Bridging the Artificial Intelligence Skills Gap in the Machine Manufacturing Industry

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INTRODUCTION

Artificial Intelligence (AI) talent is nowadays hard to find, and no company today has enough in-house AI talent. AI will transform many different jobs, and companies should give every employee the knowledge they will need to adapt to their new roles in the AI era. It is important to keep in mind that AI is much more than just a technology. It is a resource to implement new business models and better services. User acceptance is the prerequisite for solution implementation.

During the last decade, there has been an explosion in the design, development and implementation of AI in many sectors. However, little attention has been given to AI as a societal phenomenon and to the broader implications of the different approaches taken as we move rapidly toward an AI age.

Organizations do not see AI technologies or its availability as a challenge. Instead, organizations are currently struggling with AI business potential understanding and with finding AI talent.

A growing number of countries have recognized the opportunities provided by artificial intelligence and have prepared a national artificial intelligence strategy. In 2017, Finland was among the first countries to launch an artificial intelligence program. The objective of the program was to make Finland a leader in the application of artificial intelligence.

The Finnish Artificial Intelligence Programme[1] identified a small portion of companies as forerunners in AI implementation, with the majority of companies still being at the early stages of utilizing data and AI in their operations.

One of the ways, and an important starting point, to address the AI skills gap is to increase resources for digital, math and technical education in general. In addition, the current education system in Finland does not yet pay enough attention to applying AI in different fields. Academic and training programs are just not able to keep up with the rapid pace of innovation with AI. AI education should start early and take place for every education stage. Academia, companies and public sector officials must work together and ensure that comprehensive AI curriculums will be available. MOOCs (Massive Open Online Courses) show the way and are a good example of a modern way to educate masses with basic AI knowledge. However, deeper understanding of how to apply AI in company and industry contexts typically requires tailored education modules.

The manufacturing sector is currently lagging behind in AI and Machine Learning (ML) utilization compared to many other industries (Figure 1). Adopting new technologies especially in process industries requires pedantic planning which is time consuming. Companies have long histories in optimizing their production, and as the life span of investments can last for decades, changes unfortunately cannot be made rapidly. In

[1] https://www.tekoalyaika.fi/en/

addition, the safety and environmental regulations require strict governance.

Drawing from the sector estimates of the PwC AI impact index,[2] PwC estimates that by 2023, individual industry sectors may increase their operating margins (i.e. how much of each euro of revenues is left over after both costs of goods sold and operating expenses are considered) by 60-100%. The difference in the industry specific 'AI boost curve' shapes reflect the impact of two different factors: 1) the speed with which the industries are capable of adopting different AI applications and 2) the AI solution development to address the industry-specific business issues.

In manufacturing, short-term benefits are expected to come mostly from process automation and productivity-based solutions. In the mid-term, more complex processes can be automated as intelligent automation offers considerable potential, and predictive maintenance and optimization applications further boost performance.

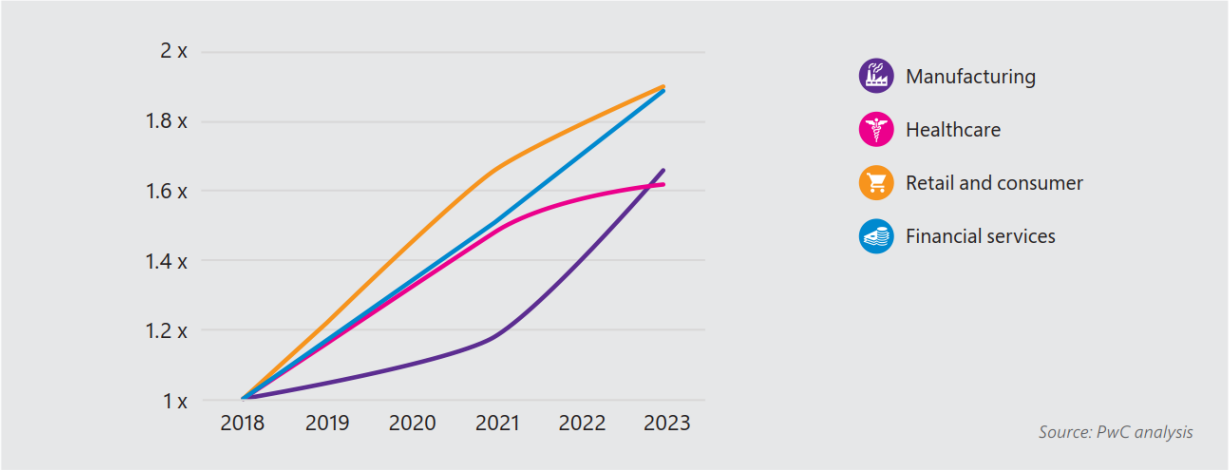

Figure 1: AI growth boost varies by industry (source: PwC Finland: Uncovering AI in Finland)

Productivity gains from AI and ML are not only dependent on the introduction of the technology itself. There is also a need to change the organization of work and increase employees' knowledge.

Skills Gap in Artificial Intelligence Adoption

Research[3] shows that the biggest barrier to AI and machine learning adoption is a lack of human skills. Most of the time, surveys refer to the technical skills needed to develop AI and ML solutions. However, the

[2] PWC Finland: Uncovering AI in Finland, 2018.

[3] e.g. O'Reilly 2018; Ernst & Young 2017

biggest skill gap in AI and ML spans across the organization.

The Finnish Artificial Intelligence Programme end report pointed out that based on their survey, Finland has high quality education for those who aim to be AI professionals (e.g. information technology, mathematics), but there is a gap in the AI applier field. In these fields, the effects of AI would be seen fastest. The working group stated that in order to achieve the ambitious AI targets, the most important things are to ensure that versatile education will be available, investments are made in new education methods and programs are created to attract talent to Finland.

Continuous education of current employees is a challenge, and different operations and mechanisms are needed to address these concerns. A critical factor is to increase management awareness and knowledge regarding the opportunities AI will bring. This is how enough input can be secured for new flexible education methods.

Employee competence requirements are affected by the changes in the work demand in the job markets. The need for new talent is increasing at a rapid pace in tasks where AI will be developed and applied. This demand cannot be addressed by the usual education path. Rather, new operations and mechanisms are needed to help improve existing employee skills efficiently.

Much of the employee competencies are based on the on-the-job learning, and thus companies have more responsibility for competence development. Companies are actively seeking for ways to re-educate their employees either internally or in co-operation with other companies.

Today, numerous approaches exist to carry out education, but suitable combinations for workplace learning in Industry 4.0 contexts do not yet really exist. But without an adequate performance appraisal strategy and adequate training of the workforce with suitable educational approaches (e.g. self-regulated, reflective, collaborative, blended learning), there is a risk that workers are excluded from being employed in Industry 4.0 environments and that the expected impact on task performance decreases (i.e. efficiency of production, product diversity and quality).[4]

To succeed, companies need to equip their existing professionals with the AI skills to apply their knowledge in the AI-driven world. This is supported by a recent study of Future Workplace and The Learning House (2018)[5] highlighting that training the workforce for AI and ML skills could be the efficient way to fill the skills gap.

Letmathe & Schinner (2017)[6] state that the success of workers will depend on their

[4] E.Ras et. al (2018): Bridging the Skills Gap of Workers in Industry 4.0 by Human Performance Augmentation Tools – Challenges and Roadmap. Luxemburg Institute of Science and Technology. Proceedings of the 10th International Conference on PErvasive Technologies Related to Assistive Environments. Pages 428-432

[5] https://www.learninghouse.com/closing-skills-gap-report/

[6] Lemathe P. & Schinner, M. RWTH Aachen University. Competence Management in the Age of Cyber Physical Systems. In book: Industrial Internet of Things. Oct 2017.

flexibility and problem solving competencies as well as their willingness to engage in lifelong learning; otherwise, they will not be able to keep up with the required changes in their workplaces and work procedures. This challenge might also explain why many companies are reluctant to invest in Cyber Physical Systems (CPS), which typically include AI. Competence management on the organizational level, as well as the reform of public education, are important factors for introducing CPS.

CASE STUDY—MACHINE LEARNING ACADEMY (MLA)

Nowadays, it is relatively easy to find free and general-level online training about Artificial Intelligence and Machine Learning from key technology providers (such as IBM, Microsoft, Amazon and Google) or from MOOCs organized by prominent universities. One example is "Elements of AI" [7], a 6-module online course created in co-operation by the Finnish technology company Reaktor Ltd. and the University of Helsinki. Typically, the aim of this type of training is "to demystify AI", i.e. to encourage a broad group of people to learn what AI is, what is it good for and what are its limitations.

Machine Learning Academy[8] (MLA) is an example of a more focused and industry-tailored approach for closing or at least narrowing the AI competence gap. It is organized by DIMECC Ltd. in co-operation with Futurice Ltd., a Finnish technology consulting company with wide experience in offering training on AI and ML to various target groups from designers to board members. The first MLA course, focusing on the Finnish machine manufacturing industry, was organized in Finland during the autumn of 2018. The second course closed at the end of April 2019. This initiative was also highlighted in the final report of Finland's National AI Programme as an innovative example of AI-related education.

MLA's primary target audience consists of R&D supervisors and engineers as well as business and product owners who are managing and/or participating in AI/ML development projects. In order to succeed in these tasks, they need to understand how to specify, plan, evaluate and manage development or insourcing of sub-entities that contain elements of AI and ML. For example, for R&D engineers it is important to understand how introduction of these new technologies will change the capabilities, boundaries, schedules and interfaces of their product development processes. After the course, participants will have an understanding of the fundamentals of AI and ML as well as an ability to recognize and manage development tasks that aim to benefit from use of these new methodologies.

MLA consists of seven full-day training modules with supporting pre-reading materials, hands-on exercises and homework. The training starts with high-level topics, such as review of typical business drivers and examples of ML applications. In the next, more technical modules, various ML methodologies are

[7] https://www.elementsofai.com/

[8] https://www.dimecc.com/dimecc-services/dimecc-machine-learning-academy/

covered (i.e. supervised learning, unsupervised learning and deep learning), followed by data understanding and ethics of AI. The sixth module helps the participants understand how real-life AI/ML projects are executed, and course projects are reviewed in the last module.

Throughout the course various types of business and technical canvases are introduced and used as learning tools. Their main purpose is to help the participants understand where they need to focus and which stakeholders they need to engage with during the different phases of their data science projects. For example, the "Business Objective and Context" canvas used in the first module directs its users to work together with business owners and those who fund the project when answering questions such as "what is the business objective [of this project]?" and "how does it fit with our business strategy?" Figure 2 describes how the expertise of a cross-disciplinary project team could be used in a typical data science project.

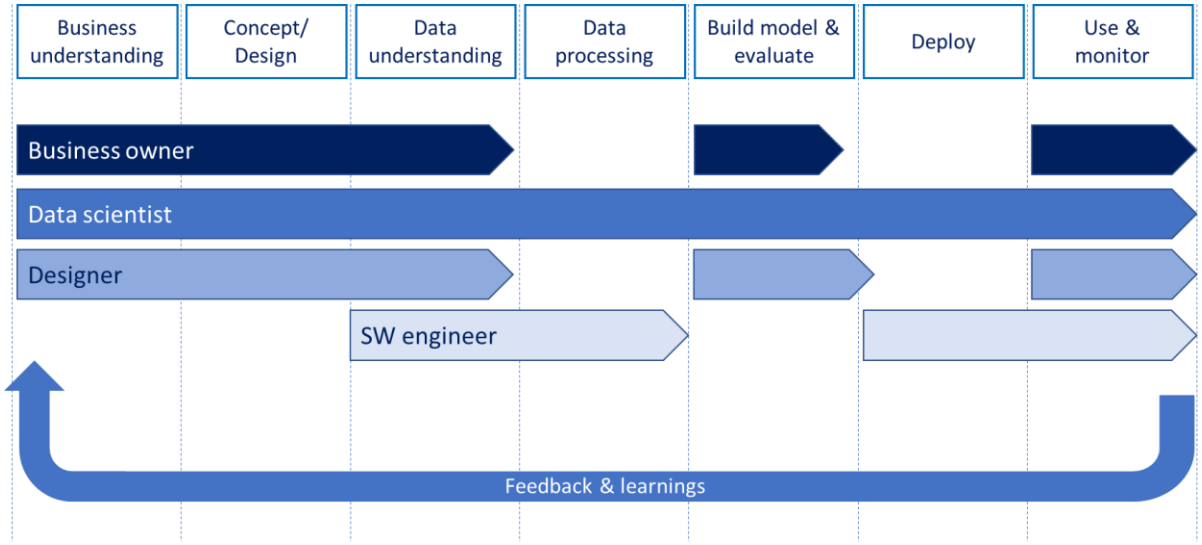

Figure 2: Roles of various stakeholders and disciplines in a data science project (adapted from material presented in DIMECC's Machine Learning Academy, source: Futurice Ltd.).

Given MLA's primary target group, it is not surprising that in their feedback the participants appreciated getting more understanding on how ML projects can drive and shape actual business impacts. Also, topics related to preparing and running practical ML projects were valued, i.e. data preparation (collecting, cleaning, pre-processing, filtering, analyzing, etc.) and comparison of different ML methods. According to one participant, "*Often we do a lot of work just to see that we are stuck with insufficient data*".

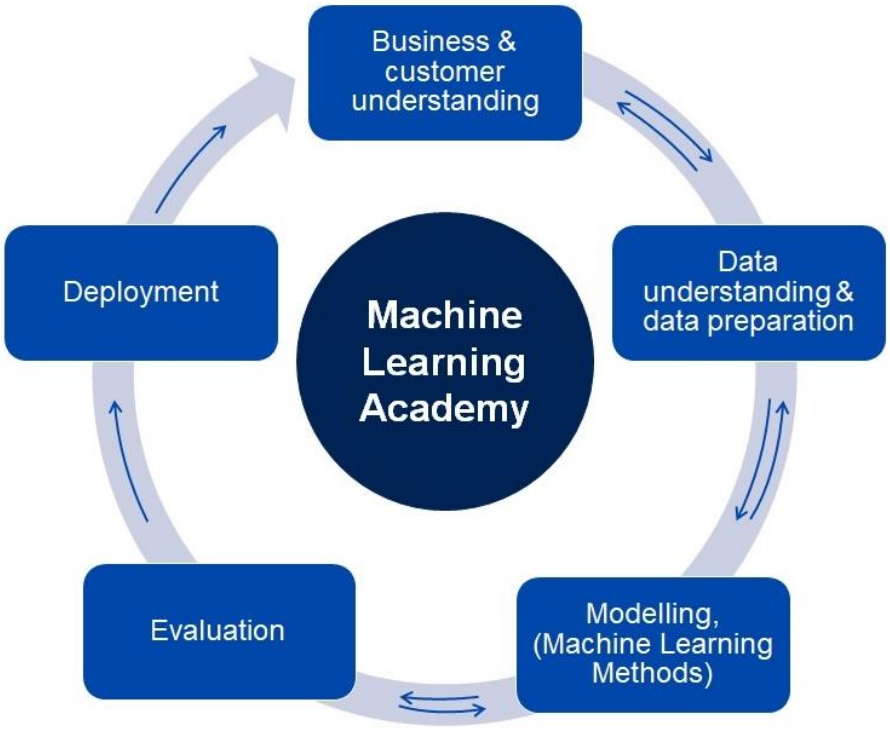

Figure 3: The cyclic nature of AI/ML projects (as presented in DIMECC's Machine Learning Academy).

One of the differentiating factors of MLA is that the participants are expected to plan and specify a real Machine Learning project. The course modules are arranged in such a way that their content follows the flow of a typical ML project (see Figure 3). The course arrangements also provide the participants with several opportunities to discuss their projects with lecturers and the other students and share and compare their approaches.

In order to successfully complete the project assignment, the participants also need to get contributions from various internal stakeholders, such as business and process owners, technology developers and product managers. As topics related to the course project are introduced and addressed throughout the course, the participants are encouraged to engage with these stakeholders and get their commitment to the new approach. The aim is that at the end of the course, each participant has a project specification which key stakeholders are already familiar with and which is detailed enough for starting an in-house development project or sourcing it from an external supplier. In the spirit of co-creation, each participant presents her/his course project in the last module at an appropriate level of detail.

Although the participants of the first MLA course came mainly from R&D, their project topics covered a wide variety of companies' internal functions, such as finance (smart cash forecasting, customer risk analysis), sales (pricing and tool, automated offer generation), manufacturing (intelligent scheduling, process control for quality optimization), customer care (predictive and preventive maintenance) and human resources

(improved competence development through job market analysis). One concrete example was PONSSE Plc's field project, which focused on after-sales services, especially field maintenance of the harvesting equipment where Machine Learning was to be used to recognize the needed oil change interval. Hydraulic oil and filters are currently changed at fixed intervals, approximately every 1800 hours, and optimized change interval would mean remarkable savings.

Machine Learning Academy lasts about three calendar months, and the planned total effort for participants, including the project work, is 100 working hours. Feedback and experience from the first two MLA courses suggest that this is enough to achieve the planned learning targets, depending on the participants' ability to study on top of their daily duties. Also, the course project seems to be a good way to make the learning more concrete and get commitment from various stakeholders.

CONCLUSIONS

This paper has discussed the current skills gap in machine learning adoption and relevance of the Machine Learning Academy, its benefits and the implications for the manufacturing and machine building industries. Although the skills gap is likely to remain for the foreseeable future, there is clear need for tailored Machine Learning Academy types of programs to help companies develop their employees to the right direction with desired skills and encourage them to start experimenting with AI. With the positive feedback received from Academy participants, it has been decided that Machine Learning Academy events will be organized also in the future.

Recommendations **on how companies, academia and governments can take positive steps to address:**

Develop a customized curriculum for your industry

Instead of trying to compete generally in AI with leading tech companies such as Google, we recommend becoming a leading AI company in your industry sector where developing unique AI capabilities will allow you to gain a competitive advantage. How AI affects your company's strategy will be industry, company and situation-specific.

Focus on educating the whole company personnel

Rather than establishing separate AI units within the organization, we recommend that AI competencies and understanding should be increased at all levels – from the management level to the shop floor. The same principle applies on the society level.

AI training should encourage concrete pilots and use cases

Build AI training curriculums that encourage concrete pilots and use cases. This helps to turn AI concepts into practical value.

Reform existing public education.

Explore opportunities to establish an AI education voucher or an education account which would stimulate functioning adult education markets.

Increase the amount of web-based training courses and open university courses for all. Integrate AI education also with vocational school curriculums.	

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