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Understanding the UK AI labour market: 2020

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About this research

This report presents findings from research into the UK Artificial Intelligence (AI) labour market, carried out by Ipsos MORI, in association with Perspective Economics, Warwick University, and the Queen's University Belfast, on behalf of the Department for Digital, Culture, Media & Sport (DCMS).

The research aimed to create a set of recommendations on policy areas that the government and industry should focus on, to bridge skills gaps in the sector. It involved:

- A survey of 118 firms and public sector organisations, including those whose core business was developing AI-led products or services, and others in wider sectors developing or using AI tools, technologies or techniques to improve their products, services or internal processes;
- A total of 50 in-depth interviews with firms, public sector organisations, recruitment agencies, employees and aspiring employees, universities and course providers;
- Analysis of AI job postings on the Burning Glass Technologies database; and
- A roundtable discussion with stakeholders from across government, the private and public sector to validate the findings.

Key findings[1]

Working in AI and Data Science

The majority of surveyed firms were micro or small in size; 41% had 1-9 employees, and 48% had 10-49 employees. Only 9% had 50 or more employees. This is reflective of organisations typically seen in the sector.

In the last 3 years, the most common uses of AI were: predictive machine learning (77%), regression for machine learning (70%) and classification (69%). The top 3 machine learning techniques used were: deep learning (71%), clustering (69%), and spatial data analysis (63%).

Career pathways

Career pathways into AI roles were diverse and lacked a clear structure. Some staff had entered their career directly from university having studied a related course, while others had not considered a career in AI when they went to university and it played no role in their course choice.

There was also evidence that vocational qualifications played only a small part in helping individuals progress into AI roles. Surveyed firms were unlikely to hire staff through an internship (11% of surveyed firms had hired some staff in AI roles through this route) or as an apprentice (3%). Although the survey did not specifically capture the reasons behind this, apprenticeships are currently not an established pathway into AI, and it is possible that recent developments in this sector could help to address this over time.

[1] The survey data has not been weighted, and so cannot be taken as being representative of the AI labour market. Where figures do not add to 100%, this is typically due to rounding of percentages or because the questions allow more than one response.

Diversity

As elsewhere in the report, it is important to be aware that the sample comprised mainly small businesses and AI teams: the average (median) size of an AI team discussed in the survey was 4 people and the mean size was 9 people.

Some firms had workforces that were very diverse but this was not the case across all the surveyed firms:

- Over half (53%) did not employ any females in AI roles. Overall, only a quarter (24%) of the surveyed firms' workforce was female, but this was greater than in the cyber sector[2] (15%);
- Two in five (40%) firms did not employ any staff from an ethnic minority background in AI roles but overall 27% of the surveyed firms' workforce was from an ethnic minority group. People of Asian ethnicity were thought to be well-represented in the sector, whereas some employers identified that people from African and Caribbean ethnic groups were under-represented.
- A similar proportion (41%) did not employ any non-UK nationals in AI roles but 32% of the surveyed firms' workforce were non-UK nationals.

Employers wanted their workforce to be more diverse, but there were various barriers to achieving this, including:

- Lack of diversity among the individuals who were applying for AI jobs;
- Employers prioritising finding candidates with the 'right' skills, attitudes or cultural fit when recruiting, over improving diversity;
- Over-use of informal networks and word-of-mouth at the recruitment stage, which hindered candidates from a different background from being selected; and
- High competition for candidates from under-represented groups, due to growing focus on achieving diversity within the sector. This was a barrier to diverse recruitment. Smaller businesses found it difficult to compete against higher salaries offered by larger firms, and so employees were often poached.

The fast pace of change within the industry was a hindrance for women attempting to return to the workforce after a career break or maternity leave. This could be contributing to the gender pay gap for women.

Current skills and skills gaps

Technical skills gaps were a concern for many firms. A third (35%) said that existing employees lacking technical skills had prevented them from meeting their business goals, and 49% said that job applicants lacking technical skills had done the same. Some employers said that it had restricted or slowed their growth, or prevented them from moving forward with projects. Combining these results indicates that 62% of firms had faced problems with technical skills gaps, which was similar to the cyber sector (64%).

Technical skills gaps were reported in: understanding of AI concepts and algorithms (55%), programming skills and languages (52%), software and systems engineering (52%), and user

[2] https://www.gov.uk/government/publications/cyber-security-skills-in-the-uk-labour-market-2020

experience (51%). However, many employers also faced issues with non-technical skills, including in communication, awareness of potential bias around the organisation's use of AI, and awareness of privacy or ethical issues.

Recent reports are unanimous that, globally, the gap between demand and supply is significant and growing. In the survey, two-thirds of firms (67%) expected that the demand for AI skills in their organisation was likely to increase in the next 12 months, as a result of both COVID-19 and also other expected changes. Most interviewees in the qualitative element expected the demand for AI skills to continue to outstrip supply. This was in spite of a predicted increase in the supply of these skills, due to increasing interest in and awareness of AI in society. Similarly, recent research by Microsoft[3] found that more than a third (35%) of UK business leaders believed there would be an AI skills gap in the next 2 years.

Training

Three in five surveyed firms (62%) reported that employees in AI roles had undertaken internal or external training in the last 12 months to improve their knowledge and skills. This was similar to the UK economy overall (61% in 2019[4]), but higher than in the Cyber sector (24%)[5]. Only a quarter of firms reported offering training on ethics in AI (24%).

Much of this training was informal or on-the job. Many employers did not expect to provide formal training to their staff in the technical aspects of AI, as they felt staff should already have the appropriate technical skills when recruited or take responsibility for keeping these skills up to date. Self-directed learning was common in the sector.

Recruitment and retention

Two-thirds of surveyed firms had tried to recruit in the last 2 years. This was similar to the cyber sector (68%). Use of informal recruitment channels and word-of-mouth was common: 2 in 5 (42%) had used word of mouth or industry networks, and 1 in 5 (22%) had partnered with a university.

Among those that had vacancies in the last 2 years, 69% said that at least one vacancy was hard to fill. This was higher than in the cyber sector (57%) and in the Information and Communications sector as a whole (39% in the 2019 Employer Skills Survey[6]). The bulk of hard-to-fill vacancies were among middle-management and other senior roles, which required 3 or more years of experience. Barriers to filling vacancies included: applicants lacking technical skills and knowledge (65%), work experience (40%), and industry knowledge (25%). This tied in with the findings on skills gaps, which identified poor commercial awareness among employees working in AI-related job roles. Other reasons for hard-to-fill vacancies were salary demands being too high (25%) and location or poor transport links (17%).

[3] Microsoft report 'AI Skills in the UK' https://info.microsoft.com/DE-DIGTRNS-CNTNT-FY21-07Jul-24-AISkillsintheUKreport-AID-3013784-SRGCM3647_01Registration-ForminBody.html#:~:text=52%25%20of%20UK%20employees%20are,AI%2C%20compared%20to%2038%25%20Globally

[4] Employer Skills Survey, Department for Education, 2019: https://www.gov.uk/government/publications/employer-skills-survey-2019-uk-excluding-scotland-findings

[5] https://www.gov.uk/government/publications/cyber-security-skills-in-the-uk-labour-market-2020

[6] Employer Skills Survey 2019 data tables, figure calculated from Table 1. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/925670/ESS_2019_UK_excl_Scotland_Data_Tables_Controlled_v03.01_FINAL.xlsx

A third of surveyed firms (32%) said that, in the previous 18 months, employees in AI-related roles had left the company of their own accord; the rate of turnover for the total AI workforce of surveyed firms was 14% over 18 months.

Job vacancies

The job postings search for AI and data science roles identified 110,494 postings in scope[7] from January to December 2020. The annual number of job postings had more than doubled since 2014, reflecting strong growth in demand for these roles among employers. Despite the challenges faced by employers in 2020 due to the COVID-19 pandemic, 2020 was the highest year to date for the number of online job vacancies related to AI and Data Science, with an increase of 16% from 2019 levels.

More than half of these job posts were in London and the South East. London was a major hotspot for AI and data science roles, with 36,715 roles identified. This was followed by Cambridge (5,453), Manchester (3,619), Bristol (2,505), Edinburgh (2,365), Oxford (2,311) and Birmingham (2,095). In relative terms, Cambridge had the highest concentration of demand for AI professionals.

A quarter (24%) of job postings were for Software Developers and Software Engineers, reflecting the breadth of technical and non-technical skills within these roles. The top 3 skills requirements mentioned in job descriptions included: Software Development Principles, Scripting Languages, and knowledge of Machine Learning.

Employers placed a very strong emphasis on applicants having Bachelor's degree or higher qualifications. In total, 91% of roles required at least a Bachelor's Degree or higher. Half (50%) of the job postings requested a background in Computer Science, and a quarter (25%) requested an Engineering (i.e. software) background. Mathematics was the third most requested subject (14%) followed by a background in Business Administration (8%), and Statistics (7%).

The mean advertised salary was £54,800 for an AI and data science related job posting (with a median value of £50,000).

The education sector (primarily Higher Education institutions) and financial sector (excluding insurance) provided the greatest demand for AI and data science professionals. Analysis showed there were a wide range of sectors employing AI and data skills (e.g. within scientific research, retail, legal services, health, consultancies, and the public sector) which suggested that AI skills can be deployed across the whole economy to improve national productivity.

Conclusions

The following recommendations are based on the evidence generated from all elements of this study. It will require engagement from government, AI firms and other employers, education institutions and recruitment agencies to take them forward:

- **Increase diversity in the AI workforce**, particularly among women, a wider range of ethnic minorities, and people from poorer backgrounds within the UK. Attracting global talent can also support increasing diversity in the workforce.

- **Improve the talent pipeline through education, student employability and diversity**. Increasing the talent pool and ensuring a future pipeline is key to the success of the AI sector

[7] Further details can be found in the technical report

within the UK. Entry into the AI sector from a diverse range of people needs to be encouraged, and can be achieved by increasing the levels of awareness about AI in general and the career opportunities in this sector. The talent pipeline can be further bolstered by ensuring that graduates have the skills required by employers. There was some evidence that employers felt that new graduates were unable to apply their skills to real life situations and/or had sufficient soft skills – Industrial Funded AI Masters have been one way of providing undergraduates with work experience to increase their employability.

- **Create more opportunities for those not currently working in AI to convert to a career in AI** and raise the levels of awareness of these opportunities. AI conversion courses[8] have been set-up to meet this demand and a new apprenticeship scheme has recently been launched. However, more thought should be given to how people at different life stages can convert to a career in AI.

- **Encourage small firms to broaden their recruitment practices and provide support to small firms/employers located outside 'hot spots' to recruit and retain staff**: small firms preferred word-of-mouth and networking to recruit their employees; this was a cost effective method of recruitment but meant that their talent pool of candidates was restricted. Employers who were located outside of the AI 'hotspots' found the recruitment and retention of staff particularly challenging, and there is a need to explore how to support these firms.

- **Firms need employees to have a range of both technical and soft skills** so that they can communicate effectively with management, other team members, internal stakeholders and clients about the AI product, its application and the benefits or limitations.

- **Identify the AI skills required by different sectors**: focus needs to shift towards thinking about the AI skills required in each sector, and how academic organisations could expand their courses to ensure that students gain the correct skill set.

- **Increase ethics and bias training** and make the case that it is in firms' commercial interests to avoid flaws related to bias and ethical issues in their products.

[8] https://www.officeforstudents.org.uk/advice-and-guidance/skills-and-employment/postgraduate-conversion-courses-in-data-science-and-artificial-intelligence/?__cf_chl_jschl_tk__=21d84366550df033f1e83554231e14eff1ee76e0-1616496462-0-Aaw8CoaLsJGcCAUPOjAbxNwryct_ZeXMwaumt6vBeDItN-df2yyHylQDA36_51bIf9Cp9zVCFIeilq1o_ltCKib29uR2FZzTwc5j3z9MScLC8dvuRrB5EZQjWNr8CDY8sBfsZ1hV19cRp27euDDcEKgnyewYKMZkq63EIe96J1ZcaAZIr_Na9GJvXx5EHOY7YXNbF3Xn5-TFvlOEvle0C-O4yUQ9BikocLy0Y5G9gBG-8xP7FppYnyWhakFD9-W5tU3SOX3NIOHPGE9_LkiqF--sUvvRqU1zLJCPpn9giRGBeuT9Y2tW1e0TyZ03DgvC9h3nkHCf6YxwAjZ6XdDNfh9i3g19A52gFfdyu2Iv95ywhiluWKIHCbmt7HfRUDmDdBgOypiuy-xT49uf3enVJfcY44mpJ7MbpbxKCtpJMX7ZQCtQntx9AgIzs54c9MckjY4DDod1b79woqFZWWjrLXyZL2R4GNGMwKg6z4yZkVOY

Introduction

Context

The UK Government Department for Digital, Culture, Media & Sport (DCMS) commissioned Ipsos MORI, in association with Perspective Economics, Warwick University, and the Queen's University Belfast, to conduct research to improve their understanding of the current UK Artificial Intelligence (AI) labour market.

The research aimed to gather evidence on:

- Current skills gaps (i.e. where existing employees or job applicants for AI roles lack particular skills that employers require);
- The role of training, recruitment and outsourcing to fill skills gaps;
- Current skills shortages and the level and type of job roles they affect (i.e. a shortfall in the number of skilled individuals working in, or applying for, AI roles);
- Where the AI jobs market is active geographically;
- The roles being labelled as AI versus ones that are not but require a similar skillset; and
- Diversity within the workforce.

The research also aimed to create a set of recommendations on policy areas that government and industry should focus on to bridge the skills gap.

Definition of AI

For the purpose of this study, AI skills are defined as the combination of knowledge, awareness and understanding, attitudes, technical skills and soft skills that all organisations developing, using or procuring AI technologies need, in order to:

- Do one or more of the following, depending on the aims and needs of the organisation and specific AI projects:
    - Carry out research and development into AI;
    - Design and develop AI models, tools and technologies;
    - Recognise and use the appropriate AI solutions for their organisation's needs;
    - Recruit the right people into AI roles or upskill people into these roles; and
    - Procure appropriate AI solutions from external providers.
- Communicate effectively with those not in AI roles who are using or making decisions based on the outputs of AI modelling

- Understand the impact of unconscious bias in any inputs into AI models and the ethical implications of any outputs.

Summary of the methodology

The methodology consisted of 5 strands, as outlined here. The role of the first strand was mainly to feed into the development of the quantitative survey (strand 2) and qualitative research (strand 3), by scoping out the gaps in the existing literature and the topics that should be explored.

- **Strand 1: Scoping stage.** The purpose of this stage was to define and categorise AI skills and job roles, define the sample for the primary research, and gather initial evidence on the current AI skills landscape, higher education and training provision, and pathways into AI jobs. It comprised:
    - A Rapid Evidence Review of policy papers, research reports and blogs;
    - Ten stakeholder interviews with experts from industry, government, and relevant umbrella bodies;
    - Development of an AI taxonomy to build a sample of AI-led and AI-enabled firms to survey;
    - An initial analysis of AI job vacancies covering job titles, skills referenced in job descriptions and job postings by sector
- **Strand 2: Quantitative survey.** This comprised a telephone survey of 118 AI firms, including firms whose core business was developing AI-led products or services, and others in wider sectors developing or using AI tools, technologies or techniques to improve their products, services or internal processes. Fieldwork took place between 25 August and 23 October 2020. A live pilot was also conducted between 18 and 19 August 2020 to test the process and questions; pilot interviews have been included in the findings.
- **Strand 3: Qualitative interviews.** This comprised in-depth interviews with 50 firms, public sector organisations, recruitment agencies, employees and aspiring employees, and course providers, including universities. Interviews took place between December and February 2021.
- **Strand 4: Job vacancy analysis.** This strand analysed online job postings in the UK. The approach involved 2 search strategies using the Burning Glass Technologies Labour Insight tool. The first search strategy focused on job postings that had been categorised against a range of Burning Glass skill clusters. The second search strategy was more extensive and included a range of keywords for inclusion and exclusion across skills, job titles, and descriptions. This second search yielded the 110,494 job postings used for analysis purposes.
- **Strand 5: Stakeholder roundtable discussion**. Ipsos MORI ran a workshop with key stakeholders from government, industry and academia to discuss the findings from the preceding strands and contribute to the recommendations. This took place in March 2021.

The separately published technical report provides more detail on the methodology, including sampling, data collection, response rates and weighting. It also includes a copy of the strand 1 literature review as an appendix.

Impact of COVID-19

In March 2020, the UK government announced lockdown restrictions in response to growing concerns about the COVID-19 pandemic. The restrictions saw many businesses being subject to enforced closures and restrictions on social contact, and a significant proportion of the workforce being asked to work remotely or from home. The survey for this study was conducted whilst restrictions were in place in England and the Devolved Nations. As a result, many AI firms were unavailable to take part or were uncontactable. There were also implications for the findings, for example around current challenges for recruitment, and the impact on future skills needs. These issues are explored in this report.

Interpreting the findings

Survey data

The survey data has not been weighted, and so cannot be taken as being representative of the AI labour market. Where figures in charts do not add to 100%, this is typically due to rounding of percentages or because the questions allow more than one response.

Due to the small number of firms that took part in the survey, it is not possible to compare the results between subgroups.

Qualitative data

The qualitative findings offer more nuanced insights and case studies into how organisations address their AI skills needs, and why they take certain approaches. Where we pull out an example or insight from one organisation, this is typically to illustrate the breadth of findings that emerged. As with any qualitative findings, these examples are not intended to be statistically representative of the wider population of UK organisations.

Acknowledgements

The authors would like to thank all the businesses, organisations, and individuals who took part in the survey and interviews. We would also like to thank the partners who also contributed at various stages to the study, including the stakeholder roundtable discussion.

01

Working in AI and data science

01 Working in AI and data science

This section reports on the types of firms that are recruiting for AI roles, the size of AI teams, and the areas of AI and data science they focus on. It then looks at the sorts of roles that are being badged as AI roles and in which sectors, departments and regions these roles are found. Finally, it examines the pathways and motivations to AI roles, the qualifications needed, and potential barriers to progression.

Types of AI firms

The sample for the quantitative survey was made up of firms whose core business was developing AI-led products or services ('core AI firms') and organisations in wider sectors that developed AI internally or used existing AI tools, but were not specifically an AI business ('non-core AI firms'). In the quantitative survey responses, there was a fairly even split between core AI firms (52%), and non-core AI firms (48%). This is in line with the split between core AI firms and non-core AI firms in the sample of organisations that were contacted to take part in the survey, which is made up of businesses identified as employing or recruiting for AI roles (45% and 55%, respectively, n=2,388).

In the qualitative research, there was a wide variety of industry sectors among firms that took part, which highlights the diversity of the AI labour market. Examples included healthcare, finance, education, engineering, software development, graphic design, gaming, oil and gas, defence and security, retail, law, and local government.

Size of AI teams

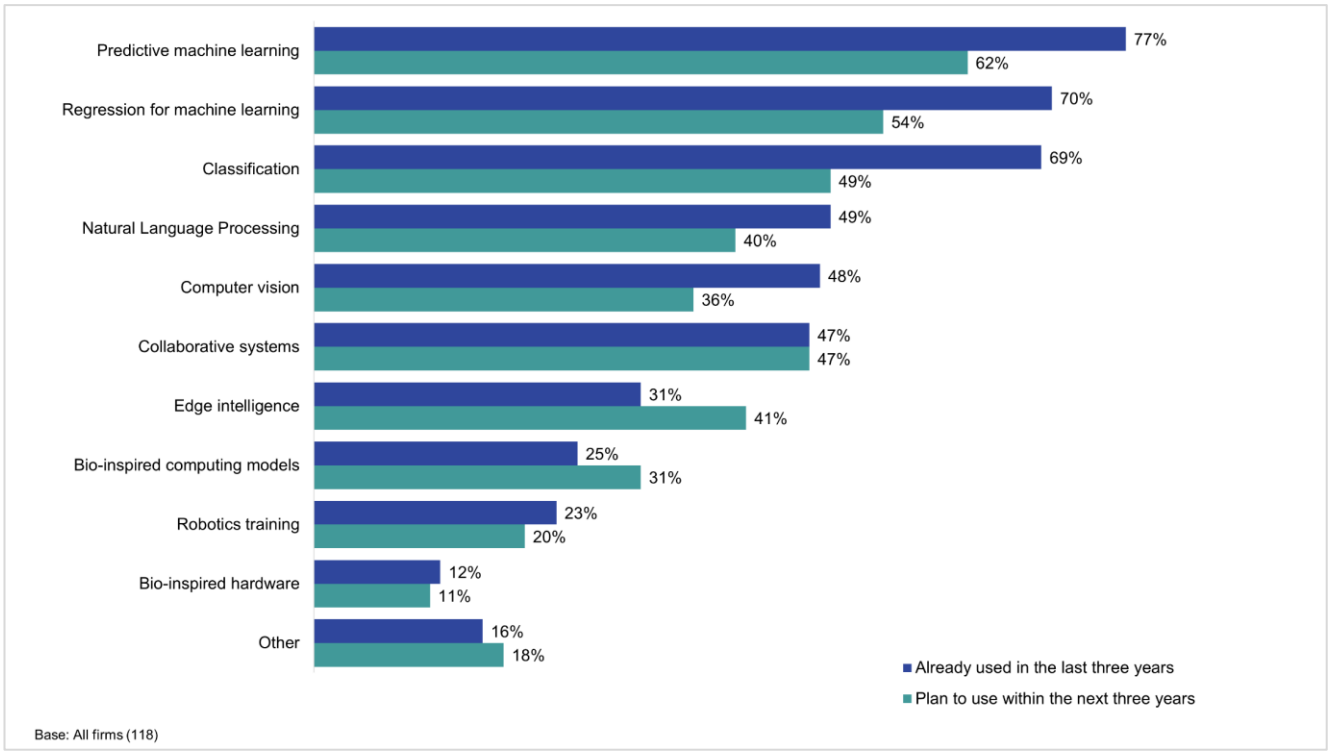
The majority of surveyed firms were micro or small in size. Overall, 41% had 1-9 employees, and 48% had 10-49 employees. Only 9% overall had 50 or more employees. The median size of a core AI firm in our sample was 9 employees, while that of a non-core AI firm was 11, and that of an AI team within a non-core AI firm was 6.

According to the UK government's business population estimates for 2020, among UK businesses overall, 82% had 1-9 employees and 15% had 10-49 employees.

Areas of AI and data science

As shown in Figure 1, firms most frequently reported working with predictive machine learning (77%), regression for machine learning (70%) and classification (69%), during the last 3 years. Very few firms had used bio-inspired hardware (12%), robotics (23%) or bio-inspired computing models (25%). The pattern of intended use of types of AI was broadly aligned to their past/present usage. The most frequently mentioned areas of AI in which firms plan to work in the next 3 years were predictive machine learning (62%), regression for machine learning (54%), and classification (49%).

Figure 1: Proportion of firms working with different areas of AI in the last 3 years and planning to use in the next 3 years



The UK was likely to see higher growth in the use of predictive machine learning among firms that were not currently using it, compared to other AI techniques, such as regression for machine learning. While the proportion of firms planning to use predictive machine learning was similar among those who had already used it and those who had not used it before (56 out of 91 and 17 out of 27, respectively), the proportion of firms planning to use regression for machine learning was higher among firms who had used it in the last 3 years (53 out of 83) compared to those who had not used it before (11 out of 35). This is shown in Figure 1.

The top 3 machine learning techniques used by AI firms were deep learning (71%), clustering (69%), and spatial data analysis (63%). Core AI firms were more likely than non-core AI firms to have used deep learning (84% vs 58%), clustering (80% vs 58%), and random forests (56% vs 28%). Less commonly used machine learning techniques included neuromorphic computing (used by 19% overall) and support vector machines (33%).

Among the 43 non-core AI firms that had a specific team or department for AI, 47% said this team's primary function was research and development, followed by data science (23%), algorithms and models (21%) and analytics (19%).

In the qualitative research, participants mentioned they used AI primarily for turning large volumes of data into useful information and insights. For example, one core AI firm was developing devices to analyse medical data and turn it into actionable insights. This involved the use of algorithms to classify large volumes of data, find relationships, and ultimately predict the appropriate course of action. In another case, AI employees sat within the insight and analytics team of the organisation, with responsibility for predictive analytics, machine learning and insights, as well as more traditional market and user research.

"[AI skills are about] deploying data insights to create value."
CEO of a software firm

Participants from large organisations reported that teams or groups working with AI might not be joined up. In one organisation, this prompted the creation of a specific institute to bring these different groups together, but another organisation noted that its dedicated AI team did not have capacity to work across all relevant teams that might be able to use AI technologies. It can be inferred from this that some larger firms have to prioritise where they implement AI within their organisation, which could be leading to untapped opportunities.

"The idea is to integrate all of the data science and digital work across the organisation in all the different departments and have an institute where this is centralised and where we can bring together people who are working in this area and also form cross-disciplinary collaborations."
CEO of a software firm

AI roles were spread across a wide range of sectors, as mentioned above, reflecting participants' reports that the application of AI is expanding throughout different sectors of the economy. Participants felt that AI roles were typically available in major towns or cities, as this tended to be where companies had their headquarters, and that research roles clustered in major towns or cities or around universities due to the established networks in those locations.

"There are plenty of open positions in London. London and Cambridge are probably the best places for concentration of AI jobs."
PhD student

In the qualitative research, a wide range of job titles and descriptions were considered AI roles. Examples included:

- Analytics and insight
- Automation
- Data analyst / consultant / manager / miner / scientist
- IT
- Machine learning
- Modelling / predictive modelling
- Software developer (for AI and/or machine learning)
- Software engineer (for AI and/or machine learning)
- Research and development
- University positions (e.g. lecturer, professor)

The findings reflected a perception among workshop participants that only technical roles tend to be badged as 'AI roles'. These participants suggested that other 'non-technical' roles relevant to AI technologies might consequently be overlooked, for example, marketing, sales, user design and user experience. This perception risked future policies and interventions not addressing the full range of reported AI labour market gaps and failing to encourage less technically-minded individuals into an AI career.

The qualitative research also identified challenges around defining and communicating the requirements of job roles. A lack of commonly understood job titles meant that, for example, 2 roles advertised as 'data

scientist' could have very different requirements in terms of skills, experience and qualifications. Confusion often arose between roles that required a basic understanding of how to use AI tools and those that required a deep understanding of AI in order to develop or improve such tools.

"When you say AI or machine learning, it means different things to different people, so you have to dig in way deeper to figure out what they actually want."
Recruitment consultant

Qualitative participants felt that it was important to distinguish these different types of AI role, as these were typically reached through different pathways, and required different qualifications, mindsets and skills (on skills, see Section 3). The main distinction was between 'development' and 'application':

- **Development of AI** – this includes roles requiring a deep understanding of AI in order to develop or improve such tools.
- **Application of AI –** this includes roles requiring a basic understanding of how to use AI tools (especially 'off-the-shelf' products, available from large technology companies like Google, Microsoft and Amazon).

"Scientists have theories and devise experiments to test your theory to come to a conclusion. You'll have lots of negative results along the road, and you might end with nothing at the end. Execution identifies a very specific problem and being able to build a solution using a very creative combination of techniques. It's a different mindset … people fall in either of the 2 categories."
CEO and founder of AI firm

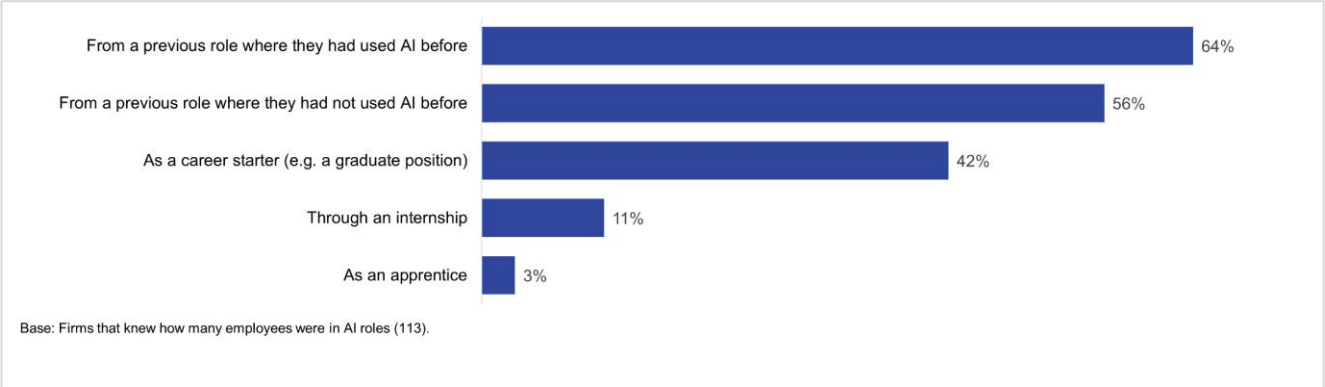
The rapid evidence review and qualitative participants noted that AI was becoming increasingly commodified and easy to use over time, and so expected more AI roles in the future would require less specialised and/or technical skills. This is in line with the findings of a House of Lords report on AI in the UK[9] and was also discussed in the stakeholder roundtable, where it was noted that AI will create evolution in existing career pathways such as law.

Career pathways

Firms in the survey reported that their employees had entered their current AI role from a number of different pathways. Firms most commonly reported that at least some of their AI staff had come from a previous role in which they had used AI (64%). Over half (56%) had some staff who came from a previous role where they had not used AI before and 42% had some staff who had entered their current AI role as a 'career starter', such as in a graduate position. Firms were less likely to have any staff who entered their current AI role through an internship (11%) or as an apprentice (3%). This is shown in Figure 2.

[9] https://ec.europa.eu/jrc/communities/sites/jrccties/files/ai_in_the_uk.pdf (paragraphs 164 and 165)

Figure 2: Proportion of firms that had some staff who entered their current AI role through the following career pathways



Among qualitative participants, career pathways into AI roles were diverse. Some employees had entered a career in AI directly from university having studied a related course, while others had not considered a career in AI when they went to university and it played no role in their course choice. These individuals had entered the workforce in another capacity, before deciding to focus on AI and retraining. While some retrained from within the workforce, others left their role to return to university.

Qualitative participants working in AI highly valued the university education they had received. This had provided them with technical skills, particularly courses which had an element of self-directed problem-solving, and an understanding of how to approach a problem in AI and what questions to ask. University was also seen as useful for developing a mindset of perseverance and self-directed learning, and for developing networks and finding mentors. However, participants also stressed the importance of ongoing learning to update their skills following university (see chapter on training).

Examples of pathways into working in AI are presented below.

Started in non-AI roles, left the workforce to retrain in AI

Some participants started in non-AI roles but decided to retrain in AI or a related field, typically via a postgraduate programme. For example, one participant used to work in the arts but had an interest in logic and mathematical analysis. They left publishing to pursue a Masters in quantitative social science followed by another in a specific area of AI. From there, they conducted research into an AI area before doing a PhD in an AI area.

Started in non-AI roles with gradual acquisition of relevant skills

Some qualitative participants started in non-AI roles but gradually acquired more and more of the relevant technical skills for an AI role. For example, one data scientist did an undergraduate degree in life sciences and a Master's degree in public health before working as a statistician. They felt statistics underpinned data science and machine learning, which they taught themselves. They moved to their current role, which combines the roles of data scientist and data consultant, to be at the cutting edge of data science and research.

Started in AI research and founded a company

Some companies grew directly out of university or commercial research projects, with the CEOs transitioning from an academic or research role to a commercial, developer role in AI. For example, one CEO and AI employer founded a company which commercialised their post-doctoral research project.

Consultancy

Consultancy was another pathway to an AI role. These participants, from a range of sectors including finance, technology and energy, worked as market or data analytics consultants before transitioning into an AI role. This gave them a good understanding of the market and how AI could be used to tackle business problems. For example, one AI employer worked as a consultant in data analysis in the energy and utilities sector. They felt the proper data analysis was not always available and so founded a company to design and build software to fill this gap, with development of the software primarily undertaken by a partner organisation.

Another example comes from an AI employee who did a Chinese Studies undergraduate degree, worked in financial services in China, then in a China-UK market entry consultancy in the UK which focused on investment in machine learning and other digital technology. They pursued this interest in the commercial side of AI technologies via an internship and later joined the same company as a solutions consultant, working across sales, R&D and engineering to develop and commercialise NLP technology.

"It's a bit like a black hole – it gets more and more interesting."

Solutions consultant

Sector experience relevant to AI

There were some who did not set out to work in AI but ended up working in an AI role because of the sector experience they had. For example, one participant had no computer science or AI experience but had a strong background in engineering. An AI company wanted to build a data scientist team and hired the participant because of their experience in a certain area, which the company considered a valuable skill. Some employers also reported hiring staff on the basis of sector or industry knowledge with a view to developing those individuals' AI skills on the job.

Management

There were training providers who reported a 'management' pathway to an AI role. They said some people came to an AI role without necessarily having skills to use or develop AI, but had experience of team management and a good understanding of AI due to their professional experience. For example, one training provider ran a course aimed at senior managers to teach them about AI so they would be able to make informed decisions about running specific tools. They noted that there was a fear of AI among senior managers relating to data privacy issues, algorithmic bias and lack of explanations, as well as a regulatory gap. A possible implication of this is under-adoption of AI by some firms. By giving senior managers a good understanding of AI issues, the training provider aimed to bring leadership and management skills into AI roles.

"It doesn't make sense for [senior managers] to be taught the software skills … These people are paid to lead and manage, not to execute."

Training provider

Current students

The qualitative research also involved talking to students looking to enter the AI labour market. For those studying AI, the course provided many of the technical skills and fundamental understanding of AI principles, with internships being an important way of gaining practical industry experience.

- **Case study:** One current student had previously worked at a financial institution. They started a Masters before switching to a PhD in a specific area of AI, with the aim of returning to the finance sector as an AI specialist and researcher. At the time of interview, they were doing an internship at an AI start-up and had another internship lined up. They felt AI industry experience would facilitate their return to the finance sector.

- **Case study:** Another current student was an EU national doing an MSc in London. They wanted to work in a large R&D team in the private sector as they felt this was where the most interesting, goal-oriented research took place. They also felt London was particularly attractive because so many large companies have their R&D headquarters there. This individual had an internship lined up in the summer and was hoping this would lead to a long-term position and a fully-funded PhD with the company.

There were also current students who were not studying AI specifically and had not thought about a career in AI before entering University.

- **Case study:** One undergraduate student was studying a STEM subject and had applied AI to solve a research problem as part of their course. The student had also undertaken an internship involving the application of AI. In future, they wanted a research position, and felt they would be able to learn AI on the job before potentially applying for a postgraduate degree in an AI related field.

- **Case study:** Another undergraduate student was studying a non-STEM subject. They became interested in using AI, and also became interested in diversity and race issues relating to AI. They have taken steps to acquire broad knowledge of AI and its applications. In future, they wanted to pursue a non-technical developer role in AI, but that would require further training in their current subject area first.

Qualifications

Staff in AI roles typically held formal qualifications. Overall, 99% of firms in the survey reported that at least some of their staff in AI roles had a university qualification: 88% reported that at least some of their staff in AI roles held an undergraduate degree, 77% a Master's degree, and 54% a PhD. The most common subject areas included Computer Science (75% of firms) or Maths and Statistics (60% of firms). In comparison, one third (33%) of Cyber firms had staff with general computer science or IT degrees, suggesting AI roles currently require a more specialist or technical computer science background.

The pathways leading to roles in the development of AI included postgraduate university training and incremental on-the-job training. Some participants had done an undergraduate degree in a relevant field, such as computer science, maths or statistics, and had gone on to gain postgraduate qualifications in related subjects. However, there were also those whose undergraduate degree was non-STEM. Some of these participants went on to retrain by completing postgraduate qualifications in an AI-related field, while others acquired practical skills and experience through on-the-job training or via self-learning.

The pathways leading to roles in the application of AI included undergraduate university training, but participants reported such training did not need to be as rigorous. Both employees and employers of these types of roles said that formal qualifications were less important than a willingness to learn and/or an ability to use ready-made AI tools without necessarily having deep technical skills or understanding of how to develop or build AI tools themselves.

"Some clients really place a huge emphasis on education, others don't really mind. If they are hiring a grad, they will mainly focus on education, but if you've been in the industry for 15 years, some clients won't bat an eyelid if you didn't go to university - it would be more about experience."

Recruitment consultant

02

Diversity

02 Diversity

This chapter explores diversity within the UK AI labour market. The Government is committed to increasing diversity in the AI workforce to ensure that everyone with the potential to participate has the opportunity to do so. This is particularly important for AI to mitigate the risk that a non-diverse workforce could perpetuate or accelerate bias; a diverse group of programmers reduces the risk of the inherent bias of the programmers embedding into the algorithm[10]. Making the AI workforce more diverse will also be important in order to ensure that AI works well for a wide range of different users; to increase the overall numbers of people with these skills and help to address skills shortages; and in order to avoid this highly remunerated and rapidly growing career being dominated by already privileged groups in society, thereby increasing inequality[11].

This chapter considers the reasons behind the profile of the workforce, whether there are barriers to particular groups entering the AI workforce, and describes attitudes towards diversity and efforts to make the workforce more diverse. Gender balance was identified as a key issue and so is discussed in most detail, but the chapter also presents findings on ethnicity, nationality, and socio-economic background.

Wider context from other research

Hall and Pesenti's 2017 report on growing the AI industry in the UK[12] emphasised the importance of ensuring a diverse workforce and noted that "Currently, the workforce is not representative of the wider population. In the past, gender and ethnic exclusion have been shown to affect the equitability of results from technology processes. If UK AI cannot improve the diversity of its workforce, the capability and credibility of the sector will be undermined."

Contributors to a 2018 Parliamentary report on AI raised concerns about the diversity of those working in AI, with mainly male attendees at AI conferences, and spoke of the need to "democratise AI" and make it more accessible to women and those from low-income households[13]. The report evidence from PricewaterhouseCoopers, who reported that only 27% of female students they surveyed said they would consider a career in technology, compared to 62% of males, and only 3% of females said it would be their first choice[14].

A LinkedIn study from late 2019 that used machine learning to analyse its members' profiles[15] found that around 16% of AI professionals in the EU were female, and in the UK this figure was slightly lower. This is backed up by a report which, when considering authors publishing at 21 key AI conferences, found that just 18% of authors were women[16].

[10] Hall and Pesenti, 2017. https://www.gov.uk/government/publications/growing-the-artificial-intelligence-industry-in-the-uk
[11] See for example the House of Lords' Select Committee on Artificial Intelligence 2018 report: "AI in the UK: ready, willing and able?". https://publications.parliament.uk/pa/ld201719/ldselect/ldai/100/10002.htm
[12] Hall and Pesenti, 2017. https://www.gov.uk/government/publications/growing-the-artificial-intelligence-industry-in-the-uk
[13] House of Lords' Select Committee on Artificial Intelligence 2018 report: "AI in the UK: ready, willing and able?". https://publications.parliament.uk/pa/ld201719/ldselect/ldai/100/10002.htm
[14] https://www.pwc.co.uk/women-in-technology/women-in-tech-report.pdf
[15] https://economicgraph.linkedin.com/content/dam/me/economicgraph/en-us/PDF/AI-TAlent-in-the-European-Labour-Market.pdf
[16] https://jfgagne.ai/talent-2019/

Estimates of diversity

As elsewhere in the report, please note that these figures are based on a sample mostly comprising small businesses and AI teams: the average (median) size of an AI team discussed in the survey was 4 people and the mean size was 9 people.

Gender

The AI workforce was predominantly male: across our surveyed firms, 24% of their AI employees were female. This is a greater proportion of the workforce than in the cyber sector (15%) and similar to the tech sector overall (26%)[17]. While some firms employed a substantial proportion of women in their AI teams, over half of firms (53%) did not employ any women in AI roles.

When participants in the qualitative research were asked about diversity among AI professionals, gender imbalance was typically top of mind and discussed in more depth, with a very widespread recognition that this was "terrible" or "a big problem", although some participants believed the gender balance was becoming more equal over time.

"What's great to see, I think this is fantastic, is much more women are moving into technology than previously. I can see that as someone who's recruited for 15 years...Nowadays, I would still say there are more male candidates than female, but it's moving in the right direction and it's getting a lot more equal."

Recruitment consultant

Ethnicity and nationality

Across all firms surveyed, ethnic minority employees made up 27% of the AI workforce, which is a higher proportion of people from ethnic minorities than in the population overall. However, the survey did not explore the representation of different ethnic groups within this broad category and the qualitative research identified that some groups are still poorly represented despite this overall figure.

Some firms had workforces that were very diverse, while a significant minority of firms (40%) had no AI staff from an ethnic minority background. Participants had different understandings of the extent of ethnic diversity. People of Asian ethnicity were thought to be well-represented in the sector, but employers had a range of views on the extent of ethnic minority representation overall, and some employers identified that there were few people from African and Caribbean ethnic groups.

AI teams appear to be diverse with regard to nationality: 32% of all the AI staff employed by surveyed firms were non-UK nationals, although 41% of employers employed only UK nationals in their AI teams. This corroborates research by Tech Nation[18], which reported that tech has a marginally higher proportion of people from ethnic minorities than the labour market as a whole (15.2% vs 11.8% for all occupations).

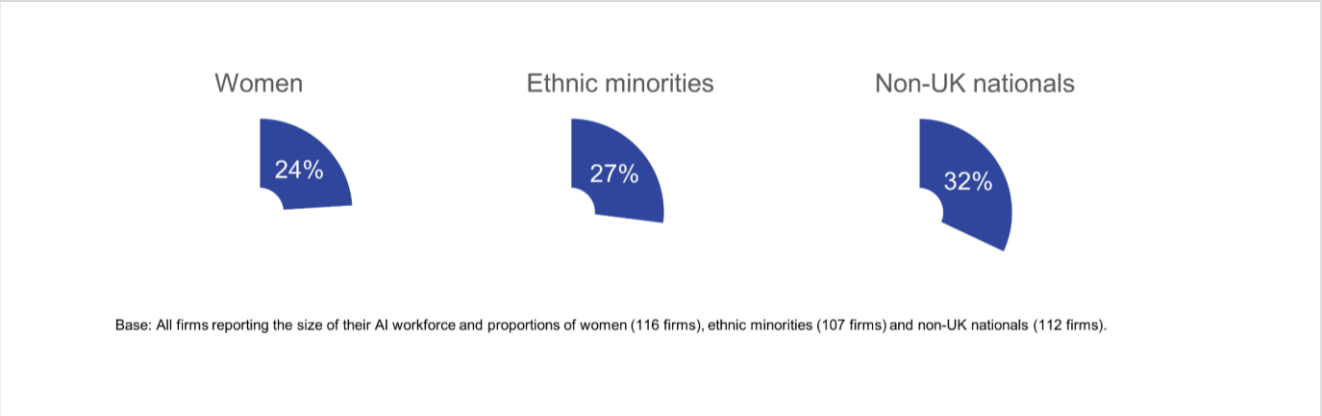
Employers interviewed for the qualitative research were often proud of having a workforce comprising people from several different countries and were keen to highlight this as something which made their workforce more diverse than it would be otherwise. Some employers had deliberately recruited non-UK nationals due to a perception that people from some countries or regions of the world (Eastern Europe, India or China) typically have better levels of STEM education than people from the UK.

[17] https://technation.io/report2021/#diversity-in-tech

[18] https://technation.io/report2021/#diversity-in-tech

The proportions of females, ethnic minorities and non-UK nationals is shown in Figure 3.

Figure 3: Proportions of various groups in the total workforce of surveyed firms



Other characteristics

Views on socio-economic diversity were mixed: some participants were concerned that there were few AI professionals from working-class backgrounds, while others did not think this was an issue, often because they were from a working-class background themselves. Employers commented that they found it harder to judge how diverse their workforce is on less visible criteria such as socio-economic background or neurodiversity.

Attitudes towards workforce diversity and the role of Government

Employers wanted their workforce to be more diverse, and they could readily identify the benefits of this. These benefits tended to be general rather than specific to AI projects: employers did not typically mention the role of diversity in mitigating potential bias in AI models, although this was mentioned by AI professionals, students and training providers. Employers saw the benefits of a diverse workforce as:

- Being able to draw on a broader range of perspectives, opinions, sources of knowledge and ideas, thereby fostering innovation and avoiding “groupthink”;

“I think it makes it more innovative and I think it makes us more agile and more flexible because we can see different ways to approach problems… It leads to diversity of thinking, which drives the innovation that drives that transformation and allows us to be at the cutting edge.”

Employer

- Being more reflective of their customers, clients or the people they serve, helping to create rapport with clients and create a better user experience;

"I haven’t hired someone that doesn’t have a beard for the last 5 years… We look like a team of geeks. And sometimes that’s good, because people feel reassured… but it doesn’t help on things like trying to show we understand the user experience, because their users aren’t going to be a bunch of geeks, their users are going to be a diverse group."

Employer

- Having a better-functioning team with a better mix of soft skills (although some of this perception appeared to be based on stereotypes, e.g. that women tend to have better communication skills);

- Reputational benefits, particularly with requirements to report workforce demographics becoming more common, e.g. when bidding for contracts or funding.

"It has been standard in policies and also in government tenders that we have to state that. Government contracts expect social inclusion and evidence of this. Questionnaires and tenders have been asking more of this in the last 2 years, so it is a driving force."

Employer

This interest from employers was reflected by the experience of recruiters, who commented that they were frequently asked to find diverse shortlists of candidates and that this had become more of a salient topic in the last 10 to 15 years among larger employers. It should be noted that recruiters tended to work with large firms.

Despite this interest and aspiration, many employers recognised that their current workforce was not diverse, particularly when considering their staff in AI roles; employers that had previously considered this issue had typically done so in relation to their workforce more widely. Employers generally discussed the benefits of a diverse workforce in hypothetical terms rather than giving specific examples related to their business.

When asked what difference their background, gender, race and other characteristics had made to their career, most AI professionals described advantages rather than disadvantages. For example, some neuro-diverse people commented that having a different way of thinking through problems had given them an advantage.

Across all the qualitative interviews, participants stressed the need for more opportunities for pupils to learn about AI careers at school, and as part of a wider range of undergraduate courses, which they believed would greatly improve the diversity of the AI labour market. They felt that the popular image of working in AI did not reflect the reality and that more should be done to challenge stereotypes, and communicate that such a career can be interesting, applied in a wide range of contexts, and highly paid.

Diversity challenges

Diversity of job applicants or candidate pool

Employers overwhelmingly attributed the lack of diversity among their staff (largely in terms of gender) to a lack of diversity in the candidate pool more widely, or in people who apply to their jobs. Employers felt strongly that their options were limited because of this candidate pool, and that it was reflective of the tech, computer science and STEM workforce more widely. Research by Women into Science and Engineering (WISE) shows that women make up around 17% of the wider tech and IT workforce, and this proportion has stayed the same over the last 10 years[19], while Tech Nation reported in 2021 that 26% of the digital tech workforce were women[20].

[19] https://www.wisecampaign.org.uk/statistics/updated-workforce-statistics-to-september-2020/

[20] https://technation.io/report2021/#diversity-in-tech

"Particularly if you're talking about hardcore AI development, you're talking about someone who has high mathematics skills. You don't see many women taking advantage of these types of degrees and then staying in the workforce a little bit later on."

Employer

A survey of young people aged 16-24 found that young women found digital careers less appealing than young men, and were more likely to say that they felt they did not have the required skills or knowledge for such a career or that it sounded boring or uninteresting[21].

However, one AI professional commented that the AI-related postgraduate courses they had taken at university had been extremely diverse in terms of both gender and nationality, and wondered why this diversity was not reflected in the workforce. They suggested that this may be typical of prestigious UK postgraduate programmes which attract people from all over the world.

Employer priorities when recruiting

Despite their appetite for a more diverse workforce, when recruiting, employers reported that they prioritised finding candidates with the right skills, attitudes, and cultural fit, over improving the diversity of their workforce. This was particularly the case for smaller firms that hired fewer people and believed they could not take the risk of not getting "the best person for the job".

"I have tried to diversify – trying to do male/female reasonably, and try all ethnicities, but I don't want these things to stop me hiring a good person."

Employer

Recruitment approaches

Smaller firms were more likely to use informal networks for recruitment, which could limit the diversity within their pool of potential candidates. Smaller firms were also more likely to consider 'cultural fit' in recruitment due to the small size of the team, which was likely to discourage candidates from a different background from applying.

"The guys go to the pub. It's not my thing but I want to be with them and have fun - but it was a bad idea and I stopped going. Somehow they are more comfortable with each other socially and they stick together."

AI professional

Competition for candidates from under-represented groups

Employers reported that a growing focus on diversity within the sector meant that staff or candidates from underrepresented groups were more likely to be poached by other businesses. This often made it difficult for smaller businesses to achieve diversity, as they felt unable to compete against high salaries offered by larger firms. An employer also described how the limited number of candidates meant that achieving a more balanced workforce in one dimension, such as gender, could make it less balanced in another, such as socio-economic background. However, employees did benefit from this: a female employee felt that this preference among employers gave her an advantage in the labour market.

[21] https://learningandwork.org.uk/resources/research-and-reports/disconnected-exploring-the-digital-skills-gap/

Financial barriers to entering the workforce

Workshop and interview participants commented that the prevalence of specific STEM qualifications and postgraduate degrees in the AI labour market could be a barrier to groups under-represented in STEM and higher education more generally. These pathways to AI roles often represented significant time and financial investment, which could be prohibitive for people from poorer backgrounds. Young people from poorer backgrounds may also lack access to hardware to use in order to practise AI skills and undertake personal projects. An Ofcom survey from spring 2020 showed that 9% of households with children had no access to a computer or tablet, and this rises to 21% among the poorest households[22]. Some young people also lack access to networks and mentors that are important for developing skills as well as securing a job. Mentioned in more detail in chapter 4, the widespread expectation that AI professionals will undertake intensive, ongoing self-directed learning once they are in the workforce may also be a barrier to people with fewer resources.

EU Exit

Firms were generally unsure how EU Exit might affect their workforce in future and appeared not to have given this much consideration, although some were concerned about migration of skilled individuals to the EU, or that fewer EU nationals might choose to work in the UK as a result of feeling unwelcome. Some firms were unable to recruit non-UK nationals due to security or travel restrictions.

Challenges faced by women in the workforce

Some women working in AI described negative experiences related to their gender, such as having their ideas ignored, feeling that they did not fit in socially as the only woman in the team, not having senior female role models, or being paid less than equivalent male colleagues. This suggests that some employers could do more to create an inclusive working environment.

Some employers commented that the pace of change in technology may make it harder to return to the workforce after a career break and that this can particularly disadvantage women. The LinkedIn study of the EU AI labour market notes that the gender gap in the AI workforce is narrower among younger generations: women currently represent almost 20% of new entrants in the AI field, whereas women represent only 12% of the AI workforce with 10 years' or more experience. This may be due to more women entering the AI workforce in recent years, more women than men leaving the AI workforce within their first 10 years, or both[23].

Approaches taken to improve diversity

Although employers consistently understood the benefits of a diverse workforce, they had different attitudes towards their role in achieving this. Some employers did not feel there were any barriers they needed to address and regarded the problem as entirely due to the candidate pool.

"The simple reason is that people who apply to our jobs are male."

Employer

Others suspected that there was some unconscious bias in their recruitment decisions, but had not taken actions to address this. Overall, most of the employers interviewed for the qualitative research did not have diversity policies. However, recruitment agencies (which were more likely to work with larger firms) mentioned that they had often been asked by employers to shortlist only certain groups.

[22] https://www.ofcom.org.uk/__data/assets/pdf_file/0030/198138/tech-tracker-internet-and-device-access-children-data-tables.pdf
[23] https://economicgraph.linkedin.com/content/dam/me/economicgraph/en-us/PDF/AI-TAlent-in-the-European-Labour-Market.pdf

"They'll be looking for a software engineer for example, but they will only look at diverse candidates. They won't look at anyone who isn't Black or female… Asian men are not considered 'diverse'."

Recruitment consultant

A minority of employers had implemented actions to increase diversity, such as blind recruitment processes, mixed interview panels, and revising recruitment materials to ensure they were gender-neutral. However, smaller employers that had more informal approaches to recruitment believed that these actions were less appropriate to them as they did not use standardised materials or processes.

Other actions employers had taken included the following, although there were few examples of these actions having a significant effect on their workforce:

- Disseminating job opportunities through a wider range of channels (e.g. using social media);
- Challenging the need for each of the mandatory or minimum requirements in job descriptions;
- Using recruitment agencies known for recruiting women. One recruiter described how they had set up a dedicated resourcing desk for recruiting women in tech. Some employers reported asking for diverse shortlists from agencies (although again, the smaller employers were unlikely to use recruitment agencies);
- Accommodating different working patterns such as 3- or 4-day weeks;
- Setting up diversity and inclusion committees and marking events such as International Women's Day;
- Working with local schools.

"We have done a couple of projects with schools – took a class of 32 people into the business and rotated them around different departments and found who was interested in mechanical and the other teams. For under £10k, we got them to build 5 miniature robots. This is more longer-term thinking and development, not immediately filling skills gaps. And it is starting to pay off – we have employed people from those opportunities to judge natural aptitude."

Employer

Some employers also described their involvement with initiatives such as Women in Tech networking and recruitment groups, Girls Can Code (a non-profit organisation teaching computer science to girls 11-18), and Tech Returners, an initiative to support and re-skill people who have been out of the labour market for a period of time, in which employers can sponsor a place and then hire candidates from the cohort. Tech Returners were seen as an effective way of getting people who already have experience and skills (and are therefore in high demand) back into the workforce.

Although not mentioned by employers or students in this study, there is evidence that the government-funded AI and data science postgraduate conversion courses, announced in summer 2019, are attracting a diverse range of students. Admissions data suggests that around 40 per cent of the total students enrolled are women, a quarter are Black and 15 per cent are students who are disabled[24].

[24] https://www.officeforstudents.org.uk/news-blog-and-events/press-and-media/new-analysis-shows-postgraduate-courses-are-increasing-diversity-in-ai-and-data-science/

03

Current skills and skills gaps

03 Current skills and skills gaps

This chapter explores the AI skills that organisations need and the extent of current skills gaps. AI skills gaps exist when individuals working in or applying for roles lack particular, necessary skills. Skills shortages occur when employers are unable to recruit and retain staff with the necessary skills. The chapter looks at the specific nature of skills gaps and skills shortages (both technical and non-technical), as well as AI knowledge among senior management. It then considers the challenges employers face in bridging the skills gaps and how they address these challenges.

Wider context from other research

In early 2020, Ipsos Belgium conducted a survey of 9,640 enterprises across 27 EU countries, Iceland, Norway and the UK about adoption of AI technology[25]. In the UK, one-third (37%) of employers cited the ability to hire new staff with the right skills as a challenge or barrier to their company using artificial intelligence, and over a quarter (28%) identified a lack of skills among existing staff as a barrier. These figures are lower than for the EU overall, where around half of employers reported these issues (57% and 45% respectively). This could be due to a higher supply of talent, but other figures from the report suggest that lower demand is also playing a role, with levels of adoption of AI technology lower in the UK than in the EU overall.

According to a recent analysis by McKinsey[26], the UK is in the top quartile of countries on AI readiness, with strong policy and academic foundations, yet faces a shortage of people with advanced digital skills, which is at odds with its strengths in academia. Similarly, research by Microsoft[27] found that more than a third (35%) of UK leaders believe there will be an AI skills gap in the next 2 years, and 28% believe the UK is already experiencing one (compared to 24% of leaders globally).

In recent research carried out by the Learning and Work Institute[28], 37% of employers reported skills gaps and 41% reported skills shortages in relation to advanced digital skills more widely. These figures are somewhat lower than those found in our research, which may reflect the focus of this research on a more specialist skillset and employers identified as needing this skillset.

The quantitative survey examined the prevalence of skills gaps and shortages by asking firms whether their ability to meet their business goals in the previous 2 years had been affected by a lack of knowledge or skills, either among job candidates or their existing employees. The question asked about both technical and non-technical skills and this chapter considers both in turn. A greater proportion of employers (49%) had been affected by a shortage of candidates with the right technical skills, compared to those reporting they had been affected by a shortage of non-technical skills (32%). However, in qualitative research employers stressed the importance of non-technical skills and their need for employees to possess the right mix of both kinds of skills.

Prevalence of technical skills gaps and shortages

Survey findings indicate that technical skills gaps were a concern for many firms. Around one-third (35%) of firms said that existing employees lacking the technical skills they need had, at least *to some extent*,

[25] https://ec.europa.eu/digital-single-market/en/news/european-enterprise-survey-use-technologies-based-artificial-intelligence
[26] Artificial intelligence in the United Kingdom: Prospects and challenges. https://www.mckinsey.com/featured-insights/artificial-intelligence/artificial-intelligence-in-the-united-kingdom-prospects-and-challenges
[27] AI Skills in the UK: https://info.microsoft.com/rs/157-GQE-382/images/AI%20Skills%20in%20the%20UK%20report-SRGCM3647.pdf
[28] https://learningandwork.org.uk/resources/research-and-reports/disconnected-exploring-the-digital-skills-gap/

prevented them from meeting their business goals. In 8% of cases, they felt this had affected them *to a great extent*. A comparison with the wider national picture suggests that skills gaps are more of an issue in AI than in the workforce as a whole. In the Employer Skills Survey[29], 13% of employers in the UK reported skills gaps (defined as 'at least some of their staff not being fully proficient at their job').

In the survey, a higher proportion (49%) said that business goals had been affected, at least *to some extent*, by a lack of job applicants with the required technical skills, with around a fifth (19%) saying this had prevented them *to a great extent*. This indicates that firms see skills gaps as more of an issue when it comes to recruitment, rather than for existing staff. This pattern was even more pronounced in the cyber sector, where a similar proportion of firms identified issues with existing employees (32%) but a higher proportion said that a lack of technical skills in job applicants had affected them meeting their goals (59%)[30].

Combining these results indicates that 62% of firms had faced problems with AI technical skills gaps, either among existing staff or among job applicants, similar to the proportion in the cyber sector (64%). Around a quarter (24%) had faced more acute problems, saying that such skills gaps had prevented them *to a great extent* from achieving their business goals. This is similar to the cyber sector where the figure was 25%.

Types of technical skills gaps

Firms reported a range of specific technical skills gaps, as shown in Figure 4. The results illustrate that there was no single technical area where skills gaps were seen as more prevalent. Instead skills gaps were relatively high (mentioned by at least half of firms) in each of the following areas: people's understanding of AI concepts and algorithms (55%); programming skills and languages (52%); software and systems engineering (52%); and user experience (51%).

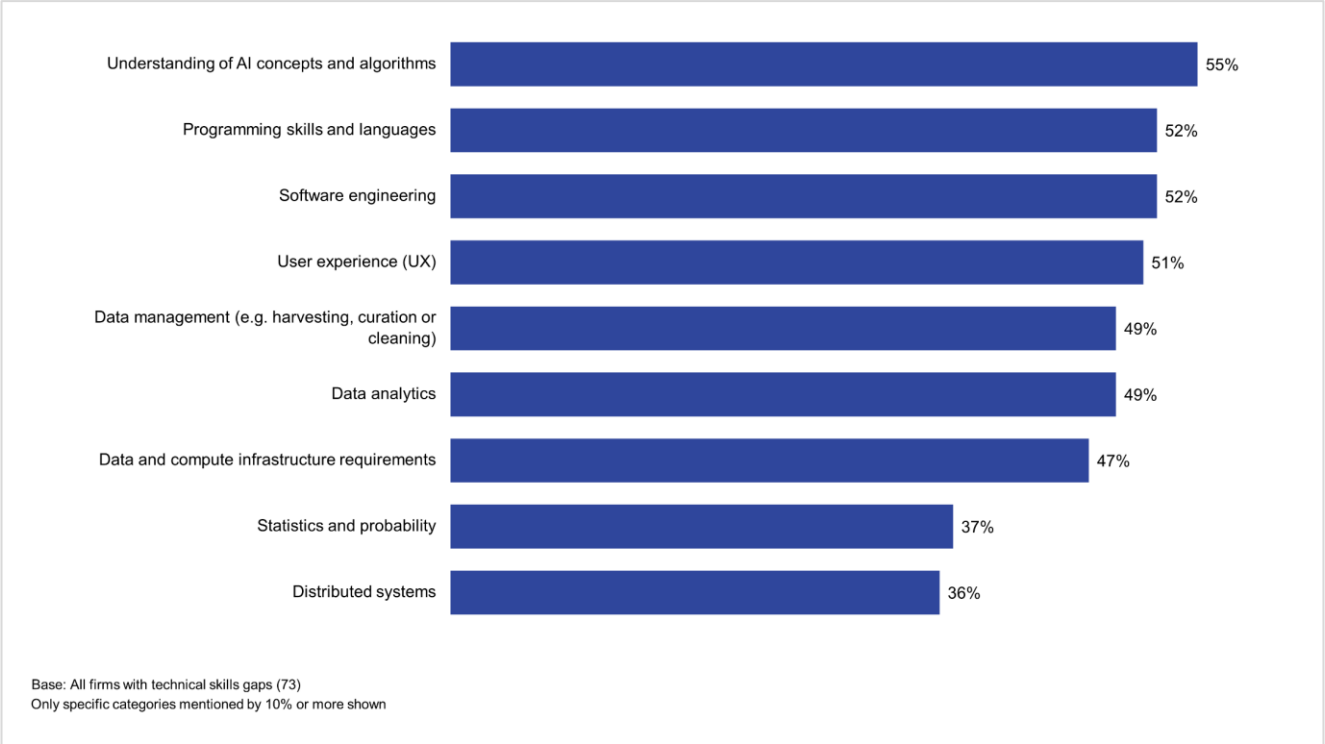
The Employer Skills Survey highlighted a lack of complex analytical skills, particularly in the Information and Communications and Public Administration sectors, although the prevalence of this skills gap in the employer population had declined slightly in recent years[31].

[29] Employer Skills Survey 2019 research report, page 44. https://www.gov.uk/government/publications/employer-skills-survey-2019-uk-excluding-scotland-findings

[30] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/959166/19-039938-01_Cyber_Security_Skills_Infographic_Digital_Cyber_Sector_FINAL__1__V2.pdf

[31] Employer Skills Survey 2019 research report, page 37. https://www.gov.uk/government/publications/employer-skills-survey-2019-uk-excluding-scotland-findings

Figure 4: Percentage of firms that have skills gaps in the following technical areas, among those that have identified any skills gaps



In the qualitative interviews, there was a broad distinction between needing staff who were highly skilled in specialist fields or applications, and less specialist staff who could implement existing technologies. Both types of staff were needed, but a number of employers stressed the importance of deep learning in their specialist roles, going beyond algorithms and 'low-level' AI.

"We need people coming through the university system to learn from first principles how to create deep learning, neural network systems, rather than relying on off-the-shelf systems that are available through the big US companies."

Employer, micro-business

Another point made by employers in the qualitative interviews was that employees were often trained only in specific fields or applications, leading to a lack of 'joined-up' knowledge. For example, one respondent felt that few staff were trained in both Python and Java, while another respondent said they struggled to find people who had the right combination of software and hardware skills. It is worth noting that some recruiters thought employers could have unrealistic expectations of the combination of skills that employees could have, for example both back-end and front-end skills or multiple programming languages that are seldom found together.

Prevalence of soft skills gaps and shortages

As well as technical skills gaps, the survey indicates that many employers face issues with non-technical skills. One-third (32%) of surveyed firms said that their business goals had been affected, at least *to some extent*, by job applicants lacking non-technical skills such as communication, leadership or management skills. In 9% of cases, they said they were affected *to a great extent*. Similarly, one-third (34%) of firms said that existing employees lacking these non-technical skills had affected their business goals, and in 4% of cases this had been *to a great extent*. These figures are similar to those in the cyber

sector (30% said job applicants lacking non-technical skills had prevented them to some extent from meeting their business goals).

Comparing these to the results above on technical skills, suggests that a lack of technical skills was perceived to be more of a problem than a lack of soft skills when it comes to job applicants, but that both types of skills were seen as equally relevant in relation to existing employees. This pattern is confirmed when looking at the reasons for hard-to-fill vacancies (see Chapter 5). While a range of reasons were given, the most common was a lack of technical skills and knowledge among applicants.

Types of soft skills gaps

The quantitative survey examined the types of soft skills gaps found in employees working in AI-related job roles. It found that nearly all firms thought these employees were good at thinking critically and logically, and in their commitment to self-learning. However, Figure 5 shows some gaps in awareness of potential bias around the organisation's use of AI, and awareness of privacy or ethical issues. Awareness of potential bias in the use of AI was viewed more positively in firms whose core business was AI than in firms where this was not their core business (75% and 58% respectively described this as good).

The survey found that skills gaps were more widespread in terms of employees' commercial awareness (only 54% of employers rated staff as good in this respect). This was echoed in the qualitative interviews, where many employers felt new graduates lacked practical experience and so were not always able to apply their training to real world situations. These staff were seen as focusing more on the 'concept' than the 'execution'.

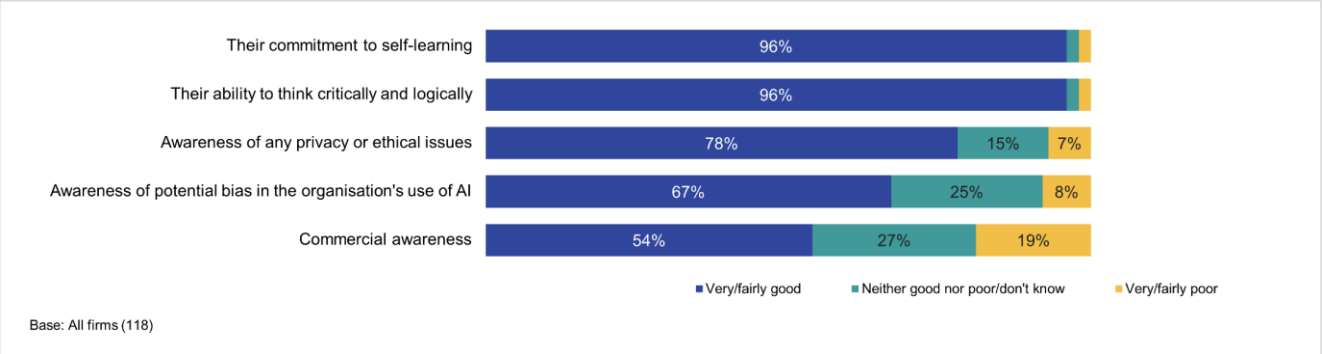
"Trying to get our new employees to quickly work out what needs to be done in order to keep a customer happy and where they can begin not to fulfil all the things that they've been taught about keeping good documentation... sometimes they should prioritise getting something out to the customer ... it's definitely a gap in expectation from when we hire them".
Employer

In particular, some employers and recruiters highlighted the importance of communication skills, either with internal colleagues, management or clients.

"We need people that can communicate across the divides and channels, which isn't always perfectly a common skill in data science in general"
Employer

"Some of the positions they are employing for are quite senior so they need to be able to talk to the business, they need to be able to articulate what they are doing to other people"
Recruiter

Figure 5: Rating of soft skills among employees in AI-related job roles



AI knowledge at management level

Firms whose core business was not AI were asked about the awareness of AI-related issues among senior management. Firms reported that their organisation's senior management had a good understanding of how AI is being used within the organisation (91%), of staffing needs (89%) and of privacy or ethical issues (79%). However, only two-thirds (65%) thought that senior management had a good awareness of potential bias in the organisation's use of AI. As seen above, some of these firms also felt that employees working in AI-related job roles had limited awareness of potential bias in the use of AI; this suggests that, among firms whose core business is not AI, this may be a skills gap across the organisation.

In the qualitative interviews, most employers felt that their organisation's senior management had a good knowledge of AI, although in some cases there were limitations, for example in appreciating the potential benefits of AI and understanding the challenges that differentiate AI from other IT projects. There were also concerns that the organisation's ability to attract and retain good AI staff would partly depend on the engagement of senior management with AI projects and their results.

"Senior management are used to a type of data and insight, around performance and KPIs … They're less used to exploratory analysis like predictive analytics … For me, it's about trying to show people that there's more to it than what they're used to … They don't understand what's possible."

Employer

"Whether we can attract data folk depends on whether [senior managers] will act differently as a result of what they've been told by these insights."

Employer

Some recruiters and training providers also felt that managers needed to engage more with AI and new technology, rather than rely on employing people to develop and use the technology. Stakeholders taking part in the roundtable also identified a need for more people in the workforce with the ability to understand AI, even if these people did not develop or directly use AI themselves.

"Yes - we need more people that can do AI, but we also need more people that know how to manage AI. These are two hands of the same person, and you need both".

Training provider

Reasons for AI skills gaps and shortages

This section examines the reasons for the existence of AI skills shortages in the market.

Recent reports are unanimous that, globally, the gap between demand and supply is significant and growing. Qualitative interviews with employers, students and recruiters all highlighted the high demand for skilled AI professionals which had out-stripped supply. This imbalance between demand and supply, particularly for more senior and experienced professionals, resulted in high salaries for these roles. Small businesses and public sector organisations reported that this made it difficult for them to attract or retain staff.

Most interviewees in the qualitative element expected the demand for AI skills to continue to outstrip supply. This was in spite of a predicted increase in the supply of these skills, due to increasing interest in and awareness of AI in society, university courses increasing in number and becoming more relevant to employers, and the likelihood of a greater emphasis on AI in school education in the future. There has recently been a significant increase in the number of courses offered in AI-related subjects: in 2020, universities offered 717 undergraduate courses in AI, robotics or data science, compared to 122 such courses in 2019. Likewise, the number of postgraduate courses increased from 189 to 342 over the same period[32].

"There are many courses now that are generating graduates with specific skills in AI and machine learning. In the past it used to be software engineering, and someone may have taken a module".
Employer

Research from the Learning and Work Institute shows that the number of people studying computer science at university has grown over the last five years, particularly at postgraduate level and particularly among women. However, the report also noted some concerning trends in less advanced digital qualifications: the hours spent teaching ICT subjects in school and enrolments in ICT-related courses at FE level have both declined in recent years. While more young people are studying computer science at GCSE since its introduction in 2014, this has been outweighed by a large decline in the numbers studying IT, so that overall more young people are leaving school without a digital skills qualification. This may create problems for the "skills pipeline" if young people lack the digital skills to move into a career in AI later in life[33].

In the survey, two-thirds of firms (67%) expected that the demand for AI skills in their organisation was likely to increase in the next 12 months, partly as a result of COVID-19 as well as other expected changes. This corroborates modelling undertaken by Burning Glass Technologies in 2019, which suggested that demand for data analysis skills (including AI) would increase by 33% over the period 2018-2023, and that demand for deep learning skills would increase by 192% over the same period[34]. The job vacancies analysis later in this report (see chapter 6) shows that despite the challenges faced by employers in 2020 due to the COVID-19 pandemic, 2020 was the highest year to date for the number of online job vacancies related to AI and Data Science.

On COVID-19 specifically, some employers in the qualitative interviews had seen an increase in business opportunities because of the pandemic due to the more widespread use of digital technology.

[32] Data from https://digital.ucas.com/search
[33] https://learningandwork.org.uk/resources/research-and-reports/disconnected-exploring-the-digital-skills-gap/
[34] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/807830/No_Longer_Optional_Employer_Demand_for_Digital_Skills.pdf

For example, one employer noted an increased need for remote products in audio conferences, while another felt the pandemic had raised the profile of AI.

"COVID has probably helped us from a data analytics and AI perspective. Insight has become more valued by senior leaders and therefore there's more of a push around how we do this better and come together to get the most out of our data."

Employer

In this context, it is useful to reference recent research by Microsoft[35], which found that more than one-third (35%) of UK business leaders believed there would be an AI skills gap in the next 2 years, and 28% believed there was one already (compared to 24% of leaders globally).

In the qualitative interviews with employers, there was a recognition that AI is a fast-moving world, and this makes it difficult for organisations to keep up-to-date in terms of skills, training and recruitment.

In some qualitative interviews, employers discussed the impact of Brexit on skills gaps. While some employers thought the impact of Brexit was uncertain, others perceived a negative impact, making it more difficult to collaborate with European colleagues and affecting recruitment from EU countries.

"Data science is such where an applicant can often choose where they want to go, more than the employer chooses who they want...Brexit has had a bit of an impact on that desirability."

Employer

Impact of skills gaps on employers

The qualitative interviews highlighted the impact of skills gaps on employers. Some employers said that it restricted or slowed their growth in terms of revenue and business size, as they did not have enough staff with the right skills to move projects forward quickly. One respondent felt that it limited their ability to do bigger, multi-faceted projects, as they didn't have all the necessary skills in the workforce and weren't easily able to recruit people with these different skills. Other employers felt that skills gaps stifled innovation and future opportunities.

"A failure to recruit good people is self-fulfilling. You don't know how useful data could be and don't invest further in data and can never get off the ground".

Employer

AI firm Peltarion surveyed UK and Nordic firms about the impact of the AI skills shortage on their businesses. In the survey "83% of the AI decision-makers surveyed said a deep learning skills shortage is hampering business productivity and competitiveness. 49% said AI projects had been delayed due to the gap, while 44% said the shortage was preventing further investment in the technology."[36]

Approaches taken to address skills gaps (including use of Government programmes)

Firms vary in their use of outsourcing for AI work. In the survey, just over half (54%) of firms had used external contractors for work involving AI models, tools or technologies. For comparison, the Cyber

[35] Microsoft report 'AI Skills in the UK' page 7
https://info.microsoft.com/DE-DIGTRNS-CNTNT-FY21-07Jul-24-AISkillsintheUKreport-AID-3013784-SRGCM3647_01Registration-ForminBody.html#:~:text=52%25%20of%20UK%20employees%20are,AI%2C%20compared%20to%2038%25%20Globally

[36] https://www.techerati.com/news-hub/uk-businesses-ai-skills-talent-gap-shortage-deep-learning-2020/

Security Skills survey found that 42% of businesses (in the business population as a whole) outsource 'any aspects of cyber security'.

Employers in the qualitative interviews also said they outsourced work to contractors or freelancers. Some organisations were content to use this approach and found it worked well, while others struggled to find suitable contractors to outsource to. This was often because potential contractors lacked complementary skills, had limited understanding of the organisation's activities or commercial needs, or faced language barriers.

Other employers avoided contractors, by building internal capability and developing existing staff. For example, some employers had changed their approach internally, by making use of technology that staff were more familiar with or offering training or knowledge-sharing among existing staff.

Some firms tried to mitigate the impact of skills gaps through partnership arrangements with other organisations or with universities. Doctoral training centres were seen as particularly valuable academic collaborators as they were able to offer a range of partnership arrangements.

"[Doctoral training centre] knew what they were doing, they were very pragmatic and able to operate in quite a business-like way - delivered things on time and to spec which is unusual for universities. The leadership had a lot of experience in business as well as in the technology. That meant there was a one-stop shop you could go to with pretty flexible partnering - direct contracting, joint partner, did work for free for someone's PhD experience as long as it could be published. We used all 3 of those models and that made it a really good partner."
Employer

Outsourcing within the UK still creates and supports jobs in the UK AI labour market. However, some employers preferred to work with contractors outside the UK due to lower costs or the existence of a wider pool of suitably qualified people (particularly in terms of mathematics skills). In other words, these employers felt unable to satisfactorily meet their needs for AI skills from the UK workforce.

04

Training

04 Training

This chapter explores organisations' training needs for their staff working with AI, and the skills needs they were attempting to meet through training; the extent and nature of training undertaken; and the challenges and barriers that organisations and individuals faced around training. It also covers training and knowledge relating to ethics in AI.

Training needs

Many employers did not expect to provide formal training to their staff in the technical aspects of AI, commenting that staff should already have the appropriate technical skills when recruited, and take responsibility for keeping these up to date. However, some employers provided training on the specific tools used by the organisation.

As discussed in the chapter on recruitment, some employers took a different approach and hired less-experienced people or people with relevant domain knowledge, with a view to training them in practical AI skills. This was typically done using online courses or via partnerships with training providers. In particular, some local authorities described running successful apprenticeship programmes to train existing staff with a background in digital or data skills.

"We're going to struggle to recruit these people, we probably have people working with data already quite significantly within the authority and although they're working with data they're probably not trained to work with data so, so we'll train them to do it and that will make better use of our data... bring them up to a skilled level so they can understand... how we would use AI to interpret that."

Local authority

Employers discussed the need for staff to be trained in non-technical skills such as sales, communication, and commercial awareness, so that they could explain the technology in a non-technical way to colleagues or clients.

"[Employee] understands the way to build things and the way to present them in the best way for a particular person or group of people. She's got the ability to get the information out of the database, a data science understanding but her real skillset is being able to present what the data tells her."

Employer

"Technical staff can find it quite difficult to give a talk that's not excruciating technical detail and doesn't focus on the stuff that isn't working."

Employer

Training undertaken by those in AI roles

Prevalence of training

The majority of firms reported that their AI staff had undertaken some training in the last year, although a significant minority had not. Three in five surveyed firms (62%) reported that employees in AI roles had undertaken internal or external training in the last 12 months to improve their knowledge and skills. This is similar to the proportion of employers in the economy overall who arranged or funded training for their staff in the last year (61% in 2019)[37], and higher than the proportion of firms who had their staff in Cyber roles undertake training in the last year (24%)[38]. This is shown in Figure 6.

Figure 6: Proportion of firms with employees that had received training in the last 12 months, across 3 different surveys - % saying yes

Prevalence and views of formal training

Many employers did not offer formal training to staff on the technical aspects of AI. Nearly all employers (99%) who reported that their staff received training in the last year said that at least some of this training was related to technical knowledge and skills. However, the qualitative research suggested that much of this training was informal and 'on-the-job' rather than part of a formal training programme. Employers provided mainly on-the-job training for many reasons:

- The expectation (see above) that staff should not need this training. Employers also felt that technical skills, such as building machine learning models, were better learned in a practical way.

"Most of the people in IT are incredible self-learners because they have to be to keep up with the technology. Learning by doing and working with other people is the best way to learn."
Employer

- Some employers reported that they could not afford the cost of training, or the cost of taking staff away from their main role.

- The cutting-edge and rapidly changing nature of the knowledge required meant that a formal training programme might not exist or be appropriate.

[37] Employer Skills Survey, Department for Education, 2019: https://www.gov.uk/government/publications/employer-skills-survey-2019-uk-excluding-scotland-findings (accessed 15th March 2021)
[38] https://www.gov.uk/government/publications/cyber-security-skills-in-the-uk-labour-market-2020

"Every problem requires us to train ourselves on how to solve it, as it's unique and we haven't done it before."

Employer

- Being unable to judge the quality and suitability of the training available.
- Some employers were sceptical about the quality of external training, for example believing that trainers might lack sufficient industry experience.

Despite these factors, 63% of firms that provided training reported that at least some of the training undertaken by their staff was developed outside of the organisation – although this figure covers all types of training, not only technical skills. Employers valued partnerships with universities, and 31% of employers who offered training reported that at least some of this was developed or delivered in partnership with a university or research institute.

In the qualitative interviews, some employers reported that they would be happy to allow staff to attend external training courses that interested them, at the expense of the firm. Students were also receptive to this and reported that they were attracted to prospective employers that offered this. However, employers who offered this opportunity reported that take-up was low.

Other employers only made use of formal, external training in relation to 'soft' skills, such as project management, team management or communication skills. This was seen as particularly useful to more junior staff with less experience of the workplace but could be prohibitively expensive for small businesses. Some firms commented that they would be more likely to offer this type of training as the business grew. Few had a graduate training programme (11%); but this may reflect that the majority of firms taking part in this research had fewer than 50 employees.

Self-directed learning and online courses

Employers and employees alike stressed the importance of self-directed learning, and shared an expectation that employees needed to take responsibility for keeping their skills up-to-date in their own time, particularly to keep abreast of advances in models, tools, and computer infrastructure (this was also identified in the rapid evidence review). Surveyed firms reported that employees in AI roles were committed to self-learning (96% reported their employees were typically good at this). Employers commented that because of this need for self-learning they needed to recruit people with the right foundation skills who would be able to pick up new concepts more easily.

"We push the edge of the technology all the time, so people are always learning on the job."

Employer

Students and employees described the ways in which they kept their skills up-to-date, for example by reading recent research papers or undertaking personal projects for fun and to demonstrate their range of skills to employers. Some course providers offered projects with real-world (and therefore incomplete) datasets in order to facilitate this.

"There's no better way to learn about these applied methods than to get your hands dirty. So, no amount of reading a textbook or even having a fantastic professor lecture at you is really going to make this stuff click. It's not until you have a question you want to answer, and you try to answer it yourself. That's when you start to see what works, what doesn't work, what you need to learn more about."

AI professional

Around a fifth of employers (22%) reported that at least some of their staff had completed a Massive Open Online Course (MOOC). In the qualitative interviews, students also described taking online courses alongside their studies. A 2019 Royal Society[39] report into data science skills suggests that these courses could be "a vehicle for developing skills ranging from informed users through to expert data engineers." However, employers and employees alike believed that online courses were useful largely as a basic starting-point, and that they could not impart in-depth understanding of either specific tools and datasets, or of the underlying mathematical and statistical theories behind them.

"As introductions, they are very good, but we have to go in-depth by ourselves."

Aspiring AI professional

Several students and employees reported that the range of free courses available could be daunting. One student had found that paid-for courses which included an element of mentoring and support, had been more helpful than basic free courses.

This expectation that workers in AI will undertake intensive, ongoing self-directed learning may be problematic for the diversity of the workforce, if this is expected to be done at an individual's time and expense. Some people may not have the time needed for this because of health or caring responsibilities and others may not be able to afford the cost of suitable hardware or paid-for courses.

Other learning opportunities

The qualitative research highlighted many examples of employers fostering a culture of learning. Informal training opportunities offered by employers included mentoring, reading groups and journal clubs, free books, and talks from invited speakers. Employers encouraged staff to attend AI Meetup groups or organised team learning events themselves, setting their staff challenges which the team would divide amongst themselves and then report back on what they had learned, or away-days where team members presented about research they had read recently.

Training in ethics

There is a consensus in the AI skills literature that courses should include training in ethics in order to ensure that applications of AI do not violate people's right to privacy or introduce bias into their models. Recent publications from the Royal Society[40] and the British Computer Society[41] have emphasised this, arguing that ethics should be embedded throughout the curriculum and as part of a professional framework.

Only a quarter of surveyed firms whose employees had undertaken training reported that they offered training on ethics in AI (24%). In the qualitative research, many employers explained that they did not offer any formal training related to ethical issues. However, 43% of surveyed firms offered training

[39] https://royalsociety.org/-/media/policy/projects/dynamics-of-data-science/dynamics-of-data-science-skills-report.pdf
[40] https://royalsociety.org/-/media/policy/projects/dynamics-of-data-science/dynamics-of-data-science-skills-report.pdf
[41] https://www.bcs.org/media/3047/ethical-ai.pdf

specifically in bias in the use of AI, and 67% believed their employees were typically well-informed on this. GDPR training also appeared to be relatively common (from the qualitative research), perhaps because the requirements of GDPR compliance are more easily defined and applied than broader ethical considerations, and the penalties associated with a GDPR breach are costly to firms.

Employer approaches to ethics varied depending on the application of AI. In some areas such as medicine, employers felt confident that formal ethical practices were already well-embedded and that there was an established consensus about how these should be applied. However, the principles of medical ethics may not be adequate for addressing the full range of ethical challenges posed by AI.

Some other employers believed ethical issues were largely irrelevant to them as there was limited potential for the AI they used to cause harm or demonstrate bias – for example, companies using AI in manufacturing or engineering. However, some employees pointed out that there are wider ethical implications of AI use, such as the very high energy consumption required by some models, which a good-quality ethical framework would include.

Employers that wanted to instil good ethical practice among their staff typically did so through regular discussion of ethics (sometimes by means of a discussion group or reading group) and considering ethics in their everyday working practices, encouraging staff to challenge one another and to be transparent about their work. These employers believed this approach was more effective than requiring staff to complete formal training, which they saw as a 'tick-box' exercise.

"For me, ethics is fundamentally an issue of your heart, rather than your training. People are either unscrupulous or they're not."

Employer

Some AI professionals, students and training providers were concerned about apparent significant variation between employers in their awareness of ethics, and likewise variation in online AI courses in terms of the extent to which this was included. These interviewees remarked that ethical standards in AI currently appeared to be up to employers' discretion, and argued that ethical standards in AI should be more formally mandated and regulated to mitigate the risks that arise from this. The work of the recently launched UK Cyber Security Council to create a code of professional ethics for cybersecurity could be used as a model for this.

Challenges around training and future support needs

Given the informal and on-the-job nature of training, employers reported that it had been more difficult to maintain this whilst working remotely. Some employers noted that this discouraged them from recruiting junior staff as it would be more difficult to supervise and train them.

When asked what support would be helpful with regard to training specifically, employers cited encouragement for more links between academia and industry, such as the AI Foundry in Manchester[42] which links 4 universities to local small and medium-sized businesses. Employers also wanted more opportunities for cross-disciplinary and multidisciplinary learning, for example multidisciplinary Masters' degrees combining AI with subject knowledge, in preference to qualifications narrowly focused on AI. Other suggestions included:

[42] https://gmaifoundry.ac.uk/about/

- Short courses for managers and procurement teams to understand AI (especially in the public sector);
- Training opportunities specifically for job-seekers with STEM backgrounds, echoing a recommendation by Hall and Pesenti that universities should develop continuing professional development courses for people with STEM qualifications[43];
- Publicising existing opportunities to learn AI skills – for example, the increasing number of short courses offered by UK universities and commercial providers;
- Fostering communities of AI professionals within the public sector;
- Further financial support for continuing to employ newly qualified apprentices;
- Providing small businesses with opportunities to undertake interesting projects for the public sector, such as the Small Business Research Initiative or GovTech Catalyst;
- Grants to help small businesses get up to speed and understand the implications for them of changing regulations (such as GDPR).

The need to develop skills among adults and the existing workforce is corroborated by findings from the rapid evidence review, which suggests that with 80% of the UK's 2030 workforce already in the workforce today, reskilling the existing workforce will be the major challenge[44]. Encouraging young people to work in AI will not by itself be capable of meeting the demand for AI skills.

[43] Growing the AI industry in the UK. Hall and Pesenti, 2017. https://www.gov.uk/government/publications/growing-the-artificial-intelligence-industry-in-the-uk

[44] https://industrialstrategycouncil.org/sites/default/files/UK%20Skills%20Mismatch%202030%20-%20Research%20Paper.pdf

05

Recruitment and retention

05 Recruitment and retention

Context

This chapter deals with organisations' approaches to recruitment and retention. It examines the prevalence of vacancies that are hard to fill, the nature of these vacancies, and the barriers employers face in filling these vacancies.

Recruitment and vacancies

Two-thirds of firms in the survey (66%) had tried to recruit someone with the knowledge or skills to work with AI models, tools or technologies in the last 2 years. This was similar to the proportion of cyber sector businesses (68%) that had tried to recruit someone in a cyber role over a 3-year period.

As seen in Chapter 1, most firms in the survey were small (95% had fewer than 50 staff), with relatively small AI teams (the median number of employees specifically using AI models, tools or technologies was 4). Most firms that had vacancies for AI roles said they had fewer than 10 vacancies in the past 2 years (85%), and the average number of vacancies was 6. According to the Employer Skills Survey[45], the Information and Communications sector has a relatively high density of vacancies (vacancies as a proportion of the number of employees).

Recruitment approaches

The unprompted list of the most common recruitment methods used to find candidates for AI roles is in Figure 7.

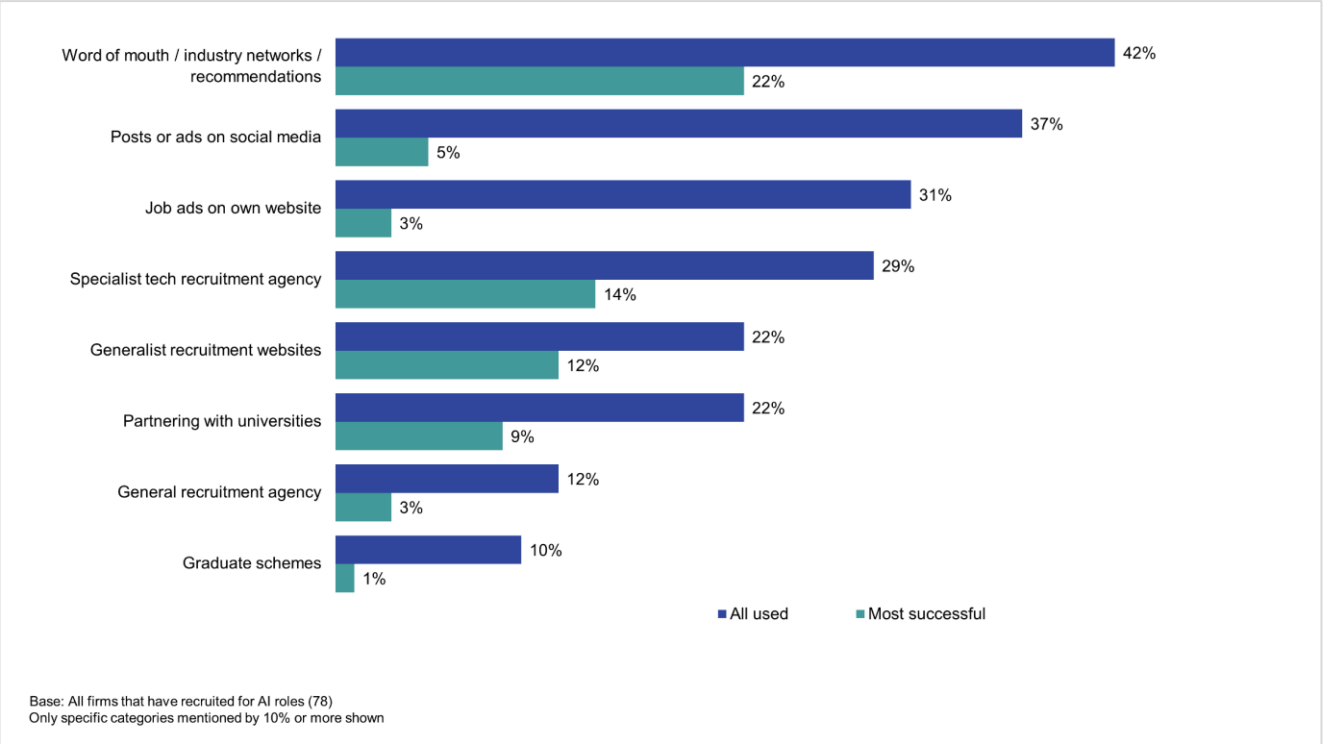
The use of informal recruitment channels was more common than more formal methods: 2 in 5 (42%) employers had used word of mouth or industry networks, and 1 in 5 (22%) had partnered with a university. Online channels were also widely used; over a third (37%) had posted advertisements on social media, and 31% had posted on their own websites. Just over a third (36%) had used recruitment agencies.

Word of mouth was also most often identified by employers as the best recruitment method; where firms had used multiple channels, 22% (out of 78 firms) said word of mouth had been the most successful, followed by specialist recruitment agencies (14%) and generalist recruitment websites (12%). The findings are broadly reflective of the Cyber sector, where the most commonly used channels were specialist recruitment agencies and word of mouth recommendations.

These recruitment channels were also similar to those used in the wider employer population (as seen in the Employer Skills Survey), where the most common recruitment methods were word of mouth or personal recommendations, adverts placed on the company's own website and adverts placed on social media.

[45] Employer Skills Survey 2019 research report, page 28.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/955172/Employer_skills_survey_2019_research_report.pdf

Figure 7: Percentage of firms with vacancies in the last 2 years that have used the following recruitment methods (unprompted)



In the qualitative interviews, recruiters discussed the channels used for recruitment. One recruiter felt that the 'academic, university route' works well at junior roles, but that networking is more important for more senior positions. Several recruiters and employers stressed the importance of social media, especially LinkedIn.

"LinkedIn is incredibly important now. It's the big social media tool for recruitment."
Recruiter

Employers in the qualitative interviews had positive experiences of using word of mouth or networking. This was seen as being cheaper than using a recruitment agency or assisted searches, while also reducing risk, as personal referrals were more likely to result in a 'good fit' with the employer. One firm used a service which pooled runner-up candidates from similar firms' recruitment processes, so that candidates had effectively been "vetted" by another business.

In addition, once candidates had been selected for interview, some employers set skills tests to check they met their requirements: these tests tended to be focused on new entrants to the workforce. Other employers used current team members to assess the candidate's skill level.

Hard-to-fill vacancies

Among firms that had vacancies for AI roles in the previous 2 years, around two-thirds (69%) said they had at least one vacancy that was hard to fill. This is somewhat higher than the equivalent proportion of

cyber sector firms (57%) and appears higher than in the Information and Communications sector as a whole (39% in the 2019 Employer Skills Survey[46]).

The bulk of hard-to-fill vacancies were among middle-management and other senior roles, which require 3 or more years of experience. Specifically, 56% said they had hard-to-fill vacancies at senior level, 35% at management or principal level, and 15% at director level or higher. One-third (33%) had hard-to-fill vacancies at graduate or entry-level.

Four in five hard-to-fill vacancies (79%) required at least a Bachelor's degree, and the majority required either a PhD or Master's degree (33% in each case).

However, this is somewhat at odds with findings from the qualitative research, where employers typically commented that experience and demonstrable skills were more important to them than formal qualifications. In fact, one employer said that their firm avoided PhD candidates, as they tended to demand too high a salary and were hard to retain. However, in practice, the majority of people working in AI roles had an advanced degree (Master's or PhD), as seen in Chapter 4. Recruiters noted that large, established organisations were particularly likely to be focused on qualifications, and that individuals who had attended prestigious universities were particularly easy to place.

Employers can broadly be divided into 3 groups in terms of the skills and qualifications that they prioritised when recruiting for AI roles. In the first group, employers prioritised candidates with advanced degrees in relevant subjects. As well as recruiting candidates with AI or computer science qualifications, some employers particularly valued candidates with qualifications in fundamental sciences (such as maths or physics), as these provided skills in problem-solving that could be applied to working in AI.

Secondly, there were some employers, usually smaller organisations, that focused recruitment on junior roles or less experienced people. The main driver was not being able to afford higher salaries, but there were other advantages, such as being able to train and develop people internally and not having people who were 'set in their ways'. However, these employers recognised that they would experience high staff turnover as a result of this approach (see section below on retention).

"We do spend a significant amount of time in educating people who don't stay long and then leave, but in order to get the staff we have to offer that because they come for the learning experience."

Employer

Thirdly, many organisations had roles requiring both AI skills and domain-specific knowledge (e.g. law, engineering, local government). While candidates with both were highly prized, this was rare to find. These organisations commented that in their experience it had worked better to recruit people with higher levels of domain understanding and develop their AI skills, rather than recruiting skilled AI professionals and building up their domain knowledge.

Chapter 3 described how employers often look for a range of technical skills in their employees. When discussing hard-to-fill vacancies, employers stressed again that they were often looking for a range of skills in candidates, and this range could be hard to find. This often included a combination of technical

[46] Employer Skills Survey 2019 data tables, figure calculated from Table 1. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/925670/ESS_2019_UK_excl_Scotland_Data_Tables_Controlled_v03.01_FINAL.xlsx

and non-technical skills, including communication skills, personality, and a 'cultural fit' with the organisation.

"A big thing for us is good communication...and the ability to work in teams effectively ... and to be an asset to the culture of our company...and somebody who thinks innovatively, who can think for themselves and add value by bringing ideas."

Employer

"Attitude is incredibly important to the success of the business: the company has to hire people who are hungry to learn and to make something happen, rather than those who have lots of AI training."

Employer

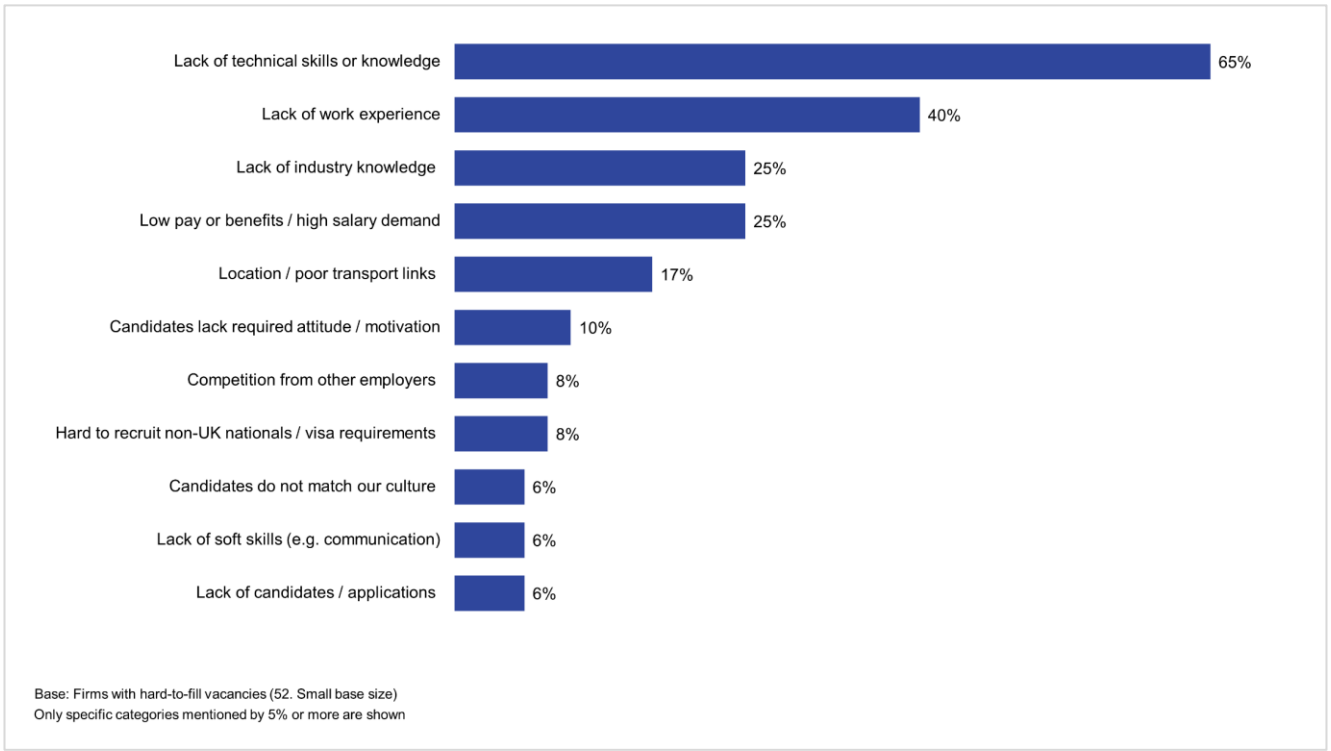
Barriers to filling vacancies

Chapter 3 looked at the main reasons for skill gaps in the market as a whole, such as the issue of supply and demand. This section looks more specifically at the difficulties employers faced in filling vacancies.

As Figure 8 shows, among firms with hard-to-fill vacancies, the single most common reason given (without prompting) was that applicants lacked technical skills and knowledge (65%).

Firms also mentioned broader skills and experience, such as lack of work experience (40%) and lack of industry knowledge (25%). This ties in with the findings on skills gaps (Chapter 3), which identified poor commercial awareness among employees working in AI-related job roles. Other common reasons for hard-to-fill vacancies were salary demands being too high (25%) and location or poor transport links (17%).

Figure 8: Most common unprompted reasons for having hard-to-fill vacancies



In the qualitative interviews, businesses outside of major cities believed they faced strong competition from firms elsewhere, such as those based in London. This could be a particular problem if the organisation was not based near to a university offering relevant courses. As seen in the Chapter on 'Working in AI and Data Science', applied AI roles tend to be located in big cities and research AI roles tend to be based around universities.

While some recruiters and employees believed that these geographical barriers would diminish due to an increase in home-working and flexible working, some businesses continued to prefer their employees to work from the office to facilitate shared learning and supervision of junior employees. This may suggest that geography will continue to be an issue particularly in relation to recruiting more junior staff.

Some graduates said they had considered working abroad, particularly in the USA. Although there were concerns over the working culture and employment conditions in the US, salaries were seen as better, with greater opportunities to work for well-known or cutting-edge AI companies.

"The great progress in AI is made by large companies. That's what drives me towards them."
Graduate

However, graduates also recognised advantages and opportunities from working in the UK. One graduate pointed out that a lot of companies have their research groups or research HQs in the UK, and another commented on the high level of activity in the UK around AI and the wealth of talent in universities and organisations.

Some organisations, especially in local government, could not offer large datasets to work on, which meant there were some types of project experience they could not offer candidates (e.g. in deep learning). However, this indicates that there is an opportunity for employers that can offer these opportunities, particularly in the wider public sector, to use this to compensate for lower salaries when attracting talent.

In addition, the qualitative research identified challenges around defining and communicating the requirements of job roles and a lack of commonly understood job titles (see "Working in AI" chapter).

In the qualitative interviews, employers were asked about the role that the Government could play to support employers. Various suggestions were made, including support for apprenticeships, increased funding and liaison between industry and universities, e.g. for internships, support linked to visas and citizenship, and Government support specifically for small firms. Recruiters felt that school education should include a greater focus on technology.

Staff turnover and retention

Employers in the survey were asked about staff turnover. As seen in Chapter 4, most firms had fairly small AI teams (the median number of employees specifically using AI models, tools or technologies was 4). One-third of surveyed firms (32%) said that, in the previous 18 months, employees in AI-related roles had chosen to leave the company, and this was higher in firms whose core business was not AI (42%) than where AI was the core business (23%). In addition, firms said that employees had left at the end of a fixed-term contract (13%), because of redundancy (5% as a result of COVID-19 and 8% for other reasons) or where employees were dismissed (5%).

Overall, 54% of firms had not lost AI-related staff for any of these reasons in the previous 18 months, and, based on these figures, the rate of turnover for the total AI workforce of surveyed firms was 14% over 18 months.

In the qualitative interviews, some employers said that they had a low staff turnover. This was linked to the type of work offered, the values of the organisation and the career prospects they offered. Some employers stressed the importance of being able to offer career progression within the organisation, although in some cases this was constrained by the scope of the work the organisation could offer and the high expectations for career progression that employees could have. Some start-ups noted that they had very good retention despite offering lower salaries than larger companies. These businesses reported that staff were retained due to a friendly/informal working culture, the interesting nature of the work, and the potential for the business to grow rapidly.

Where problems with retention were highlighted, some employers felt they lost staff to start-ups (which were viewed positively for the reasons noted above) or, on the other hand, to big multi-national corporations who were able to offer high salaries. Staff turnover could also be problematic in smaller companies that invested in training graduates who often left after short periods of time to pursue new opportunities. Some employers reported losing skilled employees to other EU countries, offering more funding and better opportunities for young people and start-ups (e.g. the Netherlands, Germany or Belgium). Staff turnover was also linked to high salary expectations.

"There is a general expectation in the industry that no matter what salary they started on, the progression rate from year-to-year is high."

Employer

The issue of supply and demand (discussed in Chapter 3) was highlighted by recruiters, with employees easily able to move if their expectations were not met.

"It's such a hot area that the best people have too many options."

Recruiter

06

AI job vacancies

06 Demand for AI and Data Science Professionals: Job Vacancy Analysis

This chapter sets out an analysis of AI and data science job vacancies, based on our analysis of the job vacancy data on the Burning Glass Technologies labour market database. It covers the number of job postings, the roles, skills, qualifications and experience levels in demand, where the demand is coming from (both in terms of economic sectors and geographically) and the salary levels being offered.

The data primarily covers vacancies posted from January 2020 to the end of December 2020, i.e. 12 months of data. However, the first 2 charts in this section show the monthly change in job postings over a longer time period, to cover trends before and since the start of the COVID-19 pandemic.

Whereas the survey results covered in other chapters are based on a sample of businesses from the wider population, the findings from this secondary analysis are based on a curated dataset of online job postings related to AI and data science roles.

Please note that the search strategy to identify such roles is deliberately broad, and allows for the inclusion of some entry-level or complementary roles in demand from employers. For example, whilst a role such as 'Computer Vision Engineer' may be recognised as a clear AI role in scope, we also allow for roles such as 'Data Analyst' to be included within this analysis, as the individual who takes on the role may build on basic data literary skills, and subsequently learn AI or Data Science skills on the job (e.g. start their role with competency in SQL, then start to use Python more regularly, then use tools such as TensorFlow for example).

However, we do explore the number of particular job titles in further depth, which highlights the demand for particular specialised roles in the UK labour market.

Key findings

- The number of job postings fell 41 per cent following the first COVID-19 lockdown in March 2020, but it has returned to, and remained at, pre-COVID levels since Autumn 2020
- There is evidence that cities such as Cambridge, Oxford, London, Bristol, Edinburgh and Belfast are driving demand for AI and data science professionals across the UK.
- There are also encouraging signs that the demand for such professionals is dispersed across a wide range of sectors, including education – helping to train new talent and address the skills gap over the coming years.
- Employers are placing greater emphasis on hiring those with at least 3 to 5 years of experience.
- Remuneration in these roles is particularly strong compared to other digital roles, with a mean salary of £54,800 and median salary of £50,000 identified. These salary levels climb rapidly in line with experience.

Roles in Scope

Within this research, we recognise that defining an 'AI role' is a challenging task. There are some roles in the labour market that might demonstrate clear alignment as an 'AI role' e.g. a Machine Learning

Engineer. However, there are also roles in which the employee may require understanding or knowledge of highly complementary or aligned skills areas. For example, it is possible that someone working in an entry level Data Analyst role may be expected to have some understanding of AI and data science techniques, which could subsequently help to catalyse that team's capabilities.

Further, there are also job roles that may cross multiple digital areas. For example, a Software Engineer working for a cyber security business may require knowledge of AI techniques.

For this reason, the following principles were used to guide the roles considered in scope for this research:

- A broad initial definition was used to identify roles with potential AI or Data Science requirements (with the ability to deep-dive into particular job titles and regions to inform policy). This includes roles where AI skills could be feasibly deployed or be in demand within the team.

- Sector agnosticism: The search strategy sought to identify roles across the entire UK economy, and was not restricted to any one particular sector.

This research ultimately sought to use the job vacancies data to identify and consider UK employer demand for AI and data science skills.

It explored the number of job postings identified through the Burning Glass Technologies platform, and provided a breakdown of these roles by job title, industry, experience, and location. This provided insight into employer demand for such skills. However, the number of job vacancies in scope was ultimately determined by the search strategy in place. This search strategy is set out in the Methodology Annex.

Number of job postings identified

The search strategy identified 110,494 unique job postings considered in scope from January to December 2020.

Please note that this figure reflects the number of unique and de-duplicated online job postings. Further, any variation in the number of job postings could also be affected by the recruitment behaviour of firms e.g. use of recruitment agencies or word-of-mouth recruitment may not be reflected by the vacancy data.

It is also worth considering that the nature and titles used for jobs can be subject to change over time. For example, a Data Scientist role in 2020 is likely to have some differences in description compared to a Data Scientist role in 2015.

However, this does provide a useful insight into the number of job postings over time, and reflects a benchmark for employer demand for such skills in the UK.

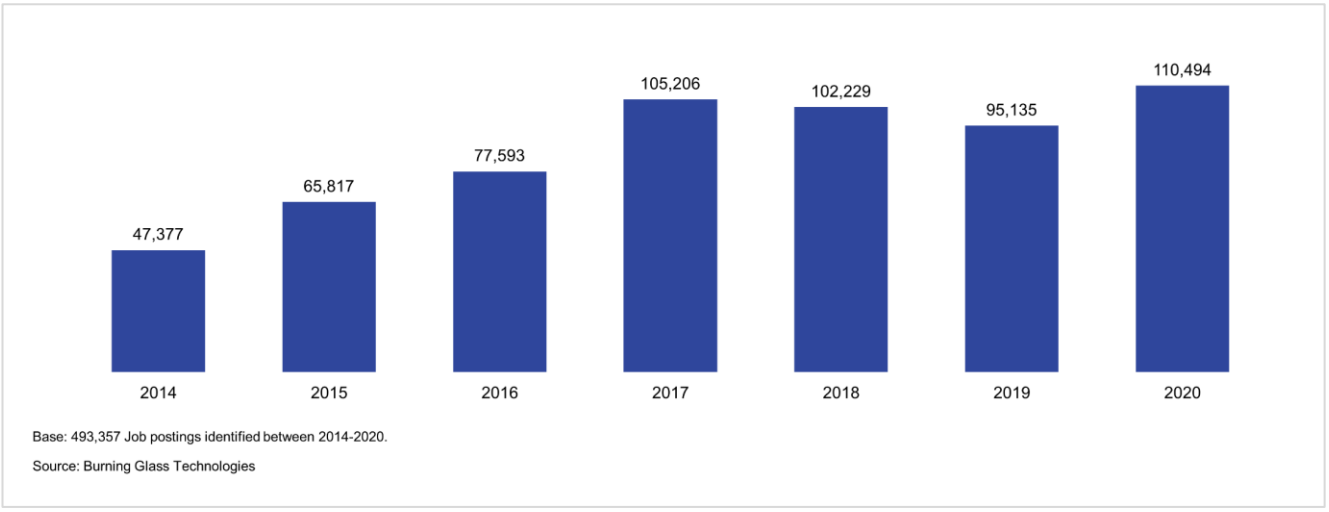
Figure 9 sets out the annual number of job postings identified (in line with the search strategy) since 2014.

This highlights that the annual number of job postings has more than doubled since 2014, reflecting the strong growth in demand for these roles among employers. However, growth in demand for these roles appears to have softened between 2017 – 2019 based on the online vacancy analysis. This might suggest employers have reduced the number of online postings, or are using other forms of recruitment (e.g. specialist recruiters, and word of mouth) to secure new talent. Further, this softening may also

indicate a real decrease, or highlight the difficulty in securing the recruitment of professionals into the field.

Despite the challenges faced by employers in 2020 due to the COVID-19 pandemic, 2020 was the highest year to date for the number of online job vacancies related to AI and Data Science, with 110,494 roles identified (an increase of 16% from the 2019 levels, and an increase of 5% compared to the previous peak of 105,206 roles in 2017). This echoes the sentiment from the qualitative findings that the COVID-19 pandemic may have increased the demand for AI and data skills in the UK.

Figure 9: Annual number of AI and Data Science related online job postings from January 2014 – December 2020



Overall, this data suggests that within the last 3 years, there have been approximately 8 – 10,000 AI and data science roles posted online by employers every month.

Figure 10 explores the number of online vacancies posted each month since mid-2019, and this demonstrates how the number of job postings fell substantially in late March and early April following the first COVID-19 lockdown (which started on 26 March), but recovered to pre-lockdown levels by Autumn 2020, and has remained consistent since.

Figure 10: Monthly number of AI and Data Science online job postings from July 2019 to December 2020

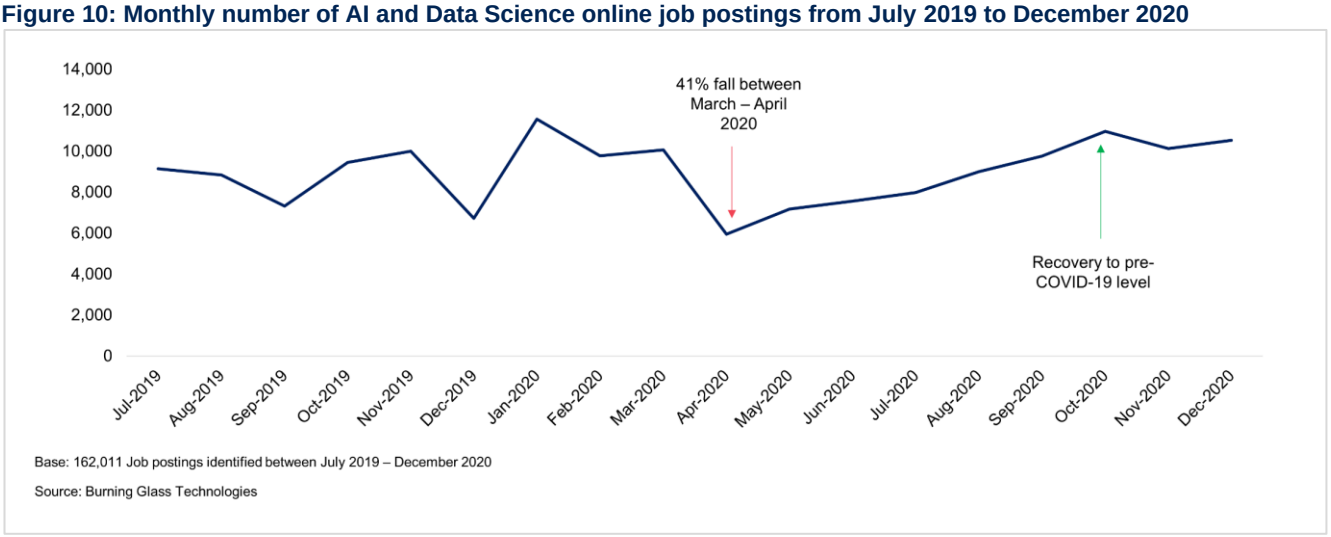


Figure 10 specifically demonstrates how the volume of job postings has changed since March 2020.

There was a 41 per cent drop in the number of AI and data science job vacancies between March and April 2020.

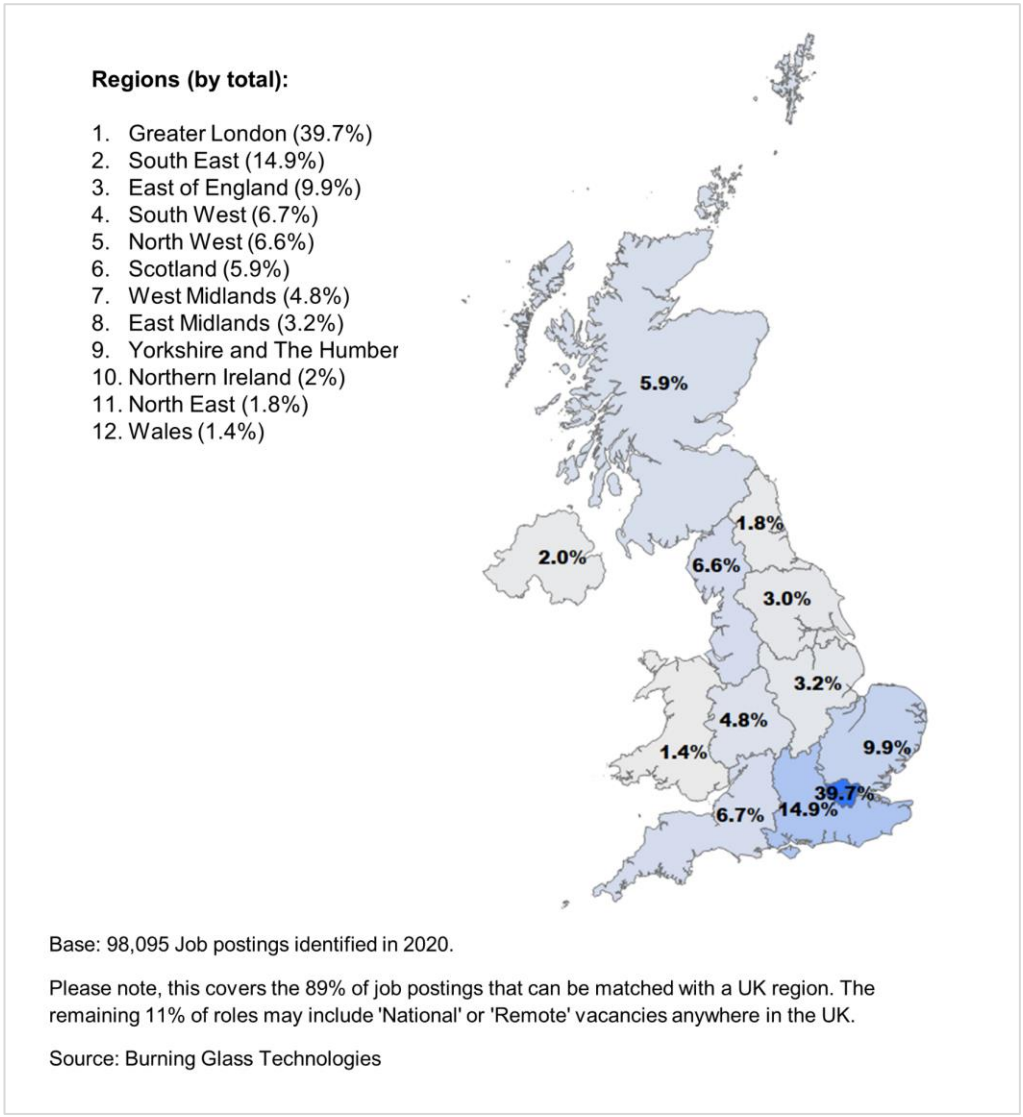
However, the labour market appears to have recovered lost ground by Autumn 2020. Indeed, in October 2020, there were 10,977 AI and data science roles posted, which is 9 per cent above the March 2020 level, indicating the extent of the recovery. Indeed, in February 2021 (not charted above), there were 13,216 job vacancies posted – the highest month on record.

Geographical demand for AI roles (by region and by Travel to Work Area)

The rest of this chapter focuses on the job postings from January to December 2020, i.e. for a 12-month period.

Figure 11 shows the proportion of job postings for AI and data science roles from each of the twelve UK regions[47] (where the region is known) for 2020. The darker the colour on the heatmap, the higher the density of jobs in that region. This shows, as expected, more than half of job posts were based in London and the South East.

Figure 11: Percentage of AI and data science job postings from each UK region



Base: 98,095 Job postings identified in 2020.

Please note, this covers the 89% of job postings that can be matched with a UK region. The remaining 11% of roles may include 'National' or 'Remote' vacancies anywhere in the UK.

Source: Burning Glass Technologies

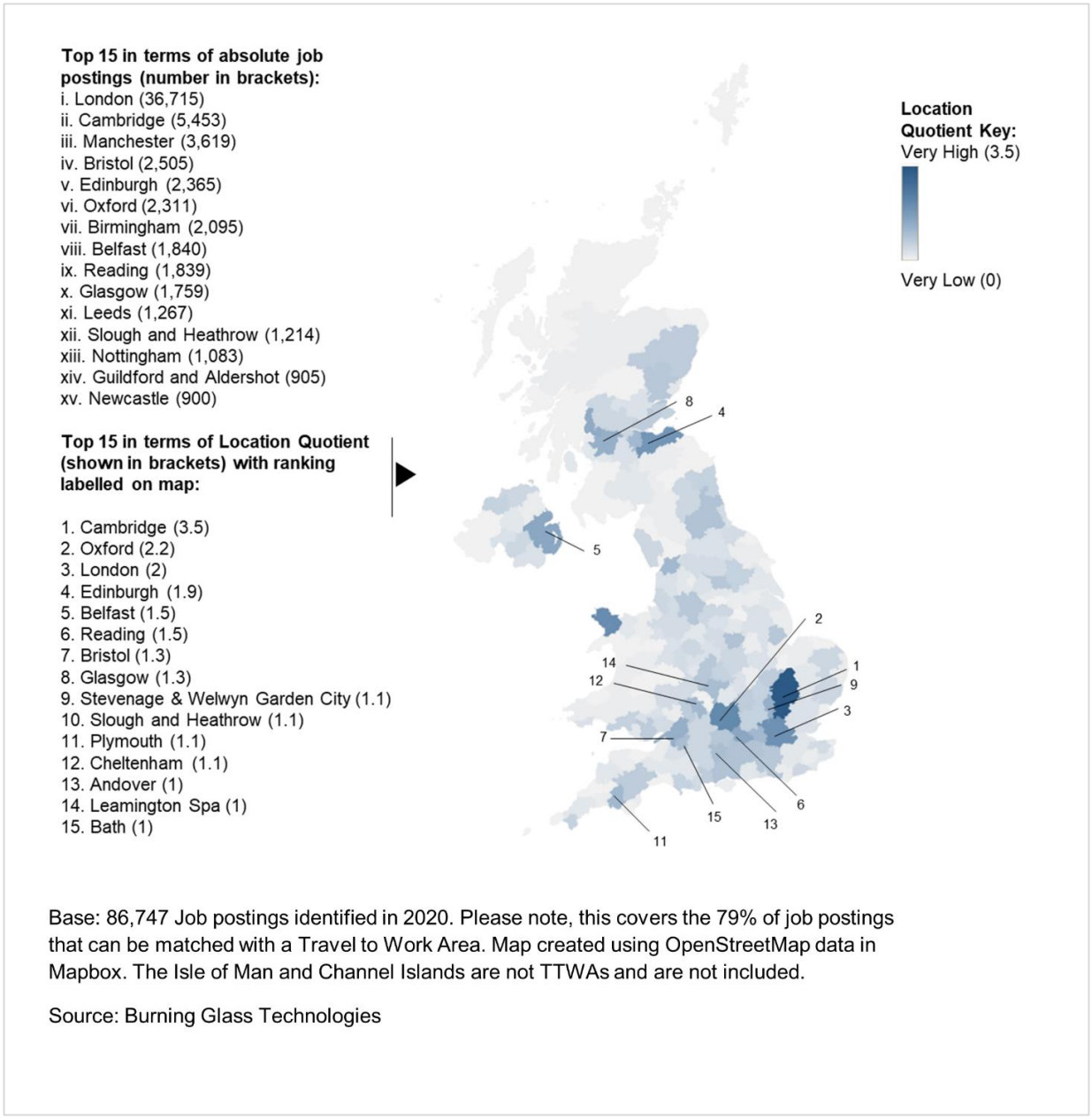
[47] For more detail on the 12 UK NUTS1 regions, please see the ONS website.

It is important to consider more granular hotspots of activity, both in terms of absolute size, and relative to the working population. We therefore have undertaken more granular geographic analysis using the Travel to Work Areas (TTWAs) in the UK.[48]

Figure 12 shows the top 15 TTWAs for the AI and data science job postings in *absolute* terms and in terms of *Location Quotients*. The latter measure shows how concentrated labour market demand is within a geographic area. The average demand is set at 1.0. A Location Quotient of 1.2, for example, indicates that the demand for employees is 20 per cent higher than the UK average.

We illustrate this as a heatmap, with darker blues indicating a higher Location Quotient. Greyed out TTWAs are places where there were a negligible number of job postings in our data (with a Location Quotient that rounds down to 0), or none at all.

Figure 12: Number of AI and data science job postings and Location Quotients in the top 15 UK Travel to Work Areas



Base: 86,747 Job postings identified in 2020. Please note, this covers the 79% of job postings that can be matched with a Travel to Work Area. Map created using OpenStreetMap data in Mapbox. The Isle of Man and Channel Islands are not TTWAs and are not included.

Source: Burning Glass Technologies

[48] For an explanation of TTWAs, see the ONS website. There are a total of 228 TTWAs. The Isle of Man and the Channel Islands are not TTWAs so are not included. Our Location Quotient calculations are based on 2016 Annual Population Survey (APS) data, and the TTWA calculations are based on the April 2011 TTWAs.

Looking across both these maps highlights specific areas, or hotspots, where there is both a high absolute number of AI and data science job postings and where they make up a relatively high level of demand compared to the workforce size within the local economy.

In absolute terms, London was a major hotspot for AI and data science roles, with 36,715 roles identified. This was followed by Cambridge (5,453), Manchester (3,619), Bristol (2,505), Edinburgh (2,365), Oxford (2,311) and Birmingham (2,095).

In relative terms, Cambridge has the highest location quotient (3.5) i.e. the concentration of demand for AI professionals is 3.5x higher than the UK average. This was not surprising, given the role of the University of Cambridge as well as significant demand from employers such as Apple, Amazon, Microsoft, Graphcore, Darktrace and more for top talent. They were followed by Oxford (2.2), London (2), Edinburgh (1.9), Belfast (1.5), Reading (1.5) and Bristol (1.3).

This data suggests that the majority of AI and Data Science roles demonstrated significant cluster effects around some of the major universities and science parks in the UK. However, encouragingly, the data also suggests employer demand was evident across most parts of the UK (towns and cities), with areas such as Reading, Leeds, Glasgow, Slough and Heathrow, Nottingham, Newcastle, Stevenage and Welwyn Garden City, Plymouth, Cheltenham, and Leamington Spa making the top areas for such roles in demand.

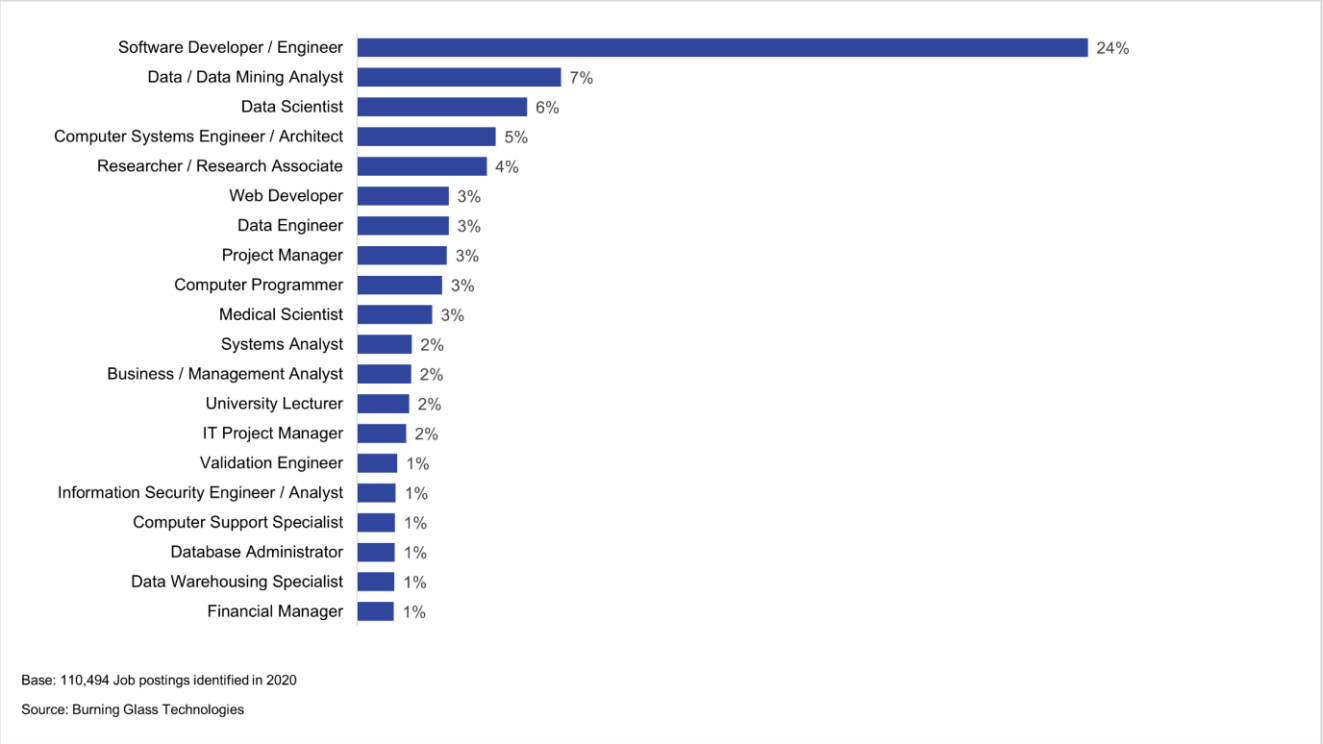
Job Titles in Demand

Figure 13 lists the identified AI and Data Science roles by job title. As set out previously, the search strategy used within this research is broad to ensure capture of a wide range of roles in demand for AI and data skills.

Almost 1 in 4 (24%) job postings is for Software Developers and Software Engineers, reflecting the breadth of technical and non-technical skills within these roles. Data Analyst roles were also in high demand, reflecting 7% of the job postings identified. Data Scientist roles were often more explicit in their requirements for AI knowledge and skills, and these reflect 6% of job postings.

The remaining job titles also show strong demand for knowledge of Computer Vision, software engineering, research, programming, management, and teaching / lecturing of AI and data skills within academia.

Figure 13: Top recurring job titles among the AI and data science job roles identified (BGTOCC[49])



Sectors demanding AI skills

Job postings within the Burning Glass Technologies dataset were often advertised through a recruitment agency. This means that the employer name – the end client of the recruitment agency – may not be contained within the job posting.

However, for the roles identified, a total of 50,017 job postings for the latest 12 months (around 45% of all the job posts identified) have a known employer name, which has been matched against the respective Standard Industrial Classification[50] (2-digit SIC) sector.

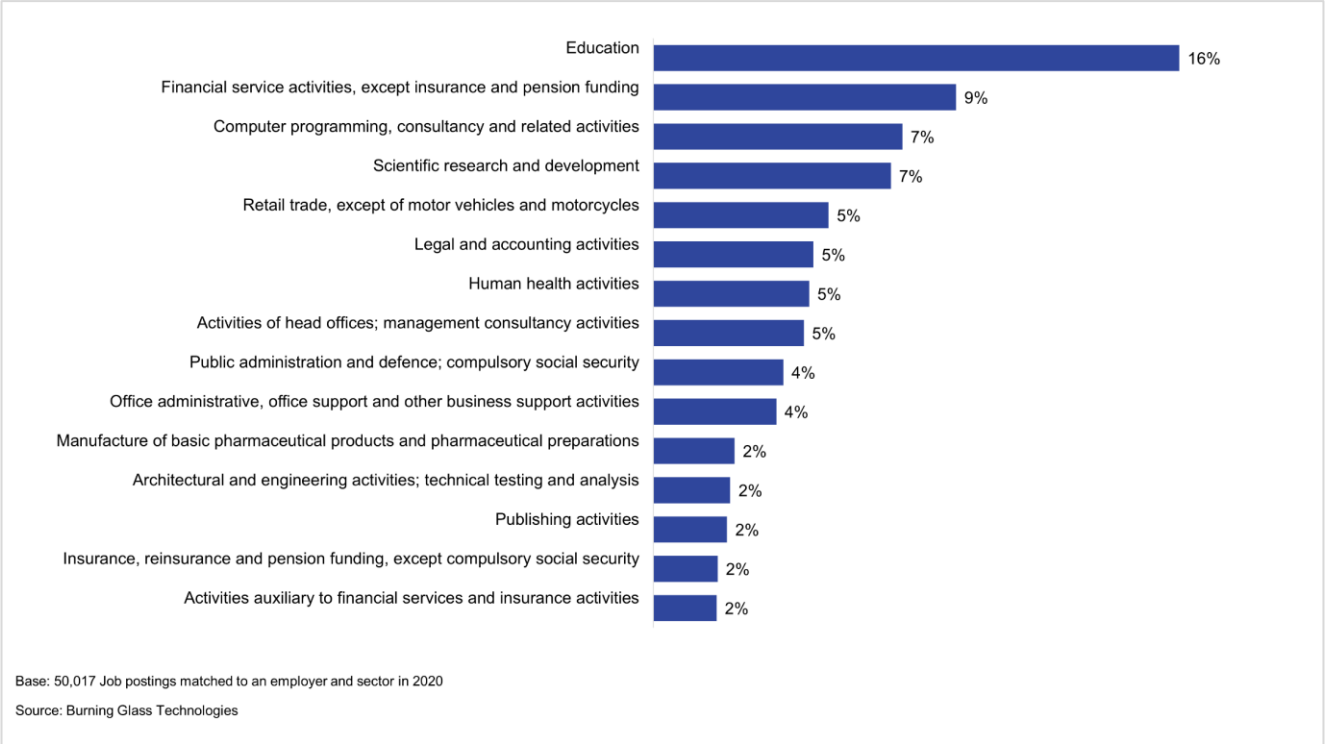
Figure 14 demonstrates that the Education sector (primarily Higher Education institutions) were in the greatest demand for AI and data science professionals. This may reflect considerable demand from universities for academic staff with relevant skills in both research and teaching. However, it is also possible that Education institutions may also be less likely than other sectors to 'hide' the employer name when recruiting (or may be more likely to use public online job advertisements), which may possibly overrepresent this sector.

The financial sector (excluding insurance) also had a high demand for AI and data science professionals, reflecting 9% of all job postings. Interestingly, companies in computer programming and consultancy (SIC62) cover 7% of all job postings – which may suggest some preference for other forms of recruitment, such as using recruitment agencies, word-of-mouth, or use of graduate schemes.

There was a wider diversity of sectors employing AI and data skills (e.g. within scientific research, retail, legal services, health, consultancies, and the public sector) which reflects the recognition that AI skills could and should be deployed across the whole economy to improve national productivity.

[49] Burning Glass Technologies Occupation Classification Codes.
[50] More detail on SIC codes available on the ONS website.

Figure 14: Percentage of job adverts for AI and data science coming from specific sectors (where the SIC sector is known)



The skills, qualifications and certifications being demanded

This analysis was based on text analytics of the descriptions given for each job posting.

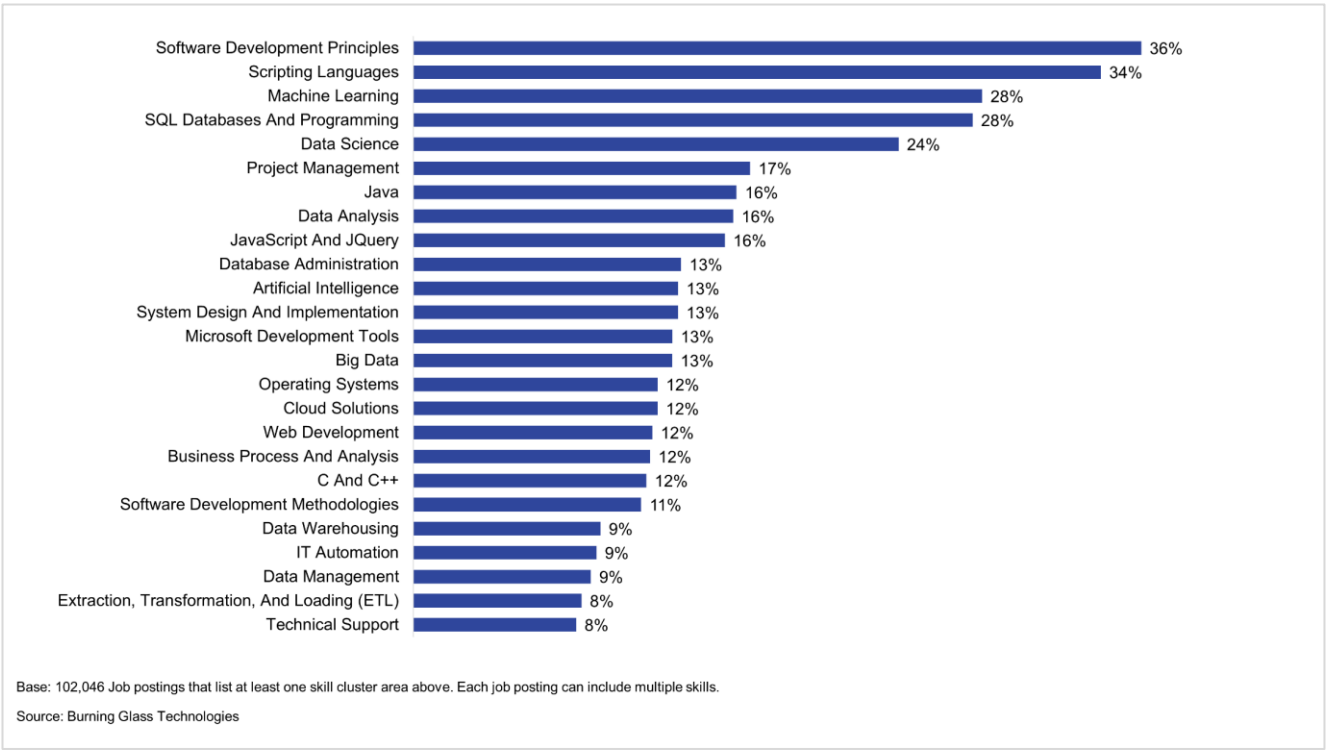
Skills in demand

Looking at AI and data science roles, the top 3 skills requirements mentioned in job descriptions include Software Development Principles, Scripting Languages, and knowledge of Machine Learning. The top skills (by mention in job postings) are set out below in Figure 15.

The most commonly demanded technical skills areas can be summed up as follows, and are also explored in Figure 16.

- Software Development, including knowledge of Scripting and Programming (including Python, SQL, Java)
- Knowledge of AI and Machine Learning techniques and tools (e.g. TensorFlow)
- Knowledge of Data Science, Data Analysis, Statistics and Visualisation
- Data Governance, including knowledge of Databases, Data Warehousing, Management, and ETL
- Knowledge of Cloud Services e.g. Azure and AWS

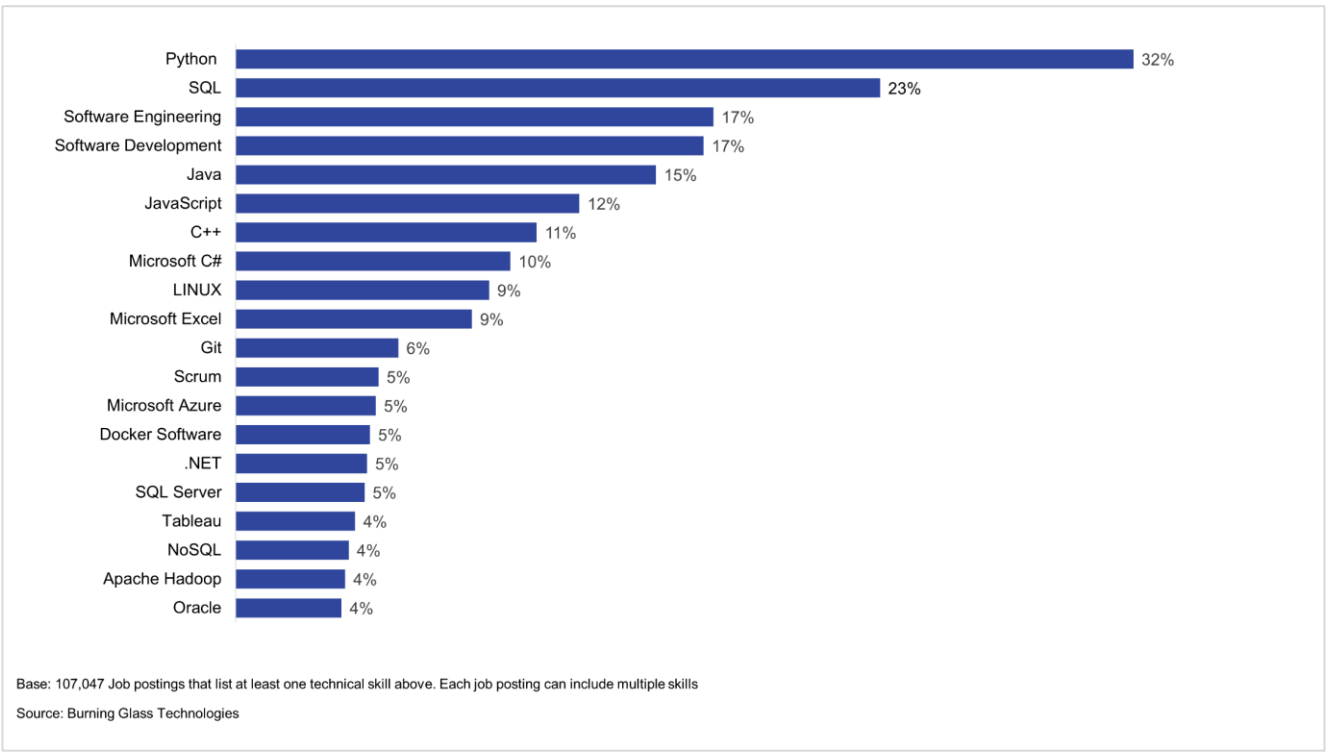
Figure 15: Top skills requested for AI and data science roles



Base: 102,046 Job postings that list at least one skill cluster area above. Each job posting can include multiple skills.

Source: Burning Glass Technologies

Figure 16: Top 20 technical skills requested for AI and data science roles



Base: 107,047 Job postings that list at least one technical skill above. Each job posting can include multiple skills

Source: Burning Glass Technologies

Education requirements

As Figure 17 shows, employers place a very strong emphasis on applicants having bachelor's degrees or higher qualifications. In total, 91% of roles require at least a Bachelor's Degree or higher (76% require a minimum of Bachelor's Degree, and 15% require a minimum of a Postgraduate Degree). A very small

number require a minimum level of education below this; however, this is likely to include schemes such as paid Apprenticeships.

Figure 17: Percentage of AI and data science job postings asking for the following minimum levels of education (where any minimum requirement is identified)

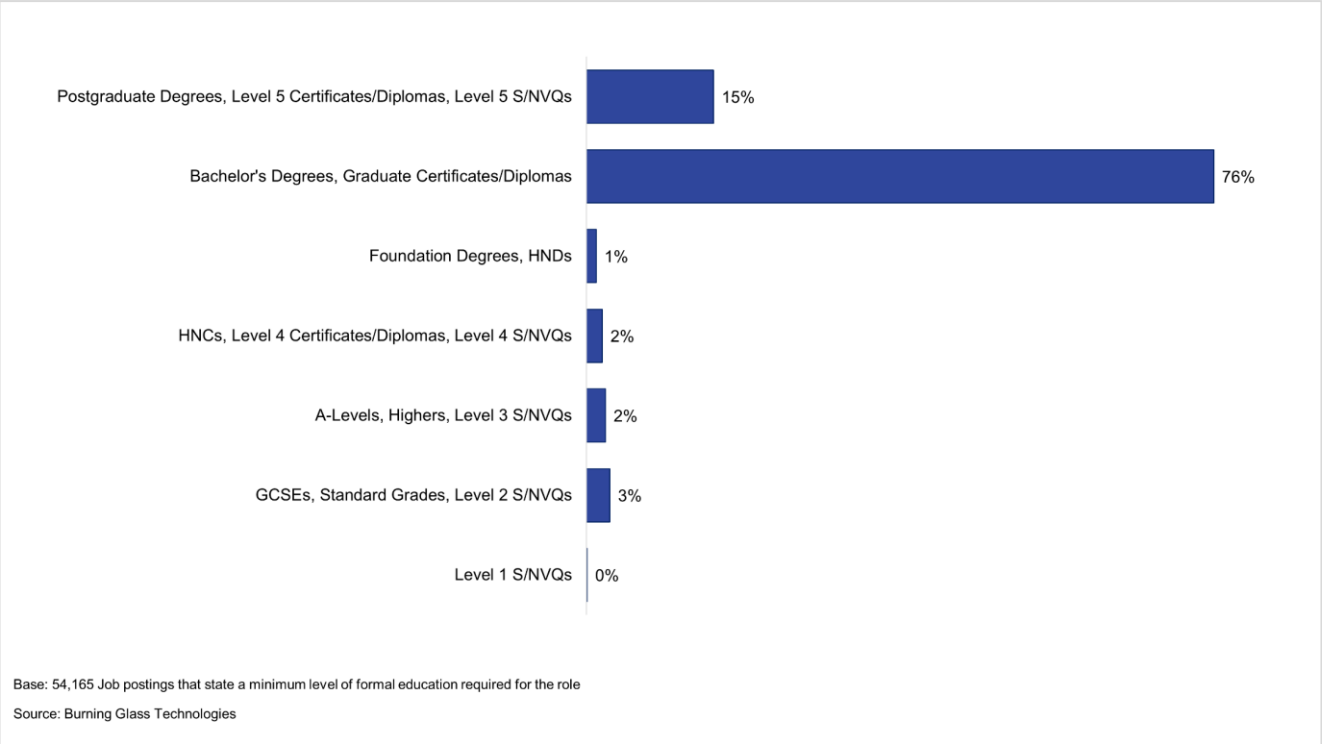
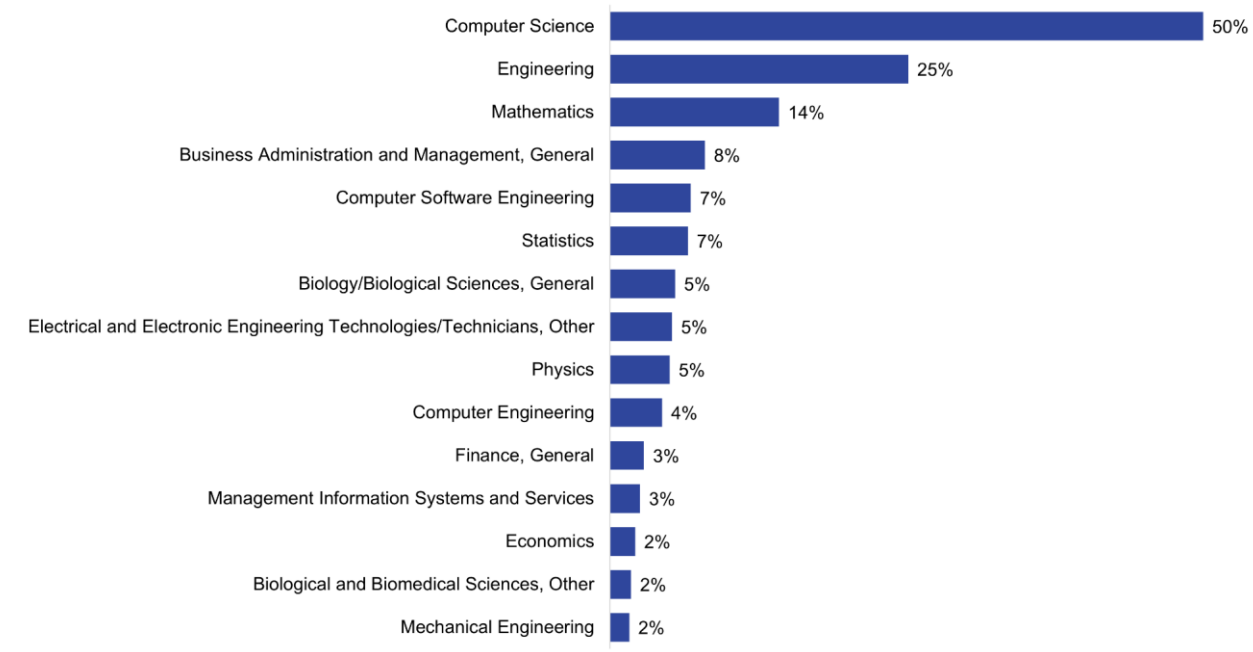


Figure 18 sets out the subject areas demanded by employers (for roles requesting minimum of degree level education). Half (50%) of the job postings requested a background in Computer Science, and a quarter (25%) requested an Engineering (i.e. software) background. Mathematics is the third most requested subject (14%) followed by a background in Business Administration (8%), and Statistics (7%).

Other science subjects were also recognised by some employers e.g. Biology and Physics, recognising the AI and data skills often built through these education routes.

Figure 18: Subject areas (degree level) requested for AI and data science roles



Base: 47,925 Job postings that request a particular subject area related to formal education. Please note this totals to more than 100% as some roles request any of a range of subject areas e.g. Computer Science or Engineering etc.

Source: Burning Glass Technologies

Demand for certifications

The Burning Glass platform also identifies where job postings request that a candidate has (either essential or desirable) a professional membership or holds a particular certification.

Interestingly, 95% of job postings do not include a certification, which suggests there are very limited requests among employers for formal certifications compared to other professions e.g. finance, cyber security etc. Further, it also highlights the lack of industry standard classifications for AI and data science roles compared to other professions. Of the 5% of roles that do request a certification, the top certifications include:

- Microsoft Certified Systems Engineer (MCSE)
- CISCO Certified Network Associate (CCNA)
- Chartered Engineer Status (CEng)
- Certified Information Systems Security Professional (CISSP)
- Microsoft Certified Solutions Associate (MCSA)

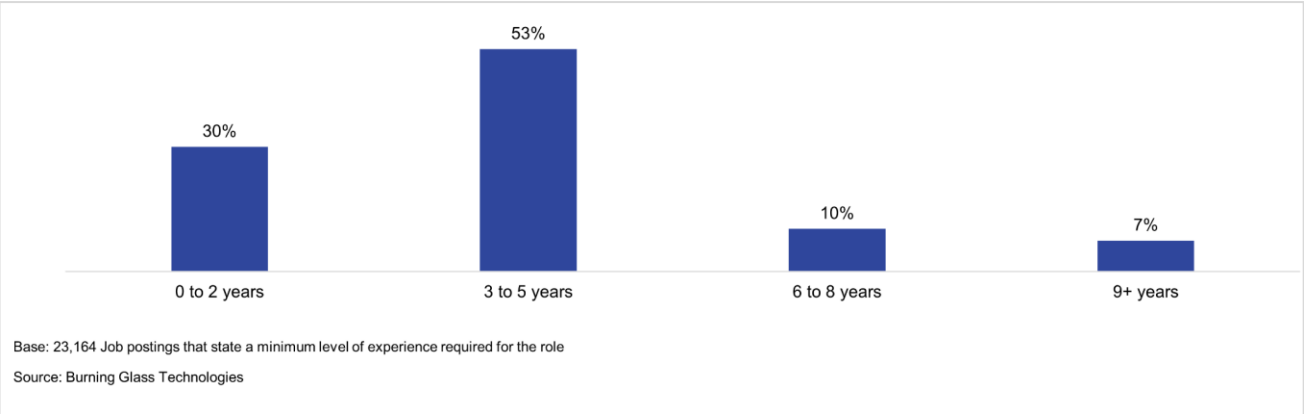
These may more reflect job titles which require AI or data science related skills (and were therefore in scope), but might also be considered within other areas of the digital sector (e.g. a cyber security engineer).

Experience Demanded

Figure 19 demonstrates that, over the last year, the most common request from employers looking to fill AI and data science roles has been for applicants with 3 to 5 years of experience (53%), followed by entry level applicants (30%).

This highlights employer preference for entrants with a few years of applied experience in the field (e.g. previous graduate level employment, and project examples with relevance to the new role). This means that employers typically expect prospective employees to have an established level of knowledge and experience, and not necessarily be trained from scratch.

Figure 19: Percentage of AI and data science job postings asking for the following levels of minimum experience (where any minimum requirement is identified)



Salaries

Across the latest 12 months, the mean advertised salary was £54,800 for an AI and data science related job posting (with a median value of £50,000).

As a comparison, for all employee jobs within SIC code 62, which is the computer programming, consultancy and related activities industry code, the mean annual pay in 2020 was £50,130 (with a median of £41,078).[51]

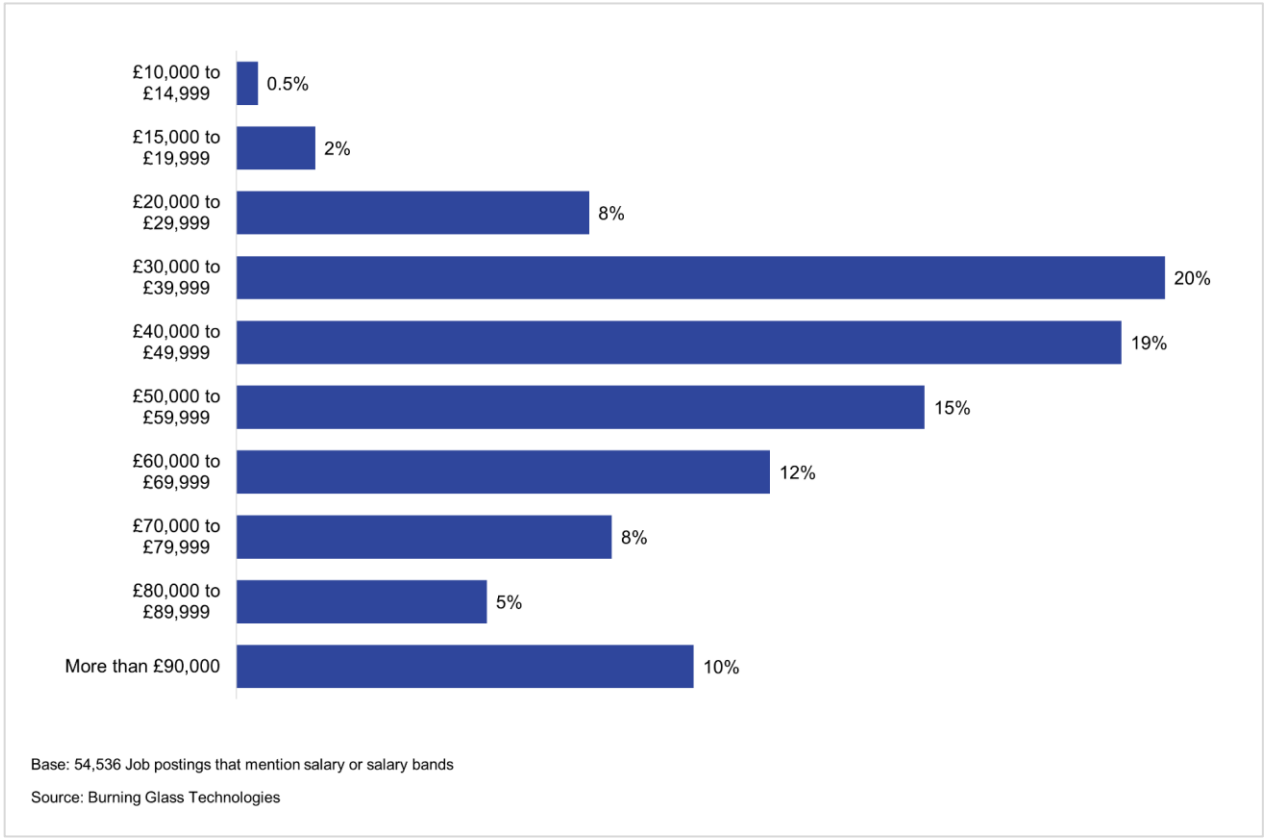
Using this value as a proxy for IT jobs in the UK suggests there is still a wage premium of approximately 22 per cent for AI and data science roles compared to IT jobs as a whole.[52] However, this does capture a wide range of roles (e.g. from some entry-level Data Analysts, through to experienced Data Scientists).

All our salary analysis only relates to advertised job postings. It is important to remember that many job vacancies can have a flexible salary structure depending on candidate skills and experience, which can be highly varied.

The proportion of AI and Data Science postings offering given salary bands is shown in Figure 20.

[51] This is sourced from the Office for National Statistics (ONS, 2020) Annual Survey of Hours and Earnings.
[52] This compared the median salary for AI and data science job postings (£50,000) and all IT job postings (defined as SIC code 62, getting a median of approximately £41,000).

Figure 20: Percentage of AI and Data Science postings offering the following salaries (where the salary or salary range is advertised)

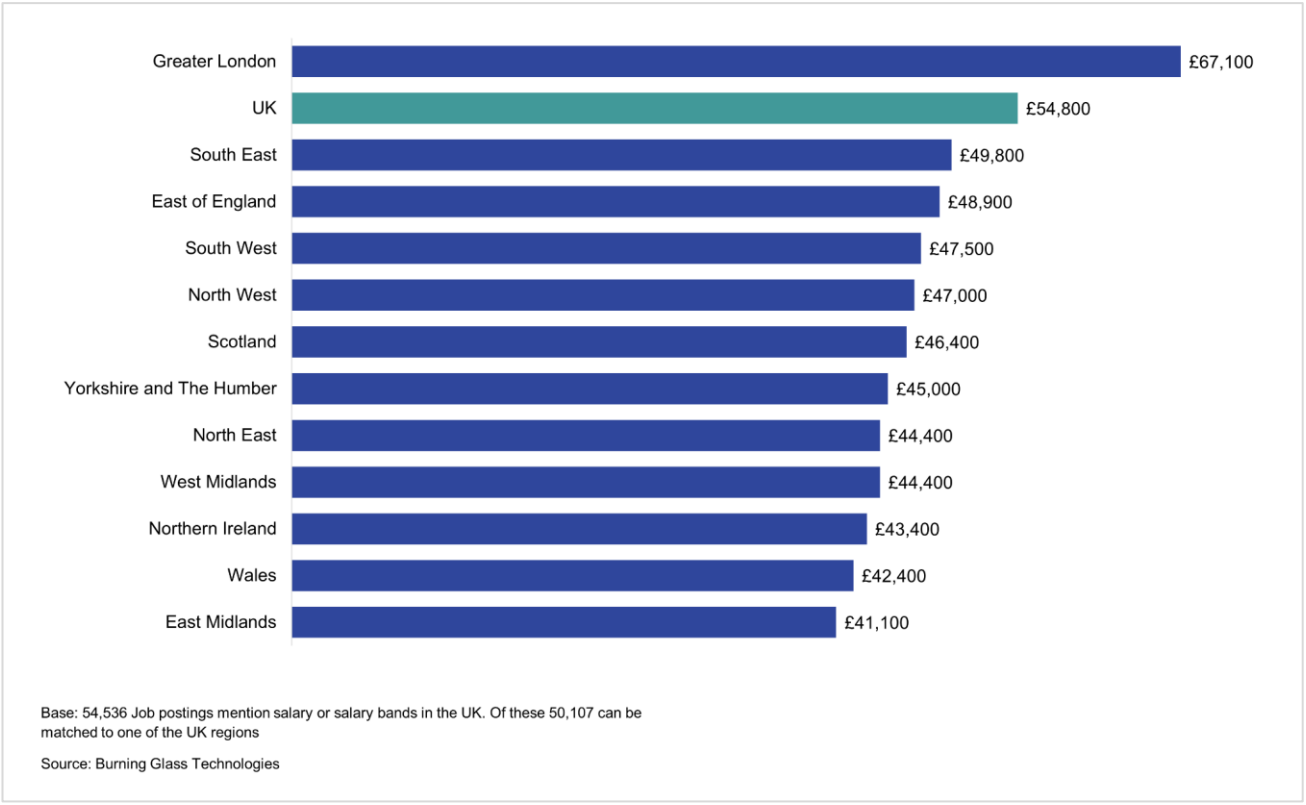


Geographic variation in salaries

London had the highest mean advertised salary for AI and data science roles. This was to be expected, given the prevalence of the finance and tech sector as well as higher typical costs of living in the capital.

At the other end of the market, the East Midlands has considerably lower average advertised salaries for these roles (a mean of £41,100, vs. the national average of £54,800), as shown in Figure 21.

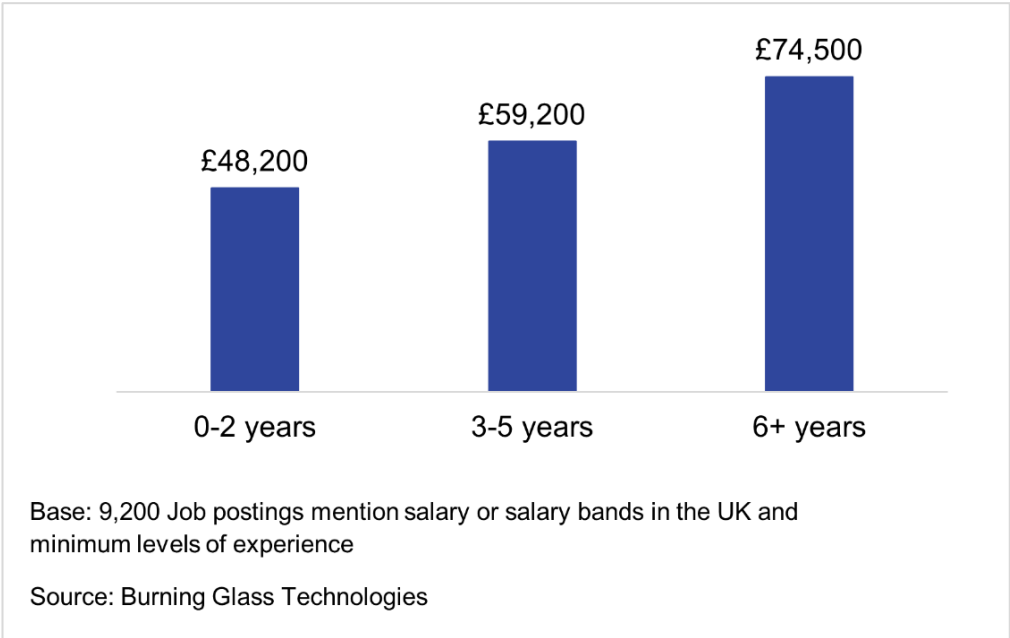
Figure 21: Mean salary offers for AI and data science job postings, by region (where the salary or salary range is advertised)



Variation in salaries by experience

Figure 22 sets out the mean salary for these job postings by experience. This highlights that entry-level salaries were relatively strong (£48,200) and could grow rapidly in line with experience (e.g. to £74,500 on average for those with 6+ years' experience).

Figure 22: Mean salary offers for AI and data science postings, by experience (where the salary or salary range is advertised)



07

Conclusions and recommendations

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Overall, this research set out to understand the overall skills landscape in the UK AI labour market. The research identified not only the level of skills shortages and where employers feel there are currently skills gaps but also the drivers of these shortages. The following recommendations are all based on the evidence generated from all elements of this study. It will require engagement from government, AI firms and other employers, education institutions and recruitment agencies to take them forward.

Increase diversity in the AI workforce: women and some ethnic minorities are under-represented within the AI workforce. Most employers did not have a diversity policy and there was a view that the lack of diversity among their employees reflected the lack of diversity within the candidate pool. However, very few employers took positive action to increase diversity and for most employers, the priority was to recruit someone with the 'right' skills.

"Diversity is the main issue. If they can fulfil that, that by itself will fill the gaps."
Employer

As well as ensuring that the AI sector is an attractive prospect for a diverse spectrum of the UK population, the diversity balance may also be corrected by attracting global talent to widen the talent pool: most firms had not thought about the impact of the EU exit on the candidate pool. Immigration from the EU has declined since the EU exit vote and it was suggested that the UK needs to change its messaging to be seen as welcoming and open country.

"***Data science is such where an applicant can often choose where they want to go, more than the employer chooses who they want...Brexit has had a bit of an impact on that desirability.***"
Employer

Improve the talent pipeline through education, student employability and diversity: there was a strong view that there is a need for more opportunities for pupils to learn about AI careers at school, and as part of a wider range of undergraduate courses. They felt that the popular image of working in AI did not reflect the reality and that more should be done to challenge stereotypes, and communicate that such a career can be interesting, applied in a wide range of contexts, and highly paid. Lack of knowledge could potentially steer pupils away from taking subjects/courses that could lead to a career in AI.

The Space sector has taken action to secure a pipeline of future talent by garnering the support of businesses and academia. The sector has agreed to promote the industry in schools etc by undertaking visits to schools to provide insight into what it is like to work in the Space sector and explain the types of careers that are available in this sector.

The talent pipeline can be further bolstered by increasing students' employability: many employers felt that AI graduates were not able to apply their student learnings to real-life situations. Some mentioned symbiotic partnerships which allowed small businesses to work with students, providing the students with real-life demonstrable experience, whilst allowing small businesses to access AI skills, that in some cases, they would otherwise not be able to afford.

An example of how matching students with firms has worked successfully is the Space Agency placement programme. Students are matched with firms, with whom they undertake an 8 weeks placement over the summer. The firm is given £3,000 to take on the student for the summer period. As a

result of the placement, some firms offer final year students' jobs, whilst others may continue to follow students who are not in their final year. Even if the student is not offered a job they have gained valuable work experience which will make them more desirable to employers when they graduate.

"A big thing for us is good communication...and the ability to work in teams effectively...and to be an asset to the culture of our company...and somebody who thinks innovatively, who can think for themselves and add value by bringing ideas."

Employer

Create more opportunities for those not currently working in AI to convert to a career in AI and raise the levels of awareness of these opportunities: Stakeholders at the roundtable stressed the potential for people with related skills to retrain in AI. For example, unemployed graduates with the right STEM skills and those working in other sectors, who may have domain knowledge but not necessarily the correct digital skills could re-train. To enable people to pivot into a career in AI, there needs to be different pathways to consider life stage and affordability. Formal entry routes include conversion Masters' courses and apprenticeships, but some employees and students used online courses (e.g. MOOC) to gain AI skills. Levels of take-up of these routes into AI seemed to be low, particularly in relation to apprenticeships.

Encourage small firms to broaden their recruitment practices and provide support to small firms/employers located outside 'hot spots' to recruit and retain staff: small firms tended to use word-of-mouth and networking to recruit their employees. Although smaller firms had a preference for this recruitment method as it took some of the risk out of recruitment and was cost effective, it reduced the talent pool from which they recruited and potentially increased the lack of diversity within the company as the same types of people tend to come through their contacts/networks.

Support small firms and employers based outside of 'hotspots' to recruit and retain staff: small firms found it difficult to recruit and retain staff as they could not compete with the high salaries offered by large companies, they often took on graduates who left within a couple of years to pursue careers with large companies. In addition, this was compounded for some firms by being based outside the hotspots for AI companies (generally in close proximity to universities or in large cities such as London, Manchester etc.). There is a need to explore how these firms can be supported (including financially) to find and retain staff.

"Whatever the government can do to promote highly skilled data scientists or AI / machine learning developers in places that are not London or the big cities, especially now home-working is a goal for many companies, that would be really welcome by companies like us."

Employer

"If I could have one thing that government would do, it would be to get the focus of AI and machine learning out of London so that it's not a case of you have to be in London to do it. How do you get this technology and this industry spread across the country?"

Employer

Firms, particularly small firms, need employees to have a range of technical and soft skills (e.g. soft skills, commercial awareness): employers found it hard to recruit employees who had both the technical development skills and soft skills such as communication or presentation skills. Some small firms

needed AI employees who were not only able to perform technical aspects of their role, but to also be able communicate effectively with management, other team members, internal stakeholders and clients about the AI product, its application and the benefits or limitations.

"We need people that can communicate across the divides and channels, which isn't always perfectly a common skill in data science in general"
Employer

"Some of the positions they are employing for are quite senior so they need to be able to talk to the business, they need to be able to articulate what they are doing to other people"
Recruiter

Identify the AI skills required by different sectors: it was suggested that the focus should move from simply thinking about increasing the size of the workforce but towards thinking about the AI skills required in each sector. Participants felt it would be helpful to focus on the core skills required by different sectors and explore how academic organisations could expand their courses to ensure that students gain the correct skill set.

Ethics and bias training: low levels of ethics training were reported in the surveyed firms, although more firms said employees had undertaken training in bias. However, some firms reported ethics under-pinned all that they did. The case needs to be made case that it is in firms' commercial interests to avoid flaws related to bias and ethical issues in their products. In light of this it was suggested that ultimately ethical standards would need to be brought in.

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