in the STEM labor market: the academic sector is generally oversupplied, while the government sector and private industry have shortages in specific areas. …

As our society relies further on technology for economic development and prosperity, the vitality of the STEM workforce will continue to be a cause for concern”.

(Xue & Larson, 2015, p. 1)

Evidencing the Policy Problem

Percentage of Graduates from STEM Programs in Higher Education, Both Sexes (%), 2016-2020, Select Comparator Countries

STABILITY: 2016-2020

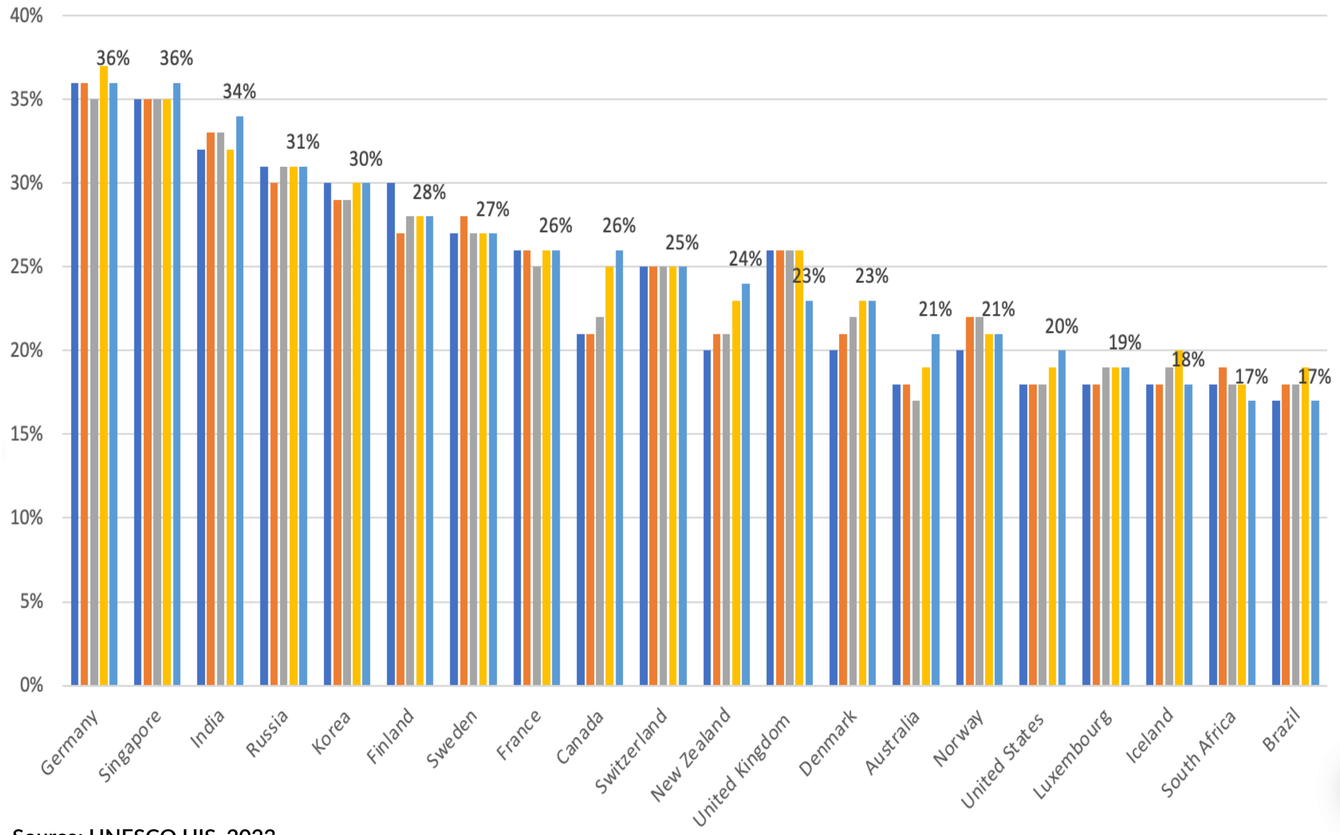
The percentage of graduates from Swedish STEM programs remained relatively stable (27-28%) over this period.

SWEDEN 7TH BEHIND COMPARATORS

Germany, Singapore, India, Russia, Korea and Finland had more STEM graduates.

COMPARATORS HAD MORE ENGINEERING THAN HEALTH

Most leading countries (but not all) had a higher percentage of graduates from 'engineering, manufacturing and construction' than 'health and welfare' programs.



Source: UNESCO UIS, 2023.

Graduates in programs – STEM and Humanities, Arts & Social Sciences

Percentage of Graduates from Tertiary Education Programs (both sexes), by Discipline (2020)

	Country	Business, Administration and Law (%)	Education (%)	Social Sciences, Journalism, and Information (%)	Arts and Humanities (%)	Services (%)	Health and welfare (%)	Engineering, manufacturing, and construction (%)	Information and communication technologies (%)	Natural sciences, mathematics, and statistics (%)	Agriculture, forestry, fisheries and veterinary (%)
Nordic countries	Sweden	16	14	12	6	2	22	18	5	4	1
	Denmark	26	5	10	11	3	21	12	5	5	1
	Finland	20	7	7	11	5	20	15	7	5	2
	Iceland	21	15	16	10	4	16	8	6	4	1
	Norway	17	16	12	9	5	19	12	5	5	1
Other European	Germany	25	10	7	9	3	7	23	5	8	2
	France	35	4	8	8	4	13	14	4	8	2
	Switzerland	27	10	7	7	5	16	15	3	7	1
	Luxembourg	37	13	11	10	0	7	8	6	5	0
East Asia	Singapore	28	7	7	9	3	9	21	9	5	0
	Korea	14	7	6	15	10	16	21	5	4	1
Anglophone	Australia	37	8	6	9	2	18	9	7	5	1
	Canada	26	5	10	8	6	15	13	5	8	1
	New Zealand	24	9	9	11	4	16	9	7	7	2
	United States	19	6	12	19	6	17	7	5	8	1
	United Kingdom	24	7	16	15	0	14	9	4	9	1
BRICS	Brazil	34	19	5	3	3	17	12	4	2	3
	India	18	10	27	6	0	5	14	5	15	1
	South Africa	34	19	17	5	1	6	7	3	7	2

Source: UNESCO UIS, 2023.

POLICY PROBLEM 4

Urgent, shifting demands on global science, innovation and education-industry knowledge exchange. ‘STEM excellence’ requires robust research and innovation ecosystems for today’s problems and opportunities; but perhaps more importantly, solutions to deal with tomorrow’s problems.

STEM is Important for University Research and Industry Innovation

“The impact of the knowledge-based economy in the globalized world has steadily increased in recent years leading to a growing expectation and demand for innovation through university [research].

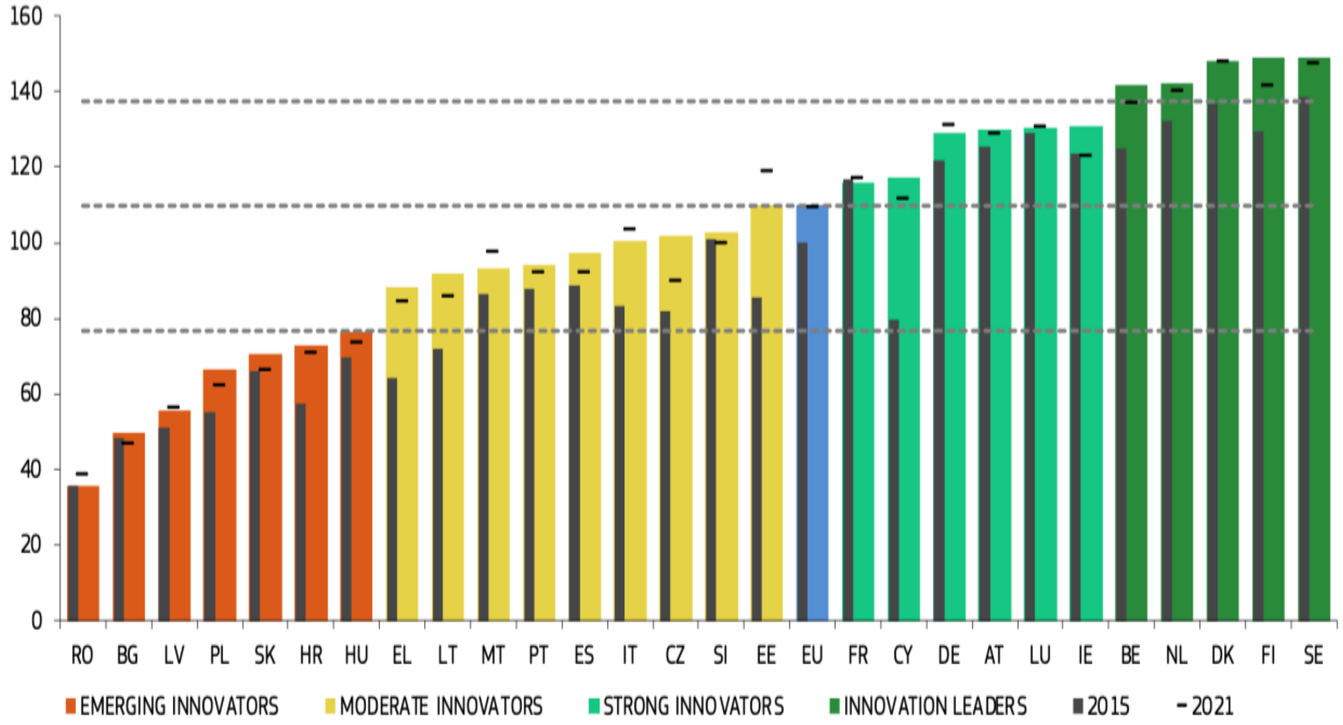
Under these circumstances, it is expected that STEM will play a central role in driving innovation.

There is a wide agreement that STEM fields play an important role in research and development, [and] produces future jobs”

(Yamada, 2018, p. 1)

Evidencing the Policy Problem

Performance of European Union Member States' Innovation Systems (2015-2022)



Source: European Commission, 2022.

SWEDEN: AN INNOVATION LEADER

The European Innovation Scorecard 2020 confirms Sweden's performance as Europe's innovation leader.

SWEDEN HAS MANY STRENGTHS

These scoreboards acknowledge Sweden's strengths in public-private and international scientific co-publication, and employment of ICT specialists.

RELATIVE WEAKNESSES

These scoreboards identified relative weaknesses as government support for business R&D, and non-R&D innovation expenditures.

POLICY PROBLEM 5

Capacity to deal with intractable global and national grand challenges (including ‘wicked problems’).

POLICY PROBLEM 6

Generalised scientific and digital literacy

for societal wellbeing.

SUMMARY: 6 POLICY PROBLEM

WHY SHOULD GOVERNMENTS INTRODUCE A STEM POLICY?

PROBLEM 1

Declining participation in school mathematics and science, extending to issues concerning curriculum, pedagogy, and subject integration

PROBLEM 2

Declining (or suboptimal) relative national and international educational performance in school mathematics and science assessments (PISA and TIMSS)

PROBLEM 3

Declining participation in STEM disciplines at higher education level, including under-representation of specific cohorts relative to industry demand for qualified, competent STEM professionals and knowledge workers

PROBLEM 4

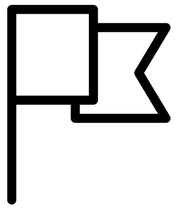
Fourth, **urgent, shifting demands on global science**, innovation and education-industry knowledge exchange

PROBLEM 5

Capacity to address intractable global and national grand challenges ('wicked problems').

PROBLEM 6

Generalised scientific and digital literacy for societal wellbeing



Defining problems, To Deal with them

“By now we are all beginning to realize that one of the most intractable problems is that of defining problems (of knowing what distinguishes an observed condition from a desired condition) and of locating problems (finding where in the complex causal networks the trouble really lies).

In turn, and equally intractable, is the problem of identifying the actions that might effectively narrow the gap between what-is and what-ought-to-be”

(Rittel & Webber, 1973, p. 159)

Nordic countries: Finland, Norway, Denmark, Iceland

Other European: France, Germany

Anglosphere: United States, United Kingdom, Australia

East Asia: Japan, South Korea

COMPARATORS

STEM POLICIES IN 11 COUNTRIES

But First, Sweden

- Sweden is a highly competitive, advanced economy with an innovative, dynamic business environment (strong engineering industry presence)
- Relatively high equality and social stability
- Concerns regarding performance in international assessments (PISA and TIMSS)
- Rapid shifts associated with technology advances, digitalisation and demographic changes
- Commitment to ensuring health, wellbeing, safety and security
- Interest in the successful transformation of economies, businesses and society
- Interest in sustainably protecting the climate, nature and the environment

Swedish Policy Priorities

- Government policy: Life sciences, methane action, the work environment, cyber security, amongst many others
- Swedish Presidency of European Union (2023): Security, competitiveness, green and energy transitions
- European Union: Skills for future competitiveness and growth, artificial intelligence regulation, digital identity
- Underpinned by excellence in science, technology and innovation, generalised STEM capabilities and extensive research infrastructure and human resources

Nordic Comparator Countries

FINLAND, NORWAY, DENMARK, ICELAND

GOVERNMENT POLICY PRIORITIES

- World-class school education, higher education and research
- Science-industry knowledge transfer and innovation
- Improving capabilities to address challenges
- Sustaining competitive, innovative business environments
- Ensuring health, wellbeing, safety and security
- Successful transformation of economies, businesses and society
- Sustainably protecting the climate, nature and the environment

Policy Responses: Nordic Comparators

FINLAND, NORWAY, DENMARK, ICELAND

	Finland	Norway	Denmark	Iceland
School, higher education and skills	– Government Programme (2019) – Education Policy Report of the Finnish Government, 2021 – Entrepreneurship Strategy (2022) – LUMA (STEM) Strategy for the Years 2014-2025 (2014)	– Science for the Future: Strategy for Strengthening Mathematics, Science and Technology (MST) 2010-2014	– Life Science Strategy (2021)	– 2030 Education Policy. The First Action Plan 2021-2024 – Science and Technology Policy 2020-2022 (2020)
Research and innovation	– Strategy for National Research Infrastructures in Finland 2020-2030 – National Roadmap for Research, Development and Innovation	– Long-term Plan for Research and Higher Education 2023-2032 (2022) – Data as a Resource. The Data-Driven Economy and Innovation (2021)	– Danish Roadmap for Research Infrastructure 2020 (2021)	– Action Plan for Public Innovation (2020)
Technology	– Finnish Technology Policy (2021)	– Digital Strategy for the Public Sector 2019-2025 (2019) – National Strategy for Artificial Intelligence (2020) – Cyber Security – A Joint Responsibility (2017)	– Digital Growth Strategy (2018) – Strategy for Investments in Green Research, Technology and Innovation (2020)	
Climate, nature and environment; Energy	– Government Action Plan (2019) – Sectoral Low Carbon Roadmaps (2021)	– Norway's Climate Action Plan for 2021-2030 (2021) – Roadmap – The Green Industrial Initiative	– Climate Act 2020	– Iceland's 2020 Climate Action Plan
Space	– Space Strategy 2025 (2018)	– The Government's Strategy for Norwegian Space Activities	– Denmark's National Space Strategy (2021)	
Security	– The Security Strategy for Society (2017) – Government Report on Finnish Foreign and Security Policy (2016)	– Multiple instruments	– Foreign and Security Policy Strategy 2022	– National Security Policy for Iceland (2016)

Other European Comparators

FRANCE AND GERMANY

GOVERNMENT POLICY PRIORITIES

- World-class education, skills development and knowledge
- Leading research systems, global science
- Technology-driven industry growth
- Collaboration between education, industry, and research institutions
- Knowledge and technology transfer
- Industrial competitiveness

Policy Responses: European Comparators

FRANCE AND GERMANY

	France	Germany
School, higher education and skills	– Digital Education Strategy 2023-2027	– MINT Action Plan (2019) – National Skills Strategy (2019) – Digital Pact for Schools – Future Contract for Strengthening Studying and Teaching in Higher Education
Research and innovation	– Research Programming Law (2021-2030) – Second National Plan for Open Science 2021-2024 (2021) – Roadmap for French National Research Infrastructure (2016) – France 2030 Investment Plan (2021)	– Future Research and Innovation Strategy (2023) – Open Access Strategy 2020 (2015) – Internationalisation of Education, Science and Research (2019) – Pact for Research and Innovation
Technology	– Government Digital Roadmap (2008) – AI for Humanity: National Strategy for Artificial Intelligence (2018) – Investment in Clean Aircraft Technologies 2020-2023	– High-Tech Strategy 2025 (2018) – Artificial Intelligence Strategy 2020 Update (2020)
Climate, nature and environment; Energy	– National Low-Carbon Strategy (2022) – National Climate Adaptation Plan – French Green Hydrogen Plan 2020-2030 (2020)	– National Hydrogen Strategy (2020) – Research for Sustainability (2021) – Sustainable Development Strategy 2021
Space	– French Space Strategy (2011) – France 2030 Investment Plan – Space Section 2022-2027	– Making Germany's Space Sector Fit for the Future (2010)
Security	– National Security Strategy (2022)	– National Security Strategy under development

Anglosphere Comparator Countries

UNITED STATES, UNITED KINGDOM, AUSTRALIA

GOVERNMENT POLICY PRIORITIES

- Foundational scientific or STEM literacy (e.g., digital skills)
- STEM disciplinary skills and knowledge
- Global science (research)
- Public-private partnerships for innovation and technology breakthroughs
- Addressing declining international performance and competitiveness
- Addressing industry demand for professionals with STEM skills and knowledge

Anglosphere Comparators

UNITED STATES, UNITED KINGDOM AND AUSTRALIA

	United States	United Kingdom	Australia
School, higher education and skills	– Rising Above the Gathering Story (2007) – Charting a Course for Success: America's Strategy for STEM Education (2018) – Raise the Bar: STEM Excellence for All Students	– The UK as a Science and Technology Superpower (2021) – Britain's Industrial Strategy. Building a Britain fit for the Future (2017) – Scotland's Science, Technology, Engineering and Mathematics: Education and Training Strategy (2017) – Welsh STEM in Education and Training. A Delivery Plan for Wales (2016) – Northern Ireland's Success through Skills – Transforming Futures (2011) and Skills Strategy for Northern Ireland. Skills for a 10x Economy (2021)	– National STEM School Education Strategy 2016-2026 (2015) – Australia's National Science Statement (2017) – Australia's Science and Research Priorities 2015
Research and innovation	– Research and innovation legislation (e.g., America COMPETES Act, CHIPS and Science Act, 2022, United States Innovation and Competition Act of 2021)	– UK Research and Development Roadmap (2020) – UK Innovation Strategy. Leading the Future by Creating it (2021) – Science for Wales – A Strategic Agenda for Science and Innovation in Wales (2012)	– Australia 2030. Prosperity through Innovation. A Plan for Australia to Thrive in the Global Innovation Race (2017) – National Research Infrastructure Roadmap (2021) – Research Infrastructure Investment Plan (2020)
Technology	– National Artificial Intelligence Research and Development Strategic Plan: 2019 Update – AIM Initiative: A Strategy for Augmenting Intelligence Using Machines (2019) – Department of Defence AI Strategy (2018)	– UK Digital Strategy (2022)	– Blueprint for Critical Technologies (2021) – Action Plan for Critical Technologies (2021) – National Quantum Strategy Issues Paper (2022) – National Robotics Strategy Discussion Paper (2022)
Climate, nature and environment; Energy	– Energy Storage Grand Challenge Roadmap (2020) – Climate Strategy (2021) – Joint Statement between the United States and the European Commission on European Energy Security (2022)	– Net Zero Strategy. Build Back Greener (2021)	– Climate Change Act (2022) – Climate Change Action Strategy. Tackling Climate Change Through Australia's Development Assistance Program 2020-2025 (2019)
Space	– US Space Policy Directive – 2, Streamlining Regulations on Commercial Use of Space (2018)	– National Space Strategy (2022)	– Australian Civil Space Strategy 2019-2028 (2019)
Security	– Interim National Security Strategic Guidance (2021) – National Security Strategy (2017)	– Global Britain in a Competitive Age: the Integrated Review of Security, Defence, Development and Foreign Policy (2021)	– Safeguarding our Community Together. Australia's Counter-Terrorism Strategy 2022 – National Counter-Terrorism Plan (2022)

East Asian Comparator Countries

JAPAN AND SOUTH KOREA

GOVERNMENT POLICY PRIORITIES

- Science, technology and innovation
- Digitalisation
- Economic competitiveness
- Enabling rapid technology advances
- National safety and security
- Sustainability and resilience

East Asian Comparators

JAPAN AND SOUTH KOREA

	Japan	South Korea
School, higher education and skills	– 6th Science, Technology and Innovation Basic Plan (2021)	– 5th Science and Technology Basic Plan, 2023-2027 – Science, Mathematics, and Informatics Education Promotion Law (2018)
Research and innovation	– Integrated Innovation Strategy 2022 – Quantum Technology and Innovation Strategy (2020)	– Government R&D Innovation Plan (2015) – Basic Framework for Regional Innovation based on Science and Technology Policy
Technology	– Declaration to be the World's Most Advanced IT Nation: Basic Plan for the Advancement of Public and Private Sector Data Utilization	– National Strategy for Artificial Intelligence (2019) – 5G+ Strategy to Realize Innovative Growth (2019)
Climate, nature and environment; Energy	– Fusion Energy Innovation Strategy (2023)	– The Korean New Deal 2.0. National Strategy for a Great Transformation (2021)
Space	– Basic Plan on Space Policy (2020)	– 4th Basic Plan for Promotion of Space Development
Security	– National Security Strategy of Japan (2022)	– Strategy for a Free, Peaceful and Prosperous Indo-Pacific Region (2022)

11 COMPARATORS – 15 STEM POLICIES

MORE RSEEARCH WILL FOCUS ON THESE STEM POLICIES

Country	Notable STEM policy
Finland	LUMA (STEM) Strategy for the Years 2014-2025 (2014)
Norway	Science for the Future: Strategy for Strengthening Mathematics, Science and Technology 2010-2014
Iceland	Science and Technology Policy 2020-2022 (2020)
Germany	MINT Action Plan (2019)
	National Skills Strategy (2019)
United States	Charting a Course for Success: America's Strategy for STEM Education (2018)
	Raise the Bar: STEM Excellence for All Students
United Kingdom	The UK as a Science and Technology Superpower (2021)
Scotland	Science, Technology, Engineering and Mathematics: Education and Training Strategy (2017)
Wales	Science, Technology, Engineering and Mathematics (STEM) in Education and Training. A Delivery Plan for Wales (2016)
Northern Ireland	Success Through Skills – Transforming Futures (2011)
	Skills Strategy for Northern Ireland. Skills for a 10x Economy (2021)
Australia	National STEM School Education Strategy 2016-2026 (2015)
Japan	6th Science, Technology and Innovation Basic Plan (2021)
South Korea	5th Science and Technology Basic Plan, 2023-2027

COMPARATORS

7 STEM POLICY OBJECTIVES

7 STEM Policy Objectives

COMPARATORS TYPICALLY HAVE OVERARCHING STEM POLICY TEXTS

MANY OF THESE POLICIES HAVE COMMON POLICY OBJECTIVES

INTEREST

Increase interest in science

PARTICIPATION & PERFORMANCE

Increase participation & performance in school mathematics and science

MEET INDUSTRY NEEDS

Meet industry demand for STEM knowledge and skills

SCIENTIFIC LITERACY

Increase scientific literacy and digital skills capability

PARTICIPATION & PERFORMANCE

Increase participation and performance in higher education STEM

RESEARCH & INNOVATION

Increase research excellence & innovation

GRAND CHALLENGES

Enable research on grand challenges & national priorities

The next Phase of this study towards shifting STEM Further Onto Sweden's Policy Agenda

Building on this evidence base, the next phase of this study will involve further:

1. Examination of Swedish literature;
2. Discussions with Swedish stakeholders to examine STEM policy challenges, contemporary programs, and existing proposals for reform;
3. Detailed analysis of comparator country's STEM policies and programs, focusing primarily on school mathematics and science, higher education STEM disciplines, research and development;
4. Development of recommendations to inform the development of a Swedish STEM policy.

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