16 October 2017 – 5:30pm GMT
House of Lords, Committee Room 1

BIG INNOVATION CENTRE

Inequality, Education, Skills, and Jobs

A theme report based on the 6th meeting of the **All-Party Parliamentary Group on Artificial Intelligence [APPG AI].**

Inequality, Education, Skills, and Jobs is a theme report based on the sixth meeting of the **All-Party Parliamentary Group on Artificial Intelligence (APPG AI) -** held on 16 October 2017 at the House of Lords.

This meeting was co-chaired by Stephen Metcalfe MP and Lord Tim Clement-Jones.

The evidence presented in the report is not exhaustive and reflects what was discussed at the meeting, and the views and experiences put forward by the people giving evidence. Written submissions by individual expert advisors in relation to this meeting are also included.

The APPG AI was established in January 2017 and its officers include:

- **Stephen Metcalfe MP- Co-Chair**
- **Lord Tim Clement-Jones- Co-Chair**
- Chris Green MP- Secretary
- The Rt Rev Dr Steven Croft-Bishop of Oxford- Treasurer
- Lord Holmes of Richmond – Vice Chair
- Lord David Willetts – Vice Chair
- Baroness Susan Kramer- Vice Chair
- Lord Robin Janvrin- Vice Chair
- Lord Alec Broers- Vice Chair
- Mark Hendrick MP- Vice Chair
- Carol Monaghan MP- Vice Chair

For further information on the APPG AI, contact:

All Party Parliamentary Group on Artificial Intelligence (APPG AI) Secretariat
Big Innovation Centre I Ergon House, Horseferry Road, London SW1P 2AL
T +44 (0)20 3713 4036
Email: appg@biginnovationcentre.com

Any enquiries regarding this publication, contact:

CEO and CoCreator: Professor Birgitte Andersen
APPG AI Rapporteur: Niki Iliadis

Inequality, Education, Skills, and Jobs

A theme report based on the sixth **All-Party Parliamentary Group on Artificial Intelligence [APPG AI]** Evidence Giving meeting**.**

16 October 2017 – House of Lords, Committee Room 1

Overview

The aim of the sixth APPG AI Evidence Giving meeting centred on AI's impact on (in)equality, education, skills, and jobs.

The meeting was co-chaired by Stephen Metcalfe MP (Government Envoy for the Year of Engineering and former Chair of the Science and Technology Committee) and Lord Tim Clement Jones (also Chair of the Lords Select Committee on AI). Eight experts were invited to provide evidence reflecting their views on (i) how the benefits of AI can be distributed across all members of society in a fair and inclusive way, and (ii) how the society can be best prepared with the skills for the future.

131 TOTAL PARTICIPANTS

8 Pieces of Oral Evidence

8 Pieces of Written Evidence

The panel included:

- **Margaret Boden** – Research Professor of Cognitive Science (Informatics, Centre for Cognitive Science), University of Sussex
- **Azeem Azhar** – VP, Head of Venture & Foresight; Chief, Exponential View
- **Laura James** – Technical Principal, Doteveryone
- **Shamus Rae** – Partner and Head of Innovation and Investments, KPMG
- **John Hawksowrth** – Chief UK Economist, PwC
- **Calum Chace** – Book Author of 'The Economic Singularity: Artificial Intelligence and the death of capitalism' and 'Surviving AI: The Promise and Peril of Artificial Intelligence'
- **Olly Buston** – CEO, Future Advocacy
- **Peter McOwan**- Professor Computer Science, Queen Mary University

AI is disrupting both the demand side of labour (changing the quantity and quality of jobs available in the market) and the supply side of labour (challenging the skill gaps amongst a growing population of potential employees). Furthermore, it is having a significant impact on existing inequality gaps related to income, gender, and regions.

Reforms in current education structures are essential to ensure future generations and the current workforce are trained/retrained with the skills needed to succeed ahead.

Theme	Description
AI changes the demand side of labour.	AI technologies are creating new pressures on the labour market, misaligning the demand and labour sides of the equation. Precisely, the demand side of labour is changing in three ways: jobs losses, job creation, and job transformation. As AI technologies have the power to automate increasingly

	more tasks, cheaper and faster, there is growing concern that jobs across levels and sectors will be at risk of automation. New technologies are also creating new jobs, but this means employers are demanding a completely new type of employee with specific qualifications.
AI changes the supply side of labour.	The supply side of labour needs to have the skills needed to compete and succeed in the AI era. Two broad categories of skills have been identified that the Government must encourage: • STEM (science, technology, engineering, and mathematics), computing, data science, and digital • problem-solving, creativity, interpersonal, and adaptability skills
AI changes (in)equality.	The significant transformations in the labour market raise concerns regarding inequalities. AI has impact on inequalities related to income, gender, race, and regional disparities. The benefits of AI don't appear to be distributed across all members of society in a fair and inclusive way. Tech giants are benefiting most of all as others are pushing to adapt and reskill. Furthermore, the impacts of AI will vary across the country. Job automation is likely to take a different form in different regions, and some constituencies are at much higher risk of automation than others.
AI needs a new approach to education.	The education pillar needs to be restructured to prepare future generations and retrain the current workforce with the skills needed in the today's labour market. Primary education needs to include basic skills for how to live with AI and how to use AI. Higher educations must boost its curriculums with special data management and neural-networks degrees to ensure UK remains competitive in making the AI technologies shaping our future.

This theme report is not research-oriented but aims to summarise these key themes, using the evidence gathered at the sixth APPG AI evidence meeting (details above). It is not exhaustive but reflects what was discussed at the meeting, as well as the views and experiences put forward by the people giving evidence. Written excerpts by individual expert advisors in relation to the meeting are also included.

The All-Party Parliamentary Group on Artificial Intelligence [APPG AI] was created in January 2017 to explore the impact and implications of Artificial Intelligence, including Machine

Learning. We aim: to unpack the term, to gather evidence to better understand it, to assess its impact, and, ultimately, to empower decision-makers to make policies in the sphere. The government, business leaders, academic thought leaders and AI entrepreneurs have come together in an effort to share evidence and beliefs, and assist in setting an agenda for how the UK should address AI moving forward.

Figure 1 illustrates the process of how APPG AI aims to contribute to increasing social value, through fact-based recommendations and well-informed stakeholders.

Figure 1. The Purpose of APPG AI

The first APPG AI Evidence Giving meeting approached Artificial Intelligence through a general lens, identifying the key issues that stakeholders should focus on within the umbrella term. The second and third APPG AI Evidence Giving meeting deep dived into ethical and legal issues in AI, regarding decision-making and the data-driven economy. The fourth APPG AI Evidence Giving meeting focused on changes in the economy, market structures, and business models. The fifth APPG AI Evidence Giving meeting looked at social and organisation transformations and the need for governance structures, in the private and public sector.

Event Summary

In the previous five APPG AI meetings, the unprecedented impact AI has - and will continue to have - on society has been made clear. The evidence gathered thus far has mirrored the recent Hall/Pesenti review of AI, urging the UK to seize the opportunities of these disruptive technologies and deliver on their economic potential. However, the community has simultaneously shed light on a set of risks accompanying these opportunities. A common worry amongst the group has been that the benefits of AI might not be distributed across all members of society in a fair and inclusive way.

Hence, Chairs **Stephen Metcalfe and Lord Tim Clement Jones** asked 8 panellists and a wider audience of 131 members including government, academia, and industry representatives to join them in the sixth APPG AI meeting to discuss AI implications on inequality, education, skills and jobs.

Professor Margaret Boden was first to provide evidence. Highlighting the growing dependence on AI technologies, she recommended a restructure of education/training at all levels, and for all ages. From primary school onwards, people will need to be alerted both to its potential and to its limitations, she advised. Some tangible constructs can include: specialty courses in data management, retraining of school teachers, and MSc degrees for knowledge transfer.

Azeem Azhar spoke next, presenting the group graphs illustrating the growth in inequality and decline in labour share of value in the UK. He proposed two potential scenarios: one of mass technological unemployment and another of job creation. Both scenarios suggest that our transition period (over the next 5-15 years) will levy mental and financial stresses on millions of people. To mitigate this distress, companies should realise their responsibility to their workforce, lifelong education must become available, and the job transition dialogue must be reframed.

Laura James took the microphone next. She reminded the group that AI doesn't decrease or increase inequality; it is only a tool that humans must decide how to use. Laura emphasised the importance for government and the public sector to get contract negotiation right. Access to data should be granted in ways that ensure public benefit reflecting the future value which can be realised from the unlocking of insights and intelligence, and positive public outcomes. Government must think strategically to make sure AI doesn't increase inequality gaps and although this might require notable investment, the long-term benefits will make the process worthwhile.

The fourth speaker was KPMG's **Shamus Rae**. He agreed with Azeem that there are two likely scenarios and noted that it is up to us for the utopian version to prove the right one. According to Shamus, in the long-term, AI will impact all jobs, regardless of whether they belong to the low-skilled or high-skilled categories. We need to rethink how we measure inequality, so that we can include capacity and capability in the assessment. We also need to be thinking of how we can educate citizens to be adaptable to the job disruption that will likely take place.

John Hawksowrth shared some of PwC's recent findings showing the economic opportunities (it is estimated that AI will boost the UK economy by 10% by 2030) but also the disruption that is anticipated to take place (30% of UK jobs are in risk of being automated). He recognised that disruption will not affect all social groups and/or regions equally, and we need to realise that AI will create clear winners and losers. He

recommended: vocational training for young people, investment in life-long learning, and the rethinking of a welfare system with a stronger safer net. John also pushed government to work fast to build the evidence now, so we can make the right decisions tomorrow.

Calum Chace took the floor, warning the community that technological unemployment is a real prospect. Unlike the past, the technologies of today are able to displace cognitive skills and, hence, it is unlikely that more jobs will be created then lost. He asked for the UK government to invest in think tanks to research the risks and opportunities of AI, and use this evidence to pave the path for how society can overcome a likely period of transition and panic.

Olly Buston emphasised the scale and scope of disruption in job markets as a result of today's automation. He announced a new report that Future Advocacy would publish the following day, illustrating the impact of automation in individual parliamentary constituencies. The report concluded that the highest levels of future automation are predicted in Britain's former industrial heartlands in the Midlands and the North of England, as well as the industrial centres of Scotland. Olly hopes that this regional analysis will make the issue of technological unemployment more relatable to individuals, and society will consequently engage more with the topic.

Professor Peter McOwan was last to give evidence, highlighting much of what was already said in the importance of policy making to seize opportunities and mitigate risks. He focused on the need for educational reform for citizens to be empowered with the skills needed to benefit from AI technologies. He asked for academics and the rest of the stakeholders to work together to demystify AI and make it more accessible to all. He also urged the need to train career teachers, and other relevant figures, for them to be equipped with the right knowledge to guide youth towards job demands of the future.

The Chairs thanked the panel and asked the MPs, Lords, and other key stakeholders to pose their questions. An engaging discussion soon flourished, brainstorming a political economy model that will seize AI benefits and, simultaneously, bring about inclusive growth - regional, social, and sectoral.

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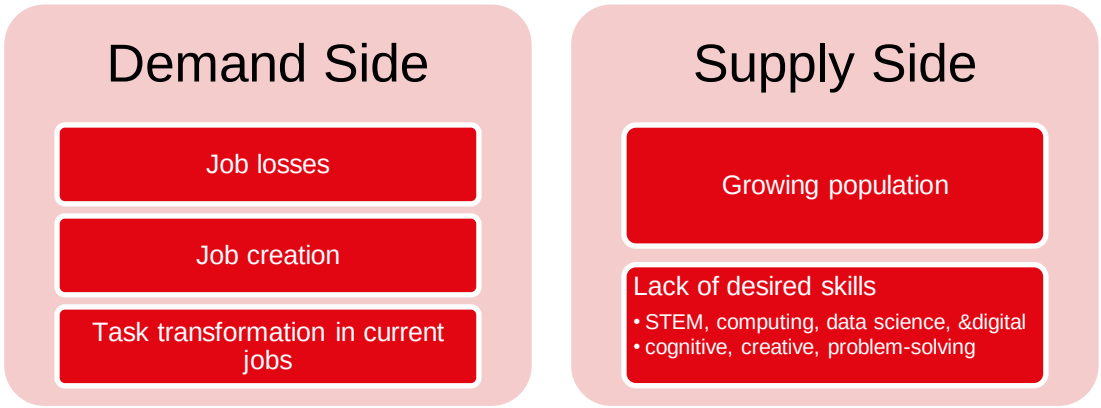
1. AI changes the demand side of labour

As a result of increasingly available big data and growing amounts of public and private investment, AI now provides machines and software the abilities to do things previously unimaginable. The APPG AI community has repeatedly highlighted the mass benefits that AI brings to society, including improvements in healthcare, education, public services, productivity, and more.

However, as discussed in the fifth APPG AI Evidence Giving meeting, along with these great opportunities comes a big challenge for policymakers to address: **disruption in the labour market.** Hence, the sixth APPG AI Evidence Giving meeting focused on this exact issue, exploring how AI has impacted jobs so far and forecasting how it will impact jobs in the future.

Providing evidence to Co-Chairs Stephen Metcalfe and Lord Clement-Jones, all eight panellists agreed that job disruption is *happening* - and at much faster speeds than most expect. AI is disrupting both the demand side of labour (changing the quantity and quality of jobs available in the market) and the supply side of labour (challenging the skill gaps amongst a growing population of potential employees).

Figure 2. Supply and Demand in the Labour Market



However, although AI technologies themselves are relatively new, the problem is not. The relationship between technology and jobs has been debated for centuries now. What economist Keynes referred to as 'technological unemployment,' or the process in which the introduction of cost-saving machines will reduce demand for human labour, has been a concern for society throughout history.[1]

Yet, technological advance has had an overall positive economic impact in the past. From

[1] Keynes, J.M. (1931), "The Economic Possibilities for our Grandchildren" in J.M. Keynes, Essays in Persuasion, Macmillan, London.

year 1750 to the late-1900s, labour productivity in the UK has continuously increased (on average by 1.1percent per year), employment rates have fluctuated around a stationary average (ranging between 40percent to 50percent as a proportion of the total population), and real wages have risen (on average by .9percent by year).[2]

In the past, labour replaced by machines brought down prices of products and, hence, increased real incomes. Over time, demand for new goods and industries to supply them increased and, consequently, new jobs were created.[3]

With the turn of the millennium and the introduction of technologies such as AI, we are now once again at a point wondering what our future jobs will look like.

As in the past, we are again seeing a notable impact on employment – with technology changing the demand side of labour in pivotal ways.

Ultimately, the demand side of labour is changing in three ways:

- some jobs are disappearing,
- others are being created,
- and all are transforming.

The APPG AI group has reason to believe that AI's impact on the labour market will be genuinely different compared to that of past technologies.

Above all, the AI technologies of today have the capacity of doing much more than the technology of the past. While in the past inventions such as the automobile or the telephone had the power to replace the human hand, **the innovations of today have the potential to replace the human brain.**

Calum Chace, Author of 'The Economic Singularity: Artificial Intelligence and the Death of Capitalism' and 'Surviving AI: The Promise and Peril of Artificial Intelligence,' shared this view with the Parliamentarians and the wider audience. He warned decision-makers that AI can displace cognitive skills and is likely to impact jobs at much higher scale than previous technologies. We shouldn't assume because technological unemployment hasn't happened in the past, it won't happen in the future.

[2] Hills, S, Thomas, R and Dimsdale, N (2015), 'Three Centuries of Data - Version 2.2', available here: http://www.bankofengland.co.uk/research/Pages/onebank/datasets.aspx

[3] Autor, D H (2015), "Why Are There Still So Many Jobs? The History and Future of Workplace Automation." Journal of Economic Perspectives, Vol29(3).

Calum Chace

Author of 'The Economic Singularity: Artificial Intelligence and the Death of Capitalism' and 'Surviving AI: The Promise and Peril of Artificial Intelligence'

Hello. My name is Calum Chace. I write and give talks about the likely future impact of AI. In my five minutes, I'm going make six bold claims.

Claim one: today's hearing is the most important one. This committee has heard many great addresses about transparency, bias, privacy, etc. These are important, as are the great opportunities that AI can bring. But none of them will crash our civilisation. Joblessness could. (Superintelligence could too, but it is further off, and we have good organisations tackling it.)

Claim two: Technological unemployment is a real prospect. **Moore's Law is not dying.** The chip industry is confident that machines will continue to get twice as powerful every 18 months or so for a long time to come. This exponential growth means that in a decade, our machines will be 128 times more powerful than they are today. In 20 years, 8,000 times, and in 30 years (if it lasts that long) a million times. More power doesn't necessarily translate exactly into smarter machines, but there is a correlation.

It is a besetting sin of humans that we fail to appreciate the impact of exponential growth. When Google chairman Eric Schmidt says he is a job elimination denier, I'm pretty sure he is not taking exponential growth into account.

Google's self-driving cars now hand over to humans only once every 5,000 miles. Machines diagnose cancer from scans better than human doctors, and they perform surgery better too. Machines are encroaching on the work of lawyers, journalists, and of course the people in factories, warehouses, shops and call centres.

Technological unemployment hasn't started yet, and it won't really get going for a few years. **But in 30 years – maybe less - it is highly likely that more than a half the population will be unemployable.** This emphatically does not mean they are useless, just that they will not be able to earn a living.

Claim three. The Luddite Fallacy argument that this will not or cannot happen because automation didn't cause lasting widespread unemployment in the past is frankly silly. **Past performance is no guarantee of future outcomes:** if it was, we would not be able to fly. In any case, it isn't true. The US horse population fell from 21.5m in 1915 to around 2m today because of automation. That automation was mechanisation. What's coming next is cognitive automation. Maybe we can all be each others' nurses and therapists when the machines take our existing jobs, but I highly doubt it.

And there is no magic jobs drawer full of new jobs as yet un-invented, which machines can never do.

Claim four. If technological unemployment is coming, it will be preceded by a panic. The canary in the coal mine will probably be self-driving cars. Human drivers contribute a quarter to a half of the cost of their vehicles. Once fleet owners can dispense with them – probably starting sometime between 2021 and 2025 – they will do so, and fast. That means a million people rapidly laid off in the UK; five million in the US. You can fail to see the deep learning algorithms in Google Translate, but you can't fail to see a self-driving car, or its impact on jobs.

If we do nothing now, the resulting panic would lead to appalling political consequences. We have recently seen populist triumphs in the UK and the US. A panic over technological unemployment would usher in something far, far worse than President Pinocchio. Fascism is not the worst possible outcome. We must avoid that.

Claim five. To avoid the panic, we need a plan. We need dedicated brainpower working out the best outcomes, and how to get from here to there. We need to establish a series of think tanks and research institutes. **This is urgent: it will take a decade for them to study the challenges exhaustively, and reach a consensus plan that will provide the reassurance.** We have started this work for the challenge of the technological singularity (superintelligence). Now we need to do it for the challenge of the economic singularity (joblessness).

Claim six. There are solutions. Universal Basic Income, or UBI, is not one of them. There are several reasons, but principally, if all we can provide for half the population is a basic, subsistence income, our societies will collapse. We must do better. Personally, I believe the solution is what is known as radical abundance, but there may be others.

–- You may be surprised to hear that I am an optimist. I believe that **an economy in which machines do most of the jobs can be one in which humans do the important things in life, like socialising, exploring, learning, having fun.**
–- Now maybe I'm wrong, and Eric Schmidt is right. If so, we would be wasting a few million quid on some think tanks. But if he is wrong and we do nothing, the consequences of the panic could be devastating.
–- I believe we can succeed, and grasp the wonderful future that AI offers us, but we must start this work now.

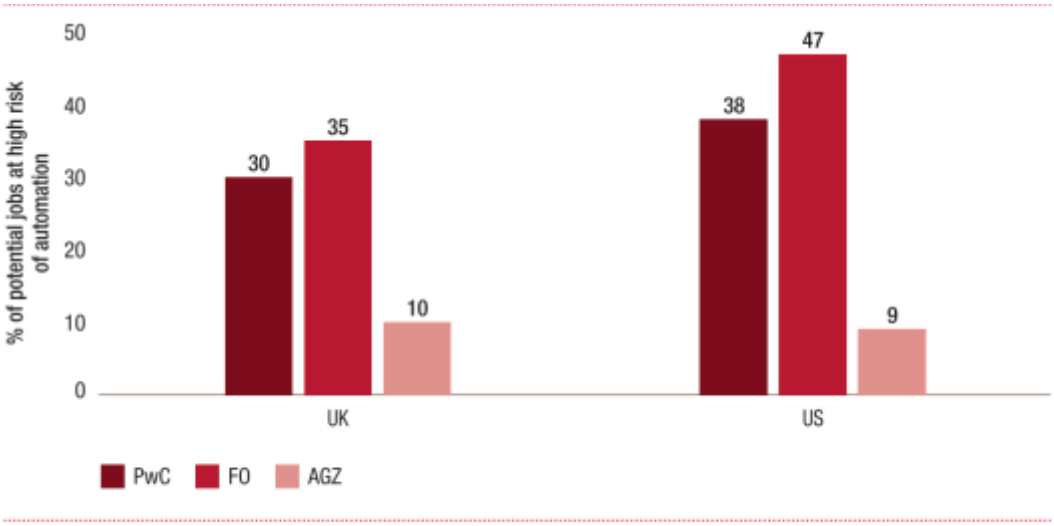
Frey and Osborne, in 2013, estimated **that 35percent of current UK jobs to be at risk over the next decade or two.**[4] According to their findings, although technologies have created vast employment opportunities for workers throughout history, today's technology is distinct in that as it does not provide the same opportunities, particularly for the less-skilled or less-educated workers. Deloitte's analysis in 2016 concluded that the UK jobs paying £30,000 to be five times more vulnerable to displacement than jobs paying £100,000 or more. While occupations involving complex perception and manipulation tasks, creative intelligence tasks,

[4] Deloitte (2015), "From brawn to brains: The impact of technology on jobs in the UK", available at http://www2.deloitte.com/uk/en/pages/growth/articles/from-brawn-to-brains--the-impact-of-technology-on-jobs-in-the-u.html

and social intelligence tasks are less likely to be substituted by technology in the near future and, therefore, in less risk for automation.[5]John Hawksowrth, Chief UK Economist at PwC, provided evidence of PwC's analysis which supports these findings. Their March 2017 report concluded that:

- Up to 30percent of UK jobs could be at high risk of automation by the early 2030s.
- These risks were found to be highest in sectors such as transportation and storage (56percent), manufacturing (46percent) and wholesale and retail (44percent), but lower in sectors like health and social work (17percent).[6]

Figure 3. What proportion of jobs are potentially at high risk of automation?



Sources: PwC analysis; FO; AGZ

Although the same report highlights the potential opportunities AI can have for the economy, John Hawksowrth acknowledges that job losses and automation are challenges for public policy to be concerned with.

He adds that the 30percent likelihood of UK jobs to be at risk of automation is based on technological feasibility, not other factors such as economic implications or regulatory concerns. These factors are likely to slow down the automation process as there will be a backlash from society calling for a political response. **In the long-term though, job losses will be broad and will cross sectors and career levels.**

[5] Deloitte (2016), London Futures. Agiletown: The relentless march of technology and London's response.
[6] PwC (March 2017), UK Economic Outlook, https://www.pwc.co.uk/economic-services/ukeo/pwc-uk-economic-outlook-full-report-march-2017-v2.pdf.

John Hawksowrth
Chief UK economist

[excerpt taken from PwC's UK Economic Outlook, Section 4: Will Robbots Steal Our Jobs?][7]

Key points

- Our analysis suggests that **up to 30% of UK jobs could potentially be at high risk of automation** by the early 2030s, lower than the US (38%) or Germany (35%), but higher than Japan (21%).
- The risks appear highest in sectors such as transportation and storage (56%), manufacturing (46%) and wholesale and retail (44%), but lower in sectors like health and social work (17%).
- For individual workers, the key differentiating factor is education. For those with just GCSE-level education or lower, the estimated potential risk of automation is as high as 46% in the UK, but this falls to only around 12% for those with undergraduate degrees or higher.
- However, in practice, not all of these jobs may actually be automated for a variety of economic, legal and regulatory reasons.
- Furthermore, new automation technologies in areas like AI and robotics will both create some totally new jobs in the digital technology area and, through productivity gains, generate additional wealth and spending that will support additional jobs of existing kinds. These jobs primarily in services sectors that are less easy to automate.
- The net impact of automation on total employment is therefore unclear. Average pre-tax incomes should rise due to the productivity gains, but these benefits may not evenly spread across income groups.
- There is therefore a case for some form of government intervention to ensure that the potential gains from automation are shared more widely across society through policies like increased investment in vocational education and training. Universal basic income schemes may also be considered, though these suffer from potential problems in terms of affordability and adverse effects on the incentives to work and generate wealth.

As a whole, the panellists agreed that **the demand for many jobs (as we know them today) will decrease significantly as a result of labour-saving technologies that are cheaper and, often, more efficient than a human being.**

However, at the same time, many of the panellists, acknowledged that new jobs are also being

[7] PwC (March 2017), UK Economic Outlook, https://www.pwc.co.uk/economic-services/ukeo/pwc-uk-economic-outlook-full-report-march-2017-v2.pdf. Pg32.

created as a result of AI. We are already seeing a **growing demand for a specific type of employee in the UK labour market.**

The private sector continues to report a lack of qualified employees coming from a STEM background. In fact, according to Engineering UK 2016, 46% of businesses reported a **shortage of STEM graduates as a key reason for not being able to recruit "appropriate" staff**.[8] Gartner recently named the skills gap the biggest factor in why almost 60% of organisations are yet to take advantage of the benefits of AI and a little more than 10% have deployed any AI solution at all.[9]

Shamus Rae and John Hawksowrth agreed with this view, sharing their own experiences at PwC and KPMG, struggling to find employees who possess the skills needed to create, use, and manage AI. The employers are increasingly demanding candidates with specific skills needed for the twenty-first century - that, unfortunately, most of the individuals in the UK looking for jobs currently lack.

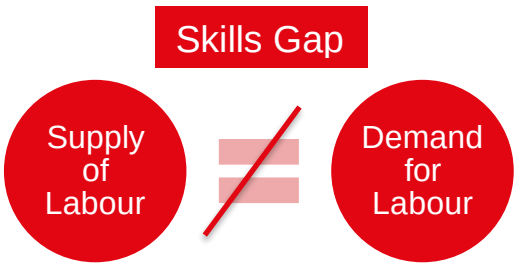
As the demand in the labour market transforms, policymakers must work with industry to ensure the transition period (as some jobs are lost, others are created, and all are transformed) is as smooth as possible.

[8] Engineering UK, (2016), "Engineering UK 2016 Report.
[9] Hare, J., (November 2017), "The Biggest Roadblock to AI Adoption is a Lack of Skilled Workers." VentureBeat.

2. AI changes the supply side of labour

Just as AI is shifting the demand side of labour, it is also having a significant impact on the supply side of labour. Precisely, **APPG AI has recognised the skills gap as a major obstacle preventing the supply of labour to match the demand for labour.**

Figure 4. The Challenge of the Skills Gap for the Labour Market



All the panellists at the sixth Evidence Giving meeting informed the group that a key responsibility for policymakers is to help decrease the skills gap and, consequently, address the labour supply to increase productivity. Policymakers must seek to make the British labour market more flexible, so it is able to match the workforce to the ever-changing demands placed upon it by employers and by the introduction of new technologies.

There is a growing concern that UK's existing social structures - and especially the country's educational institutions - are not adequately preparing people for the desired skills.

Shamus Rae, Partner and Head of Innovation and Investments at KPMG, advised the group to stop debating between a utopian or dystopian future and realise that disruption is "inevitable." Not only low skilled workers will be displaced in the long run, and it is important for UK policymakers to reform education to better prepare future generations.

Shamus Rae

Partner and Head of Innovation and Investments at KPMG

1. **Don't waste too much time arguing over Utopian v dystopian views.**

People seem to spend a lot of time arguing whether there is a utopian or dystopian future. Whilst this is an interesting and theoretical debate it overlooks the pain of disruption that is inevitable over the next 10 to 15 years. With Andy Haldane from Bank of England talking about 15 million jobs being potentially rotated over the next 10-15 years we have an issue of transition to the future whether good or bad. My argument is, therefore, we need to set up for success now and manage towards a utopian future even though I think it will be difficult to achieve. Don't let the arguments of whether we will have mass job disruption or not get in the way of the very real job of minimising its impact.

2. **Don't believe that this automation is just Low skilled work.**
The common arguments put forward are that it will be the lower skilled jobs that go... well if investment bankers, lawyers and accountants are low skilled then yes, I'll accept that. In reality, Goldman has been automating brooking and investment banking jobs, the big 4 has seen its margin decline from over 30% to 20% this year and are now automating. The new automated legal services are already starting to appear. There are over 10,000 AI start-ups globally focused on disrupting professional services let alone the broader services market place. So, this will impact jobs across the spectrum.

3. **New Data Scientist/Software Engineer jobs won't fill the gap.**
The ratio is looking like one engineer to four jobs displaced and that is in high-skill areas. Low-skill areas will have a higher ratio of jobs "rotated"
We need to be focused on:

- Raising the number of technically capable people in this country and that must start with education. Not the Computing Science GCSE that is there now.
- Fuzzy techs as well as pure techs.
- Create the infrastructure to make this industrial revolution equal across the country.
- Develop IP hubs up and down the country. Creating eco-systems with academia, SME's and larger businesses.
- We need to create world class data sets that are accessible by start-up and not just the big five tech houses. Health data in Finland (Kanta Project) shows the way.

4. **Inequality - we need to be more sophisticated about how we measure and target resolutions. We should have measures and targets for them.**

- Gini Coefficient, Our Gini coefficient is not perfect but not as bad as the US but this may change. UK is better because of the reduction at the top and not a rising of the average
- Under Employment. We need to have a target for Under Employment but let me be clear about my definition as there are a few around. Here, I am talking about measuring the percentage of people who have jobs that I beneath their skills and training. A graduate making coffee is a classic example
- Philips curve
- Operating model changes are likely to be more significant and more profound over the next ten years than any other time in corporate history. Therefore, we have a one off moment to right the wrongs of organisational design and corporate history creating less hierarchical structures, distributed workforces and diversity in all its forms at the heart of the model

Two categories of skills have been identified as those that will empower individuals with the competencies to compete in today's job market and, even more so, in the job markets of the future. They are:

- STEM (science, technology, engineering, and mathematics), computing, data science, and digital
- problem-solving, creativity, interpersonal, and adaptability skills

The first category builds on the demand for more individuals who can design and deploy AI technologies. These skills fall mostly under the STEM (science, technology, engineering, and mathematics) category, and represent the individuals who can create, use, train, manage, and monitor these emerging technologies. Specifically, this category seeks to improve education and training in **maths, computing, data science, and a full range of digital skills.**

The Department of Digital, Culture, Media, & Sport launched the UK Digital Strategy in March 2017, identified lack of skills as one of the seven pillars to focus on moving forward.[10] Minister Matt Hancock said: "At every level, from getting people online for the first time, to attracting and training the world's top coding talent, Britain needs stronger digital skills if we are to thrive in the years ahead."[11]

Professor Peter McOwan gave insight about the lack of skills in our current education system, calling for the UK government to be quick in addressing the lack of qualified teachers who can prepare our upcoming generations.

Peter McOwan

Professor of Computer Science at Queen Mary University

AI is a fundamental interdisciplinary discipline with profound technical, scientific and societal impacts. **A significant issue for a future integrated with AI technology and fully exploiting the transformative economic benefits is in the skilling and reskilling of the workforce.** In schools, apprenticeships and colleges AI sits most naturally in the study of computer science, however, there is currently a severe deficit in appropriately skilled teachers to deliver the curriculum.

A recent CAS report found over 75% of Computer Science Teachers are non-specialists, this means the UK need to train and support another 8000 teachers to the level that they can teach GCSE CS confidently over the next five years. This is if we are to hit the UK digital strategy target by 2022 of

[10] UK Digital Strategy, (March 2017), Department for Digital, Culture, Media, & Sport. https://www.gov.uk/government/publications/uk-digital-strategy
[11] Hancock, Matt, (November 2017), "The Foothills of the Digital Age," https://www.matt-hancock.com/news/foothills-digital-age

increasing the number graduating in Computer Science from 16 000 to 40 000 each year. These teachers need to be supported with up to date age appropriate classroom materials target specifically on AI techniques, its wider societal context and employability career advice.

The **curriculums across subjects should also be examined to look for suitable areas where AI elements can be naturally included to assist in demystifying the subject.** Resources, such as computer science for fun, that transfer state of the art research into usable school classroom materials should also be supported and expanded.

As well as addressing the pipeline issue for teachers we require **high quality informed dialogue with the wider public about the impacts of AI.** To enable this, we should harness the considerable power of university and industry researchers in the area by making it a condition that those who are funded from public funds to undertake public engagement activity about their research and the AI field more generally. Regarding incentives to enable this, it is interesting to note the increased uptake in Athena swan applications and a higher profile for diversity in universities since the holding of an Athena Swan award became a requirement in applying for some types of research council funding.

The second category highlights the growing demand for **problem-solving, creativity, interpersonal, and adaptability skills** - as those are arguably the group of skills that humans have a comparative advantage in over machines. Many jobs require uniquely human characteristics like empathy, creativity, judgment, and critical thinking. It is this group of jobs - that rely mostly on heuristics - that are in less likely to face technological unemployment.[12]

NESTA conducted a report focusing on how skills will change as a result of technological advance, globalisation, and other key trends in society. The report highlights the skills that are likely to be in greater demand in the future, are those that rely on interpersonal skills, higher-order cognitive skills, and systems skills - sometimes called 21st-century skills.[13]

Co-Chair Lord Clement-Jones asked the group: What skills should we focus on when we make sure youth is training on something that is useful for the future? John Hawksowrth argued we need to focus on skills that have adaptability in order to compete in the future. Olly Buston agreed with the point and highlighted the importance of problem-problem solving and creativity in the future.

Policymakers must work together for the skills of the labour force to match the growing demand for both categories of skills. Otherwise, the UK is at risk of shaping people, young and old, who will lack the skills needed for the modern world. The supply side of labour has to be empowered with the necessary skills to succeed and compete in the future.

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[12] Frey, C B, and Osborne, M A (2013), "The future of employment: how susceptible are jobs to computerisation.", available at: http://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf

[13] Bakhshi, H., Downing, J., Osborne, M, Schneider, P., (2017), “The Future of Skills: Employment in 2030.” NESTA.

3. AI changes (in)equality

The significant transformations in the labour market raise troubling questions regarding inequalities. In previous APPG AI meetings, the group has discussed how certain groups/individuals are likely to be impacted by AI in different ways than others. Some will reap full potential of AI while others will be left displaced by the great transformations.

The sixth APPG AI meeting looked at inequalities in society including those related to **low-income versus high-income, gender and regional disparities**.

Laura James, Technical Principal at Doteveryone, reminded the group that AI itself is not the curator of inequalities. AI is a tool. **Humans must decide how to use AI and this will ultimately affect whether AI increases or shrinks inequality gaps.**

Laura James
Technical Principal at Doteveryone

Artificial intelligence does not in and of itself reduce or create inequality. **AI is a tool, and its outcomes are determined by the way we humans use it.**

Currently, the biggest users and developers of AI are the organisations with access to the most expertise, data and computer hardware. These are largely private sector companies working to solve private sector problems, creating wealth for a few.

Socially important sectors, like care and education, may not benefit much from AI in the near term, if appropriate data, and investment, is not available. Furthermore, if the data that is available does not capture a sector's breadth and human impact, AI and big data solutions more generally will not meet real human needs. These are examples of sectors or situations that are hard to measure, or where measures miss important human factors, and AI can exacerbate a metrics-driven culture which neglects human values and contact.

We must look beyond productivity and GDP, to triple bottom line (financial, environmental and societal) and other forms of measurement, to ensure we do not neglect externalities and human values in how we apply and assess the success (or otherwise) of AI.

Inequality is not just about the fairness of algorithms and AI, or automation of some job types. **It is about whether AI is indeed offering the benefits it promises—whether it is an effective tool.** This is especially the case for under-served populations who may suffer disproportionately if promised benefits are not delivered.

We must evaluate AI critically, and avoid 'magical thinking'—knowing that both information and software can be wrong. Replacing humans with AI may be beneficial in some cases. But we must remember to value the human aspect and not see every task or role or decision as something that could be automated.

This is particularly important for people who need care, or whose circumstances are difficult and multifaceted. Automated decisions made here may not be sufficient or may be informed by poor quality data—a particular risk for those less able to access, evaluate and request changes to the information held about them.

Automated decisions in key areas such as justice and recruitment are already disproportionately affecting low wage earners. For example, automated job application processing is more likely to be used for high-turnover, low-skilled roles. Predictive policing is used predominantly to address street crime, rather than fraud, tax evasion and similar white-collar crimes.

As a society, we should make fuller use of the vast quantity of good-quality data that are publicly held and collected. (ONS's Data Science Campus is a good, but small, example of this already happening.)

Such publicly-held data, that is not open data because of personal content, could offer enormous value through AI, and this should be realised as shared public value, not private wealth centralisation.

Access to this data should be granted in ways that ensure public benefit reflecting the future value which can be realised from the unlocking of insights and intelligence, and positive public outcomes. For instance, NHS data used appropriately, and with appropriate patient involvement, could develop and advance healthcare.

There are a number of issues that need to be considered, and steps taken, for this to happen effectively and efficiently.

In the short term, there needs to be joined-up thinking, across Government and the public sector, in drawing up data and AI contracts with outside organisations.

Public bodies lack the competence and experience required to negotiate data contracts effectively, particularly with private-sector companies that have far greater experience and resources.

The drawing up of individual contracts for data deals between different public-sector bodies and the same external companies. For example, the use of AI chatbots for local council services could lead to larger costs and a greater chance of mistakes being made.

The compliance failures in the agreement between The Royal Free Hospital and Google DeepMind exemplify many of the major issues at stake.

If Government and the public sector don't get contract negotiation right, there is great potential for harm to privacy rights, to public trust in data sharing and use, and a great danger that valuable publicly held data assets would be handed to private companies, leading private value to be created from public assets, without appropriate recompense and increasing inequality.

Public sector bodies must take greater steps in sharing best practice around wise deal-making, learning from mistakes and successes.

Centralisation of AI contract-making should also be explored as a solution to the skills shortage in negotiation around data. The decentralisation of some services may need to be considered for this to happen, for example within regions or the NHS.

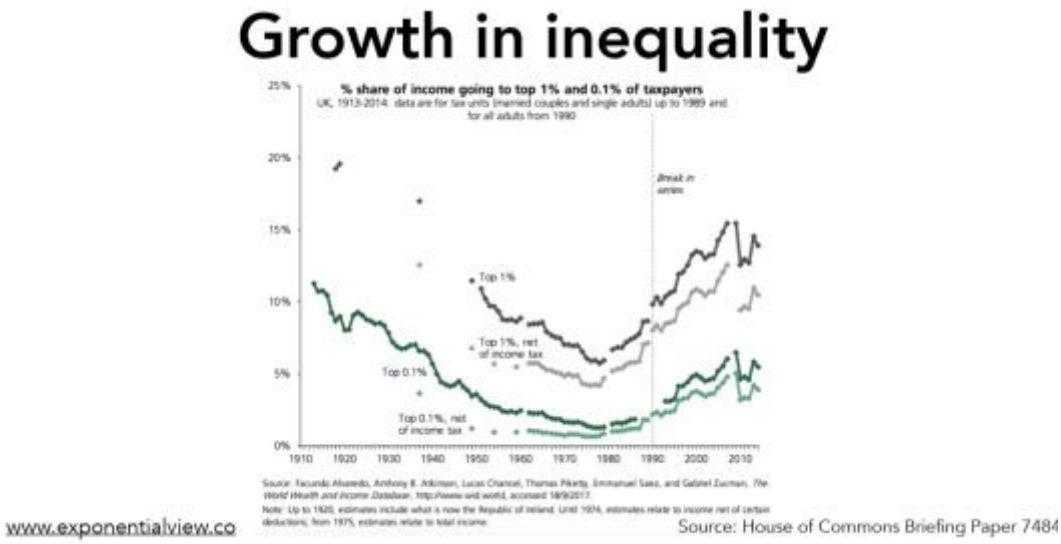
Longer term, to capture genuine public benefit from publicly held data, **Government must also access its own AI expertise**, and develop its talent, capacity and collaborative potential. It should not rely on corporations alone to unlock the potential.

This will require Government and the public-sector to recruit and develop strong, knowledgeable, responsible AI specialists—and leaders.

The near-term costs of doing this are not insignificant. But the long-term economic benefits of building the UK's AI capability—for the shared benefit of the population—would make the investment worthwhile.

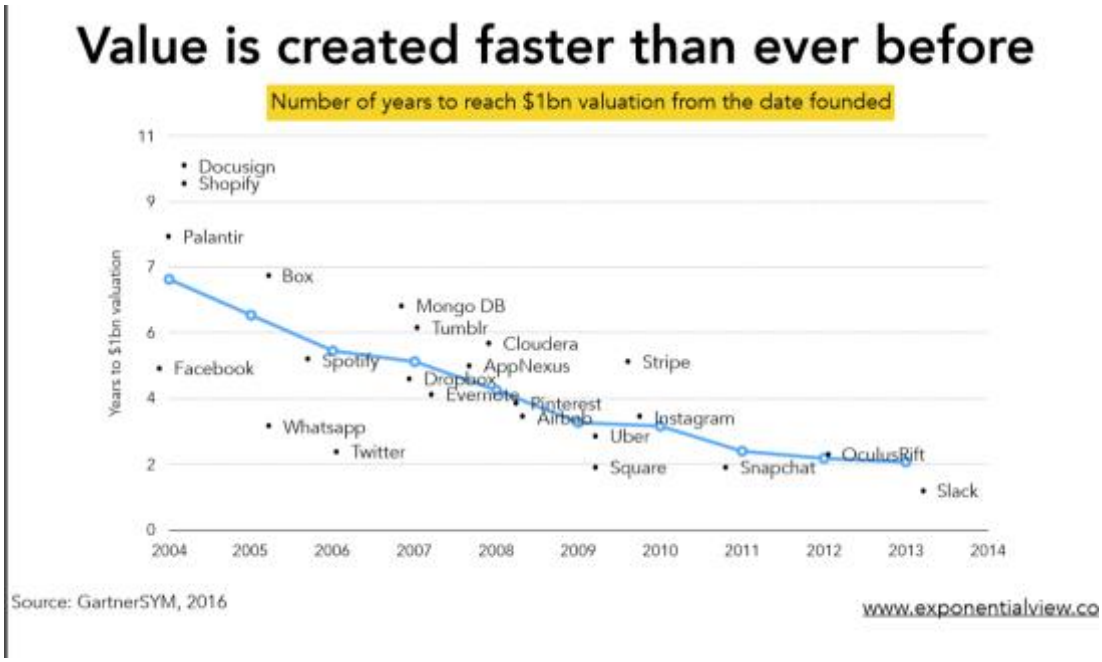
Azeem Azhar, entrepreneur and author of the 'Exponential View,' presented a slide-deck illustrating how inequality has grown in the recent years. According to House of Commons Briefing Paper, the percentage of income going to the top 1percent and .1% of taxpayers has been in constant increase after 1990 (Figure 5).

Figure 5. Growth in Inequality (Source: Exponential View)



Automation has created a few superstar firms in the last years that have tremendous profits and a huge value per employee in superstar firms. This value creation happens faster than ever before. Azeem Azhar shared a slide showing how fast successful tech companies of today are reaching the £1 billion valuations compared to those of the past (Figure 6).

Figure 6. Value is created faster than ever before (Source: Exponential View)



These trends are increasing inequality gaps amongst the few wealthy and the rest of the society. With technology moving as fast as it is, it appears that this inequality gap will continue to increase as tech giants continue to reap the benefits while others push to reskill and restructure their business models to compete in the AI era.

Azeem Azhar
Chief of Exponential View

As we look at this new wave of AI-driven automation, forecasters see two scenarios.

In one, they envisage a world of mass technological unemployment. Jobs are scarce because industrial and creative output can be delivered by machines. The few jobs remain are in strategic and leadership positions and in the provision of social care (also assisted by machines).

In the other, they imagine that as with previous paradigm shifts in out techo-economic dynamics, new jobs emerge of greater interest, safety, satisfaction and compensation. The weavers put of work by the gig mills could never have imagined the bounteous satisfaction of being a java developer, structured derivatives analyst or pilates teacher. The result: net no job losses and possibly job creation.

In either of those scenarios, **we can be certain of one thing: millions of people will find their employment will change. It will change because they may lose their job or it will be redefined.**

Given that jobs give us income and social, psychological and emotional anchoring, both scenarios suggested that **our transition period (over the next 5-15 years) will be levy mental and financial stresses on millions of people.**

Since this will happen we need to take adequate mitigation steps:

1. COMPANIES SHOULD NOT REPUDIATE THEIR RESPONSIBILITIES
Firms need to be active and engaged with their workforce in the planning and deployment of automation. They need to provide on-the-job training, and in the case of laid-off workers, post-job training and emotional support. We should think about how the gains from automation are shared between the firms and the workers. There will be an externality here which firms should meet, much as they meet the carbon externality.

2. LIFE-LONG TRAINING AND EDUCATION MUST BE AVAILABLE
There is an emphasis on analytical and computational thinking in much of the literature. But I concur with the World Economic Forum that social and leadership skills (including empathy, teamwork and listening) are crucial to develop for the future economy.

3. REFRAMING THE LANGUAGE AROUND JOB TRANSITION
Society needs to reframe the language around job transition and job loss to destigmatise it. These changes are going to happen and so finding ways to reframe them, as well as ensuring practical financial, psychological and educational support, is essential.

Further to inequalities in regard to income, there has been much concern on the lack of females in the tech industry. This is problematic for two main reasons. First, it means that the technology is created by one dominant group, lacking the perspective of an entire gender. Second, it means that men will reap many more benefits of AI – especially economic – compared to females and the gender gap will, in consequence, continue to increase.

Lastly, Olly Buston, CEO and Founder of Future Advocacy, discussed the different impacts AI will have in different regions across the UK. Looking at job displacement and automation, he announced a new report by Future Advocacy that illustrates how each constituency will be impacted. The report concluded job disruption will not be even across the UK.

The **proportion of jobs at high risk of automation by the early 2030s varies from 22% to 39% for different constituencies**. Shadow Chancellor John McDonnell's constituency of Hayes and Harlington is predicted to see the highest rates of automation, while another Labour MP Ian Murray's Edinburgh South constituency is predicted to have the lowest levels of automation. The highest levels of future automation are predicted in Britain's former industrial heartlands in the Midlands and the North of England, as well as the industrial centres of Scotland. These are areas which have already suffered from deindustrialisation and many of them are already unemployment hotspots.[14]

Olly Buston
CEO and Founder at Future Advocacy

Future Advocacy is a think tank and consultancy working on some of the greatest challenges that humanity faces in the 21st century. Our vision is a world in which the social, ethical and economic opportunities of artificial intelligence are maximised, while the risks are minimised.

We recognise that as AI and other automating technologies improve, more tasks will be automated, and many jobs will be displaced. Simultaneously, new jobs will be created by these technologies, both directly and indirectly, but the degree of job creation is hard to estimate and thus there is significant disagreement on the net impact of AI. These disagreements aside, it is clear that the scale and scope of change will be unprecedented, and in the long-term, it is likely that there will be less work for humans to do.

We, therefore, need to get more granular in our research to understand exactly who and where AI will hit hardest. Equally, we need to move beyond national-level predictions and draw on more local, targeted understanding when developing policy recommendations.

It is for this reason that we carried out research looking at the impact of AI on job displacement by UK Parliamentary constituency. We found that the proportion of jobs at high risk of automation by the early 2030s varies from 22% to 39%. The highest levels of future automation are predicted in Britain's former industrial heartlands in the Midlands and the North of England. These are areas which have already suffered from deindustrialisation and many of them are already unemployment hotspots.

[14] Future Advocacy, (October 2017), "The Impact of AI in UK Constituencies: Where will Automation Hit Hardest?" http://futureadvocacy.com/publications/

With this in mind, we call on the UK Government to:

- Commission and support further detailed research to assess which employees are most at risk of job displacement by automation.
- Develop smart, targeted strategies to address future job displacement, based on the results of research into the differential impact of automation by sector, region and demographic group in the UK.
- Draft a White Paper on adapting the education system to maximise the opportunities and minimise the risks created by AI, focusing not only on STEM and coding skills, but also on creativity, resilience and interpersonal skills.
- Conduct research into alternative income and taxation models that result in fairer distribution of the wealth that these technologies will create.
- Make the AI opportunity a central pillar of the UK's Industrial strategy and of the trade deals that the UK must negotiate post-Brexit.
- Ensure that the migration policy in place following Brexit will still allow UK-based companies and universities to attract the brightest and best AI and robotics talent from all over the world.

Olly Buston, and the others providing evidence asked policymakers to be conscious of the inequality gaps and make sure policies protect the groups that are most vulnerable to disruption – making sure **the benefits of AI are inclusive and spread across the entire country.** The Government should commission and support further research to identify groups of society most at risk and adopt a targeted approach to distribute AI opportunities.

4. AI needs a new approach to education

Education is key to addressing the jobs, skills, and inequality challenges. All the panellists at the Sixth Evidence Giving meeting agreed that the UK education system must be boosted in order for AI's opportunities to be untapped.

Margaret Boden, Research Professor of Cognitive Science at the University of Sussex who helped develop the world's first academic programme in cognitive science, provided evidence explaining how the education system must be transformed so individuals can be prepared:

- To live with AI,
- To use AI,
- And to make AI.

Margaret Boden
Research Professor of Cognitive Science (Informatics, Centre for Cognitive Science) at the University of Sussex

Our society will be increasingly reliant on AI, including machine learning (ML) and robotics. Some citizens will choose to make it, many will have to use it, and all will be forced to live with it.

This will require education/training at all levels, and for all ages.

Making AI/ML can be done only by very highly-skilled individuals. These will be professional computer scientists, plus others specially trained to work with them.

Much (not all) ML—especially the types that deal with Big Data--is based on statistics and probability theory, and much (not all) of that uses neural networks. Traditional "symbolic" AI doesn't use probability or neural networks but is based instead on logic. So, today's computer science degrees are not a good training for high-level work in ML: that must change.

There will also be a need for intensive MSc degrees for knowledge transfer, aimed to provide these newly-relevant skills to post-graduates who are not computer scientists, and perhaps not even STEM-educated. The obvious parallel is the Alvey Programme of the 1980s, which provided skills in writing and working with AI expert systems to students from a wide range of backgrounds.

Even high-level skills are grounded in early education. Hence the (very welcome) recent decision to make computer coding mandatory in schools. However, future primary/secondary courses (and youngsters' computer clubs) will need to introduce children also to neural networks, data bases, and probability. This is a challenge, because we think more naturally in terms of logic and arithmetic than probability theory.

Special diplomas should be available for schoolteachers. At present, only a minority of schoolteachers have any computer qualifications, and these are unsuitable for ML anyway.

Using AI/ML will be a dominant feature of work for many people, in virtually all areas of employment. Both further and higher education should provide courses to prepare people for such experience. Sixth-form colleges should do so, too.

Specialist courses in data-management should be made widely available, too. Preparing data for use in Big Data aoplications is far from a trivial exercise.

Living with AI/ML will not be open to choice, as this technology will be ubiquitous. At every educational level, from primary school onwards, people will need to be alerted both to its potential and to its limitations.

For example, to what extent are probabilistic ML systems "black boxes", which even skilled computer scientists can't predict and don't understand? (The designers of AlphaGo, which beat the human Go champion in 2016, don't know why it made the winning moves that it did.) What sorts of bias can be knowingly or unknowingly included in data bases? Are any sorts of data impossible to digitize? To what extent can individual-specific information be recovered by inference from anonymized data?

In sum, It won't be necessary for every citizen to be a good coder, much as not every car-driver needs to be a mechanic**. But everyone will need a sense of what sorts of things AI systems can do, and—perhaps even more important—what sorts of things they can't (yet?) do.** If they have some idea of how the systems work, and therefore of what general sorts of things might go wrong, so much the better. That will protect the populace from being misled by the various types of hype which attend AI/ML.

The other seven panellists agreed with Professor Boden, advising the Parliamentarians to look at the education pillar while addressing job, skills, and inequality challenges created in the AI era.

The transition people will be unsettling for thousands of UK citizens as millions of jobs will see changes in tasks, responsibilities, and skills. Therefore, we must ensure teachers are equipped with the skills needed to train the next generations of labour. Students must be empowered and guided to develop both STEM-related and creative/interpersonal skills in order to be able to live with AI, use AI, and make AI. Also, an emphasis was put on the need to boost the vocational training as well as life-long learning to train those individuals whose jobs will be impacted.

Action Points

Education policies must be designed (i) to improve the quality and quantity of the demand and supply of labour, and (i) to help reduce inequality gaps across the country.

Theme	Action Points
AI changes the demand and labour side of labour	• Commission further research to understand changes in the labour market. The research should illustrate implications on different regions, social groups, and sectors.
AI changes (in)equality	• Draft policy which will protect the most vulnerable groups in society and assure that they also benefit from AI's potential.

AI needs a new approach to education	Primary Education
	• Build curriculums that prepare future generations in two main categories of skills:
	  ○ STEM (science, technology, engineering, and mathematics), computing, data science, and digital
	  ○ problem-solving, creativity, interpersonal, and adaptability skills
	• Create diplomas to train and support teachers, so that they are able to deliver these curriculums
	  ○ As most AI technologies rely on the study of computer science, ensure teachers are at the level that they can teach GCSE CS confidently over the next 5 years
	• Introduce children to neural networks, databases, and probability from a young age
	
	Higher Education
	• Include neural networks in the curriculums of Computer Science Degrees.
	• Invest in specialist courses in data-management
	
	Life-long Learning
	• Work with industry, to ensure wider public is alerted to AI's potential and limitations
	• Incentivise vocational training schemes and life-long learning courses aimed to retrain the current workforce

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The All Party Parliamentary Group on Artificial Intelligence (APPG AI) was set up in January 2017 with the aim to explore the impact and implications of Artificial Intelligence, including Machine Learning.

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The APPG AI Secretariat is Big Innovation Centre.

Contact details

Big Innovation Centre
Ergon House, Horseferry Road
Westminster, London SW1P 2AL

info@biginnovationcentre.com
www.biginnovationcentre.com

www.appg-ai.org
www.biginnovationcentre.com