POLICY BRIEF
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GOVERNMENT'S ANALYSIS, ASSESSMENT AND RESEARCH ACTIVITIES

Perspectives into topical issues in society and ways to support political decision making

Finnish AI Competences and How to Make Them Stronger

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This policy brief describes the artificial intelligence (AI) competences in Finland in the areas of research, education and the corporate and public sector. The main finding of this study is that Finnish competences in AI are on par with those of similar countries. Our key recommendations for strengthening AI competences are as follows:

- Formulate a clear national AI competence strategy based on ten sub-fields of AI, and improve the efficiency of research&development by decreasing the effort needed for applying for research project funding.
- Move away from congested mainstream AI topics to niches where Finland can be strong.
- Make all AI-related university courses open, visible and accessible to everyone.
- Start piloting and using algorithm-based decision making in non-critical tasks.
- Integrate AI as part of all public sector digitalization plans.

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INTRODUCTION

Competence in artificial intelligence (AI) is seen as a key factor for the future success of organizations and nations. The Finnish AI competences in the fields of research, education and enterprises have been analysed. Based on this analysis, policy recommendations are given.

AI has been divided into ten sub-fields

Given that AI is a complex and multidimensional collection of technologies, it has been divided into ten sub-fields, which are listed below. This should help in better understanding the topic and consequently conducting more elaborate and fruitful discussions on AI. The report **Tools for artificial intelligence discussion** published in June 2018 describes the ten sub-fields in detail.

1. Data analytics
2. Sensing and situation awareness
3. Natural language and cognition
4. Human interaction
5. Problem solving and computational creativity
6. Machine learning
7. Systems level architecture, dynamics and complexity
8. Computational environment of AI; platforms and services; ecosystems
9. Robotics and machine autonomy – physical dimension of AI
10. Ethics, morals, regulation and legislation

What was studied and how

The task was to analyse Finnish competences in artificial intelligence. As the focus was on technological competences, applications and exploitation of AI were of secondary importance for the study.

The analysis is structured along two dimensions. The first dimension consists of three fields, namely, research, higher education and AI competences in private companies and the public sector. The second dimension is the ten sub-fields of AI, as described above.

Research competences were analysed using standard bibliometric methods and semi-structured interviews with key persons in academia and research funding. The bibliometric methods emphasize the number of scientific papers published in highly regarded forums.

Competences in higher education were evaluated by assessing the number of courses and curricula with strong AI emphasis in universities and universities of applied sciences. Questionnaires, data collection from the web and interviews were used to gather information.

Competences in companies were analysed using two rather large existing databases, namely, Digibarometri and Slush, analysis of AI-relevant employee profiles in seven sample companies as available on LinkedIn and, finally, via semi-structured interviews with nine company representatives who are at high-ranked executive positions (CxO level). As in the other two fields, Finland was compared with other countries.

AI competences in Finland

Finland ranks number 17 after South Korea and ahead of Austria when analysing the *quality of published research papers*. The volume of Finnish research publications represents 0.5% of global output. The relative quality of published papers in the ten sub-fields of AI are listed in the first column of table 1.

Finnish competences in Artificial intelligence in general are on par with similar countries

Higher education system offers a variety of courses and curricula in AI technologies. Eleven universities and five universities of applied sciences offer courses in AI technologies. All ten sub-fields are covered by the course offering. The number of individual courses is approximately 250. AI-related Bachelors, Masters and Doctoral programmes are available in some

Sub-field	Research [1]	Higher education (course offering)	Companies and public sector
Data analytics	1.32	In almost all universities	In broad use, several tech and service providers; it is also in use in the public sector
Sensing and situation awareness	1.24	In several	Used by a few tech providers
Natural language and cognition	1.36	In a few institutions Finnish language processing in Turku and Helsinki Universities	In early stages, a few tech companies Finnish language processing developed in a few companies, Finnish "AI Accelerator" started a focus group
Human interaction	1.2	In several	Few companies, but a couple of them are quite successful
Problem solving and computational creativity	1.34	In several	Very few companies
Machine learning	1.29	In several	Use growing, several companies
Systems level architecture, dynamics and complexity	1.2	In only one	Observed in the public sector
Computational environment of AI; platforms and services; ecosystems	1.18	In several	Widely used, tech and service providers. Also core tech development in international tech companies.
Robotics and machine autonomy – physical dimension of AI	1.19	In several	Broadly used in industry.
Ethics, morals, regulation and legislation	1.87 (NB! The number of publications is very small)	In a few	Growing interest, government and public sector activated.

Table 1. Summary of Finnish artificial intelligence competencies in the fields of research, higher education, and in companies and public sector

Deep green indicates relatively optimal position, while lighter green and no colour indicate a relatively weaker position.

[1] Normalized ratio of high-quality papers. 1 = world average, the higher the better. For example, figure 1.4 means that the ratio is 40% higher than the average of 50 countries producing most papers.

universities. The broadest course offering is provided by Aalto University and University of Helsinki. The results are summarized in the second column of table 2.

Finnish companies and the public sector have taken a strong interest in artificial intelligence technologies, and several organizations already deploy them. In particular, data analytics and robotics are in production use, while the strongest interest and development projects focus on the use and development of machine learning methods.

The conclusion is that Finnish competences in Artificial Intelligence are, in general, on par with similar countries, i.e., the Nordics, and other advanced small European countries. The key findings regarding Finnish AI competences in research, higher education as well as in companies and public sector are collected in table 1.

Research competence of different nations

The quantity and quality of publications are important indicators of research competence. The quantity and quality of publications are unlikely to be independent of each other. Large countries producing a large number of publications probably also produce a higher number of top-quality papers than small countries. This is a valid conclusion in a statistical sense if one assumes that the distribution of talent and research facilities are approximately equal among different nations and countries.

The number of research papers on artificial intelligence in different countries gives a good indication of the volume of research. The number of publication in ten countries is presented in table 2 (source Scopus; for more details see **interim report**).

Country	China	USA	UK	India	Germany	Spain	France	Japan	Sweden	Finland	Denmark	Norway
Number of publications 2003–17	29422	29374	11111	10833	9241	7964	7943	7043	1402	1257	951	770

Table 2. Publication volume of the largest countries and the Nordics

Measuring the quality of research publications is not an easy task. Here, we use a method based on the *percentage of publications published in high-quality forums*, i.e., papers and conferences (see also footnote 1 on previous page) of all AI publications.

The results are given in table 3. The columns give rankings for each country in the ten sub-fields of AI. More detailed analysis can be found in a more detailed report (**link**, in Finnish).

The table contains the rankings for Finland and three groups of countries. The first group includes three other Nordic countries, which form a natural reference group for Finland. The second group contains three nations with large research and publication volume, namely,

United States, United Kingdom and Germany[2]. The third group could be characterized as small giants in AI research, namely, Hong Kong, Singapore and Israel.

Finland has the highest ranking of Nordic countries in four sub-fields. In other sub-fields, various Nordic countries have the best rankings. For example, in data analytics, Denmark is very strong, as it ranks number 4.

Research papers from the USA and the UK rank quite well in all sub-fields, while Germany is clearly weaker. The large volume of published papers and their relatively high quality is a proof of the competence and strength of these three nations in AI research.

The third group, Hong Kong, Singapore and Israel are small countries with very good rankings in all ten sub-fields. The potential reasons for their success are a strong national emphasis on research, development and innovation activities, extensive international collaboration in co-authoring high-quality publications and the general positive attitudes towards science. Hong Kong and Singapore also benefit from an influx of talented researchers. Hong Kong receives much talent from China while Singapore recruits researchers globally and especially from nearby South-East Asian nations.

China, India, Japan and Russia are absent in the list of 23 countries producing “top papers”. Chinese, Indian and Japanese researchers produce a large number of publications, but the

Country	Data-analytics	Sensing and situation awareness	Natural language and cognition	Human interaction	Problem solving and computational creativity	Machine learning	Systems level architecture, dynamics and complexity	Platforms and services; ecosystems	Robotics and machine autonomy	Ethics, morals, regulation and legislation
Finland	7	16	15	15	6	11	13	20	19	5
Sweden	13	12	22	-	15	14	17	21	5	-
Denmark	4	14	17	16	8	8	12	9	-	17
Norway	-	23	23	13	16	15	8	-	8	18
United States	9	5	4	7	10	9	11	4	10	7
UK	10	8	5	8	12	10	16	11	12	16
Germany	22	15	-	18	22	12	18	-	23	-
Hong Kong	1	1	1	1	1	1	2	1	2	1
Singapore	2	3	2	3	2	6	7	2	9	6
Israel	11	2	7	5	9	2	9	19	3	13

Table 3. Ranking of ten countries based on the percentage of all publications that are published in high-quality forums

The numbers in the table are the ranking of each country in a sub-field. Rank 1 is the best. Dash (-) means that the ranking is 24 or below that.

[2] China (or India) are not present in the table because they do not rank among 23 “best” countries in any sub-field. One should note, however, that there is a large number of top papers from China (and India), even if their relative share does not merit a position among the 23 countries.

share of those published in high quality forums is not sufficient to merit a place among the 23 best-ranking countries. The absence of Russia may result from the obvious reason related to the quantity and quality of publications. Publishing in their native language forums may also be a reason, as those forums may lack visibility in databases.

Where the competence comes from and how it moves

Competences related to AI can be either scientific and technological or related to applying AI to certain domains and exploiting AI in business. Competence can reside in persons, technological artefacts such as machines, software, and platforms or organizations.

Competences move with people, technologies and, in some cases, with organizations, e.g., when a large company buys a start-up. Competences move within Finland and across borders. Inside Finland, competence moves when graduates from universities take their newly acquired knowledge to the industry and the public sector. Additionally, there is movement from research to companies and between companies and the public sector. Figure 1 depicts the creation and transfer of competences.

The emigration and immigration of experts can be regarded in terms of brain-drain as a zero-sum game. Taking a more positive view, Finns leaving the country can be seen as ambassadors of Finland and immigrating experts as sources of renewal and diversity for the country.

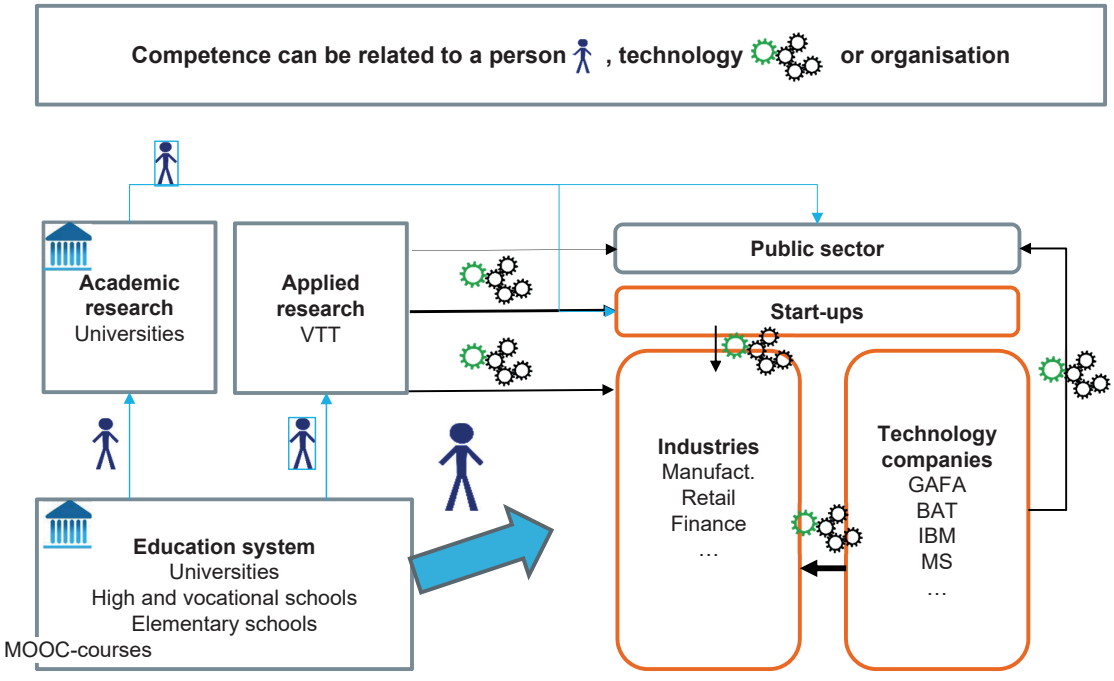

Figure 1. Creation and transfer of AI competences

Conclusion

Taking into account the size of the nation, Finland is strong in AI competences. There is no reason why we should lose this strength. In contrast, Finland can be one of the countries that benefit the most from the use of AI technologies.

Based on the understanding of the AI landscape, we can create a successful national AI strategy

The discussion on AI should be analytical and result in a good understanding of the AI landscape and future opportunities. Based on this, we can choose and prioritize the areas where Finland should focus, and create a successful national AI strategy.

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