




**UK Electronics
Skills Foundation**

Future engineering skills in the age of artificial intelligence

A report from the UKESF



March 2023



“We are now entering the age of AI and it’s clear that AI will be the most important technology for the next 50 years.”

Simon Segars
former CEO of Arm

“AI will be the most profound change in human history.”

Professor Stuart Russell
The Reith Lectures, BBCR4 December 2021



Foreword

In recent years, we have witnessed a dramatic rise in computer power and data processing, coupled with scientific breakthroughs such as deep learning and neural networks. Together, these advances have heralded a new age of data science, machine learning and the emphatic arrival of Artificial Intelligence (AI), that is ‘machines that think’, as imagined in Alan Turing’s ground-breaking 1950 paper.

The UK Government has an aspiration to make Britain a global AI superpower. Over the next ten years, the impact of AI on businesses across the UK and the wider world will be profound. UK universities and start-ups are already at the forefront of building these tools for the AI age, and so have the potential to make a profound contribution to a healthy, robust UK economy.

However, there is a danger that a lack of understanding about the nature of AI could restrict the UK’s growth and success in this area. AI is not a stand-alone technology. It is much broader than simply machine learning algorithms. In order to sense,

understand, act and, crucially, learn to do things better, AI Systems combine algorithms with sophisticated electronics, pervasive connectivity, electro-mechanical modules and machines, and physical infrastructure.

To take full advantage of the opportunities offered by AI, the UK needs a skills pipeline that will support the development AI systems across all these technology layers, rather than just algorithms. It is essential to ensure that educational and training capabilities are in place that are relevant to, and support, the full AI ecosystem. Companies in the ‘deep tech’ sector (semiconductors, electronics, sensors) are at the forefront of the evolution of AI systems and their applications. In the absence of foresight, planning and engagement between industry, government, academia and secondary schools, there is a serious risk that future engineering graduates will fail to meet these emergent needs of a ‘deep tech’ sector powered by AI systems.

Contents

Summary of findings	4
Introduction	4
Why it's important to understand the skills required to deliver future AI capability	5
What is AI?	6
UKESF AI skills research and its findings	7
Final thoughts	8
Online survey questions and responses	9
Endnotes and References	10
About the UKESF and TechWorks	11

Summary of findings

An overwhelming number of respondents to our survey reported that a shortage of skills was a concern. Looking ahead, almost three quarters stated that different, specific, technical skills will be required in the future and two thirds said that wider AI related skills was also a focus.

95%

said a shortage of skills in the external labour market concerned their companies

73%

said they envisaged that they would need different technical skills at their company/organisation

84%

said they had plans to up-skill and re-skill their workforce

67%

said they would be focusing on wider AI related skills

Introduction

Governments around the globe recognise the increasing importance of Artificial Intelligence (AI), machine learning and big data in driving economic growth and generating both societal and environmental benefits. The UK Government has already committed to making our country a leader in the use of AI through its announcement in 2018 of the billion-pound AI sector deal, which aims to ensure the UK is at the forefront of the AI and data-driven economy.

As Artificial Intelligence (AI) becomes embedded in people's lives, the UK finds itself at a pivotal moment. Estimates show that AI could deliver a 10% increase in UK GDP in 2030. The Government believe that, if approached correctly, this would offer huge benefits to the economy, to recovery and resilience, the environment and for people from all walks of life across all parts of the UK. However, a shortage of skills is frequently cited as a critical challenge. For instance, the Turing Institute reported in a 2021 survey of the UK's "AI Ecosystem" that: *Only around one in five respondents (19%) thought that business currently had the necessary skills and*

knowledge to understand where value could be gained from using AI; and only 18% agreed there was sufficient provision of training and development in AI skills available to the current UK workforce.

Their report, along with results of a study by Microsoft, were referenced and included in the Government's National AI Strategy, published in July 2021, which noted: *The gap between demand and supply of AI skills remains significant and growing despite a number of new AI skills initiatives since the 2018 AI Sector Deal. In order to meet demand, the UK needs a larger workforce with AI expertise. Last year there was a 16% increase for online AI and Data Science job vacancies and research found that 69% of vacancies were hard to fill.*

However, these studies all focus on the broader aspects of working on and with AI. To date, there hasn't been any research specifically about the future skills needed to create and engineer the technology to delivery future AI capability. The UK Electronics Skills Foundation (UKESF) has now undertaken this research and their findings are presented in this report.

Why it's important to understand the skills required to deliver future AI capability

AI capability depends upon physical 'systems', as well as machine learning algorithms. These systems combine software with sophisticated Electronics, pervasive connectivity, machines and infrastructure in order to sense, understand, act and, crucially, learn to do things better. The UK has all the expertise required to develop a full computing stack, that ranges from materials and devices to applications and algorithms.

However, in order that the UK can grow and flourish as an area of AI systems expertise, it is essential to ensure that the appropriate educational and training capabilities are in place. These are required to support the anticipated growth and to attract more talent and inward investment.

There is increasing focus on Digital/ AI Engineering among the professional engineering institutions and higher education. However, there is little published research available to identify and quantify future industry demand around Digital/AI Engineering. Therefore, there is a serious risk that future engineering graduates will fail to meet these emergent needs of the deep tech sector.

Frequently, the rallying call is that we are 'data rich, but insight poor' and that AI will help to make sense of a deluge of data. In one sense, AI is an amorphous term, covering many different types of technologies.





What is AI?

Currently, AI is most commonly used as a term to describe neural networks, specifically convolutional neural nets (CNN) and deep neural nets (DNN). It is recognised that the UK has some leading strengths in large-scale neural computing systems as well as in algorithmic development for AI-dedicated hardware – including material science, nanoscale memristive devices, analogue/digital circuits and systems design, and multi-core architectures. There are also rule-based AI systems and other techniques for pattern recognition that we will consider as part of our investigation.

It can be considered that AI is a broadly used term that can cover linguistics, sensor data analysis or image analysis. For instance, large AI frameworks will use data from LiDAR, radar, camera and sonar sensors to train autonomous, self-driving vehicles. There is also facial recognition, where frameworks are trained with pictures of faces in order to count heads and recognise specific people.

For applications such as the Internet of Things, AI can look more like digital signal processing (DSP). Indeed, well-established DSP chip IP suppliers have ported their cores to AI implementations in pattern recognition. This can use DNNs or signal envelopes with rule-based logic to provide local decision-making capabilities. This means the vast majority of microprocessor and microcontrollers that ship will include some form of AI in hardware.

UKESF AI skills research and its findings

The UKESF conducted a series of in-depth interviews with key industry stakeholders for the purposes of this report. To complement this qualitative research, an online survey was also undertaken to gather quantitative data from across a wider industry stakeholder group.

Qualitative interview findings

The UKESF interviewed 30 industry stakeholders working in senior roles.

The interviews revealed that companies see the 'era of data and AI' as one of significant change. First, in terms of the chip design process itself. Interviewees envisaged AI enhancing the design tools they used, for better simulation, place and route (P&R) and Design for Test (DfT). Also, for using AI as part of the chip to facilitate gathering of data for future, things like using AI on the chip to identify cybersecurity hazards, functional safety, identifying when performance changes or drops.

More broadly, the interviews revealed that the education system isn't currently producing engineers fully adept in AI: *"Today, if you go out and look for AI engineers you do not find many. We have been looking for people that are really good at hardware or software design or are capable of learning. The ML side can be learnt so it's more important to find good engineers who can do a lot of lateral thinking and learn fast, with broader skill sets."*

The need to combine skills and create 'systems' engineering mindset was highlighted by respondents: *"I think there's more system engineering skills involved. Now we must combine lots of different compute engines and understand how the algorithms run across them all. For example, we need highly skilled people with Verilog for hardware, C or Python for software, driver and compiler experts."*

Finally, there was common consent that more collaboration was needed between Higher Education and industry: *"A lot of this comes down to collaboration between industry leaders and the universities to keep course content current. Scholarship schemes and industry experience are the best ways to turn out graduates that are better placed to solve problems."*

Quantitative survey results

The survey was completed by 131 individuals from 119 different companies and organisations. Almost half (44%) of the companies were SMEs with less than 100 employees. Respondents covered the whole technology 'stack' and most were involved with chip design, manufacturing and software. A summary of the survey results is included at the end of this report, they key findings were:

- **95%** of respondents said a shortage of skills in the external labour market concerned their companies.
- **84%** said they had plans to up-skill and re-skill their workforce.
- **73%** said they envisaged that they would need different technical skills at their company/organisation.
- **67%** said they would be focusing on wider AI related skills.

Furthermore, of the 70% of respondents who stated that apprenticeships were part of their plans, half said their focus was on degree level programmes.

Final thoughts

Commentators and industry participants are all unequivocal that AI will be the most important technology in the next 50 years.

We know that the impact of AI over the next decade will be profound and that the UK Government has an aspiration to make Britain a global AI 'superpower'. However, it is often overlooked that AI is much broader than purely machine learning algorithms.

It is important to appreciate that AI Systems combine software with sophisticated electronics, pervasive connectivity, machines and physical infrastructure in order to sense, understand, act and, crucially, learn to do things better. Currently, this AI Systems engineering skill set is not really addressed by the Government in either their AI Strategy, or the Digital Skills Strategy.

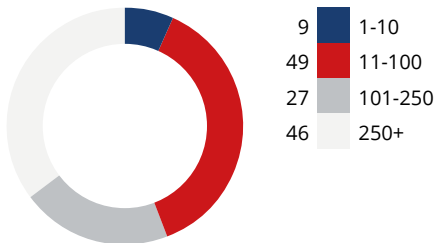
As a result, employers in "deep tech" have told us that they are concerned with the shortage of skills for the era of 'data and AI', particularly at the post-graduate level.

Therefore, there is a clear need for Government level focus on the broader AI engineering skill set required in the future, to ensure there are the AI systems graduates needed by the 'deep tech' sector.

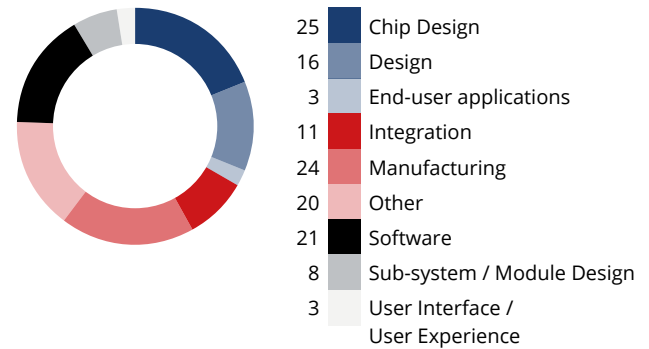


Online survey questions and responses

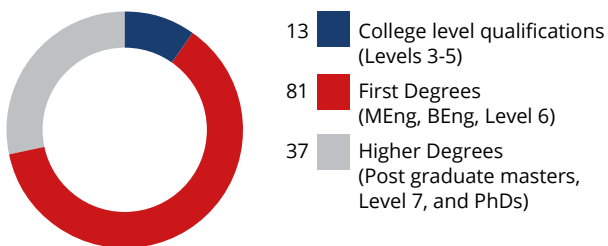
Question: What is the size of your company / organisation?



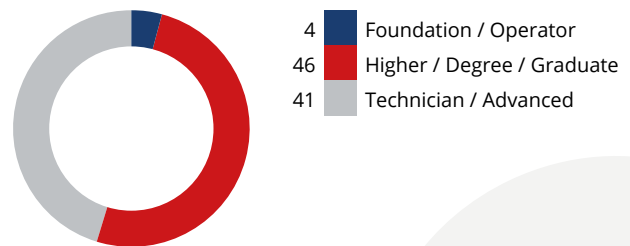
Question: Please indicate which represents your company / organisation's main activity



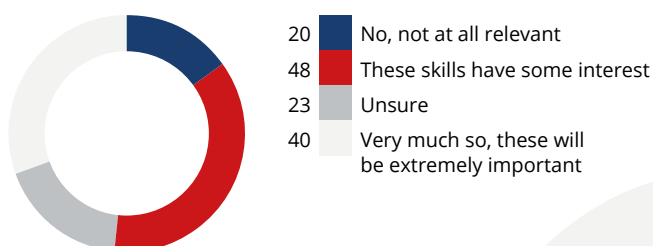
Question: In terms of education, training and skills development, what do you need most in order to accelerate your growth plans?



Question: If apprenticeships are part of your skills plans, then at what level?



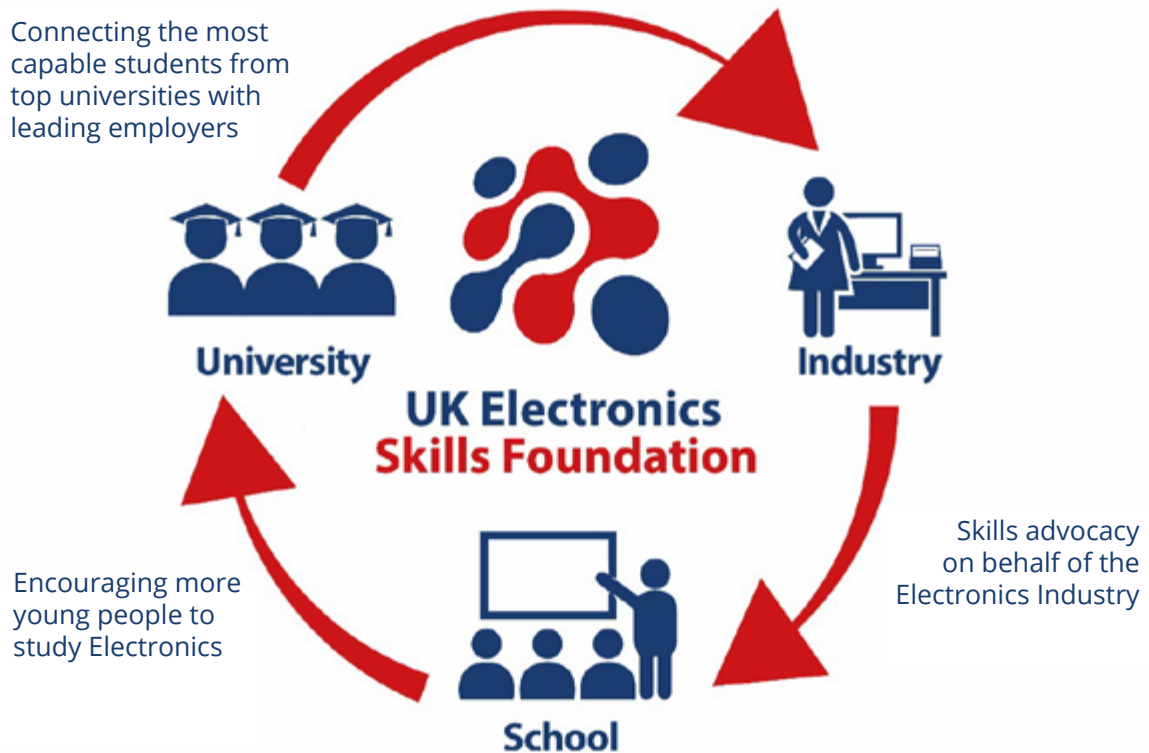
Question: In addition to technical skills, will your company / organisation be focusing on wider AI related skills, for instance, associated with social science, psychology, and ethics?



Endnotes and References

- i [The economic impact of artificial intelligence on the UK economy PwC \(June 2017\)](#)
- ii [AI Roadmap, published by the AI Council Executive summary - GOV.UK \(www.gov.uk\)](#)
- iii [ai-strategy-survey_results_020921.pdf \(turing.ac.uk\)](#)
- iv [AI Skills in the UK report-SRGCM3647.pdf \(microsoft.com\)](#)
- v [National AI Strategy - HTML version - GOV.UK \(www.gov.uk\)](#)
- vi [EPSRC & eFutures Neuromorphic Report \(efutures2.com\)](#)
- vii The popularity of this type of AI rests on the use of the frameworks. For example GPT-3 has billions of parameters for natural language processing (NLP) and this is used widely for voice recognition by smart speaker developers, app developers and call centres. The development of the frameworks used for CNN and DNN are popular, with TensorFlow from Google, Microsoft CNTK, Caffe from Berkeley AI Research and the ONNX framework interchange format as well as new frameworks such as Poplar from GraphCore. These tend to be built in C++ or Python, which highlights an underlying skill requirement.
- viii LiDAR is a detection system which works on the principle of radar but uses light from a laser.
- ix A summary of the areas that were 'in scope' for the UKESF investigation includes: Industry 4.0, Edge AI, digital twin, DSP, analogue signal processing, wireless sensor arrays, IoT, C, C++, Python, the implementation of DNN and CNN frameworks and tools for ML, training and inference of DNN (such as TensorFlow, Caffe, CNTK, ONNX, Poplar).

This report has been produced by the UKESF, with support from TechWorks



The purpose of the UKESF is to tackle the Electronics' sector skills shortage in a coherent way. With our partners, we provide opportunities for young people to develop their interest in Electronics, Technology and Engineering, through to university study and/or apprenticeship. At university, we ensure that undergraduates are encouraged to pursue careers in the Electronics sector and they are supported in their professional development so when they graduate they are equipped with work-ready skills and experience. [Learn more: here](#). The UKESF is part of the TechWorks 'federation'.

TechWorks' mission is to strengthen the UK's deep tech capabilities as a global leader of future technologies. To do this they form adjacent connected communities that are influential in defining and shaping the advancements of industry - providing a platform to help our members strategically leverage products and services to drive profitable growth. [Learn more: Main - TechWorks](#)