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AI Skills

A Preliminary Assessment of the Skills Needed for the Deployment, Management and Regulation of Artificial Intelligence

National Skills Council

Expert Group on Future Skills Needs

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List of Acronyms	
AI	Artificial Intelligence
CAHAI	Ad hoc Committee on Artificial Intelligence
CPD	Continuing Professional Development
DETE	Department of Enterprise, Trade and Employment
EU	European Union
ICT	Information and Communications Technology
IT	Information Technology
KPI	Key Performance Indicator
NACE	Nomenclature of Economic Activities
NERI	Nevin Economic Research Institute
OECD	Organisation for Economic Co-operation and Development
STEM	Science, Technology, Engineering and Mathematics
UNESCO	United Nations Educational, Scientific and Cultural Organisation
WEF	World Economic Forum

Foreword

Artificial Intelligence is part of a suite of digital technologies which are already becoming critical drivers of productivity and competitive advantage for Ireland. It will affect virtually every sector of the economy and society. Therefore, almost everyone will need some knowledge or understanding of AI as it becomes embedded into our jobs and lives. AI will become integrated into the way we work, and job roles and tasks will inevitably change. Those who have the skills to work in this changing environment will benefit the most.

Ireland recently published its National AI Strategy, AI Here for Good. This report responds to the Strategy by providing an introduction and framework to the skills-related issues and challenges relevant to the adoption of AI in Ireland. The study does not limit itself to the high-level, technical skills needed by developers and experts, but considers skills needed for the deployment, management and regulation of AI. Thus, not only the need for skills in industry are identified, but skills needed in the public sector, by educators, and by the general public, so that society as a whole can have the trust and confidence to embrace the opportunities of AI.

This study has identified different levels of skill necessary for the adoption of AI. High-level technical, AI-related skills will be needed, but only by a minority of people. Many of those working in organisations that use or develop AI systems will need to be dual-skilled; they will need to supplement their core, domain-specific skills with a knowledge of AI if they are to identify the business opportunities and work productively with AI experts. This also highlights the importance of inter-disciplinary teams, as well as management and organisational skills to deploy these technologies effectively AI projects are more likely to be complex and to result in unexpected or unintended consequences if not well planned. Those who use and procure AI systems will need sufficient knowledge to make informed purchasing decisions. The general public also needs a basic awareness and understanding of AI so that they can trust the technology and be empowered consumers and citizens. To support the skills needed by all these groups, teachers, trainers and educators will need to be ahead of the curve if they are to exploit the possibilities of the technologies themselves and provide the necessary knowledge and understanding to their students.

The report makes a range of recommendations. Some of these are encompassed in existing national enterprise and skills development strategies. For example, there are plans to improve digital skills and literacy across the population which form a critical foundation for more specialised AI-related skills. This activity has obviously gained momentum because of the pandemic. Other recommendations relate to teacher CPD and qualifications, while the importance of appropriate AI regulation is reflected in the proposals to enhance the skills of public servants. AI technologies have the potential to improve efficiency, reduce costs, improve services and support decision-making. However, this demands an understanding of their capabilities, constraints and context for deployment.

I would like to thank the project Steering Group for their efforts and for the enthusiasm and knowledge that they brought to the study during 2021. In addition, we are grateful to those who gave their time to participate in the workshop and survey that were conducted as part of the study. Particular thanks go to Barry O'Sullivan, who chaired the Group through the year, giving generously of his time. As professor at the School of Computer Science & IT in University College Cork, founding Director of the Insight Centre for Data Analytics, Director of the SFI Centre for Research Training in AI and vice chair of the European Commission High-Level Expert Group on AI, Professor O'Sullivan brought a particular expertise and authority to this project. The EGFSN looks forward to supporting the ongoing work needed to bring the recommendations in this report to fruition.

Tony Donohoe
Chairman
Expert Group on Future Skills Needs

Executive Summary

AI is becoming an ever more important and pervasive technology. According to Ireland's National AI Strategy, AI Here for Good, "AI is one of the technologies with the greatest potential for transformation in all areas of productive activity."[1] It is timely therefore to conduct an initial assessment of the skills that will be needed if Ireland is to reap the benefits and avoid the potential pitfalls of the adoption of AI over the coming years. The aim of this study is to identify and understand the skills implications of the growth of AI over the next 5 to 10 years.

AI is described as a general-purpose technology and, as such, will have potential application across a broad range of sectors and occupations. According to the OECD,[2] it is not likely that AI will cause net job losses, but it will have an impact on a lot of jobs. Some jobs will continue to be automated and will therefore be lost, but many jobs will experience increasing levels of AI being integrated into certain tasks. Those who are ready for these changes will benefit the most.

Different groups of people will need different skills depending on how they interact with AI. Those who develop AI systems or teach high-level AI courses need very specialised AI knowledge and skills. Many others in the same organisations will need to know enough about AI and its implications to work in well-functioning teams that either develop or use AI systems. Those who use or procure AI systems, whether in the public or private sectors, will also need a sufficient level of knowledge to understand the implications of the systems they are employing. In terms of education, school children will need broad digital skills and digital literacy as a matter of course, within which an understanding of AI can be built. Therefore, their teachers will also need the relevant skills and knowledge to teach them. Finally, each member of the public needs to know enough about AI to ensure that they are empowered consumers and citizens in a world increasingly infused by AI.

It is relevant to consider a number of skills categories. First, the high-level technical AI-related skills needed by a minority of people. Second, the supplementary AI knowledge that other workers in organisations using AI will need – we can refer to this as dual-skilling, whereby individuals combine their domain-specific skills with a knowledge of AI. Such dual-skilling is particularly needed by senior management levels in organisations using or procuring AI systems. Third, there is a need for well-functioning inter-disciplinary teams, particularly given the relative complexity of AI systems and their development. Therefore, some thought needs to be given to management and organisational skills if AI systems are to be successfully developed or used. There are also many transversal skills that are needed, particularly skills like critical thinking, design thinking, collaboration and team building. Many people will also need the skill to apply AI and work with the technology, even if they are not high-level AI experts or developers. A general context of digital skills and digital literacy will provide a basic foundation for more advanced skills that relate specifically to AI.

New skills can be said to come from three sources: education, training and recruitment or (im) migration. Education covers the school system, Further Education and Training, and Higher Education, and many people will continue their interactions with this system throughout their careers by means of lifelong learning. Training may also be provided by employers or be taken on by individuals privately. Organisations can also bring in new skills by hiring staff with the skills they require. Government policy can be used to encourage the migration of the talent needed in the economy. Countries and regions compete for the best talent in much the same way that firms do.

1. AI Here for Good, DETE 2021, p 2
2. The Impact of AI on the Labour Market, OECD, p 4

> "AI is described as a general-purpose technology and will have potential application across a broad range of sectors and occupations. Those who are ready for these changes will benefit the most."

In the context of schools, what is important is ensuring basic digital skills and digital literacy for all, from an early age, with an understanding of the implications of AI being integrated over time. A number of strategies, such as the Action Plan for Education[3], the Digital Strategy for Schools to 2027[4] and the STEM Education Policy Statement[5], are responding to the needs of school children.

Further and Higher Education provides more specific, technical courses that relate directly to AI. An important element of this is adult digital literacy. Higher Education needs to provide not only degree and post-graduate specialist courses in AI but also modules that can be combined with other disciplines. Micro-credentials may be an important channel for facilitating such dual-skilling as they become available over the coming years.

Many employers provide training for their staff, but it is recommended in this report that individual workers should not wait for such training to be provided and should seek out the skills they need for their future careers. Both Education and Training Boards[6] and Skillnet Ireland[7] provide a wide range of government subsidised programmes around the country.

A lack of the required skills is seen as possibly the number one barrier to the adoption of AI. Lack of awareness of what AI is and what careers it will affect hinders the development of relevant skills by individuals. Digital literacy needs to improve across the whole of society: a wide range of workers, young and old, will need to get ready for changes to their job roles if they are to reap the potential benefits of AI; and learners need to be prepared for a future that will have increasing levels of technology, including AI, embedded in all aspects of it.

3. https://www.gov.ie/en/collection/b1330-action-plan-for-education/
4. https://www.gov.ie/en/publication/69fb88-digital-strategy-for-schools/
5. https://www.gov.ie/en/policy-information/4d40d5-stem-education-policy/
6. Home - FET Course Hub (fetchcourses.ie)
7. See a list of Skillnet Ireland's regional Skillnets here: View All Our Business Networks | Skillnet Ireland

Overall, this report finds that a very broad range of skills – from specific, technical AI skills to basic digital skills to 'soft' or transversal skills like critical thinking – are needed by workers, learners and educators across the economy. The particular skills that are needed by each individual will depend on their specific role. The main message is that AI skills are not just for AI experts. Everyone will need some knowledge of AI and its implications.

> "The main message is that AI skills are not just for AI experts. Everyone will need some knowledge of AI and its implications."

Due to the broad relevance of AI skills, the report identifies actions that should be taken by individuals, by industry, by the education and training system and by policy makers, legislators and regulators. Each will have a need for certain AI-related skills if they are to reap the benefits, avoid the pitfalls of AI, and be empowered and knowledgeable participants in the economy and society to come.

Many of the actions required are already in train or have been identified in the context of existing national strategies. In addition to delivering on these actions, ten further recommendations are set out at the end of this report and taken together, these actions and recommendations will help to deliver on the key messages of this report.

1 Introduction

1.1 Aim of the Study

AI is becoming an ever more important technology and an ever more common term in everyday conversation. Ireland has recently published its own AI Strategy, AI Here for Good, which sets out eight key themes for AI policy including a range of actions and recommendations. Among those recommendations is a request that the Expert Group on Future Skills Needs carry out an examination of the skills implications of AI, focussing on deployment, management and regulation. This report responds to that recommendation.

The aim of this study is to identify and understand the skills implications of the growth of AI over the next 5 to 10 years. It will act as an introductory paper to uncover the skills-related issues and challenges that will need to be tackled if the opportunities and potential of AI are to be realised. It provides a framework, or common starting place, on which further in-depth skills analysis can be built, and from where specific interventions can be recommended with confidence.

The study takes a broad focus, not limiting itself to high-level, technical AI skills, but considering the skills that will be needed for the deployment, management and regulation of AI. As such, the findings in this report will be relevant for workers in all sectors, for students of all ages, for citizens, and for both public and private sectors.

The report makes recommendations on how Ireland should ensure that the necessary skills are in place for Ireland's adoption of AI over the coming years. It is not intended to set specific targets or KPIs at this point, rather to identify the areas where attention needs to be focussed and where work needs to be done so that Ireland puts the necessary skills in place for AI adoption.

1.2 International Policy Context

The European Commission and the OECD, among others, have set out proposals and recommendations on AI since 2018. One key focus of the Commission has been the ethics around AI and the importance of ensuring that the AI systems we adopt and deploy are trustworthy. In 2021, for example, the Commission released a legislative proposal aiming to ensure that AI is deployed in a way that is safe and respects existing laws on fundamental rights[8]. UNESCO[9] and the Ad Hoc Committee on Artificial Intelligence (CAHAI)[10] of the Council of Europe have developed similar guidelines and initiatives in recent years relating to the ethics of AI deployment.
The European Commission's High-Level Expert Group on Artificial Intelligence produced a set of policy and investment recommendations for AI in Europe which included a section specifically on skills and education.[11] More recently, the Commission has updated its Coordinated Plan on AI for 2021 and included a number of actions for itself and recommended actions for Member States.

In 2019, the OECD published a Recommendation on AI,[12] adopted by all the OECD member countries, describing a set of Principles for AI which include that it should benefit both people and the planet, that it should respect the rule of law, human rights, democratic values and diversity, that it should function in a safe and secure manner throughout its life cycle, and that those "organisations and individuals developing, deploying and operating AI systems should be held accountable for their proper functioning in line with the […] principles".

8. COM(2021) 206 final – Proposal for a Regulation laying down harmonised rules on artificial intelligence
9. Draft text of the Recommendation on the Ethics of Artificial Intelligence - UNESCO Digital Library
10. 16809eccac (coe.int)
11. https://digital-strategy.ec.europa.eu/en/library/policy-and-investment-recommendations-trustworthy-artificial-intelligence
12. OECD – Recommendation of the Council on Artificial Intelligence, 2019

1.3 Approach of the Study

This is a preliminary study of the skills requirements for AI. An expert Steering Group was set up initially to guide the project, Chaired by Professor Barry O'Sullivan (School of Computer Science & Information Technology at University College Cork). A full list of the Steering Group members appears as Appendix E. The Group held a series of meetings from March to October of 2021 involving detailed discussions of skills issues around AI from a number of perspectives. Additionally, an online survey was designed to facilitate consultation with a wider group of stakeholders. This was launched in June 2021 and received almost 370 responses. (The survey questionnaire is provided at Appendix B.) A workshop was also held in June with a broad range of stakeholders and experts from public and private sectors and academia. (A summary of the structure and outputs from the workshop is provided at Appendix C.) This paper reports on the results and themes arising from the workshop and survey, as well as providing an overview of international evidence on AI skills.

1.4 Structure of the Report

The report is divided into seven chapters. A synopsis of each chapter is provided below:

Chapter 1 provides an introduction to the study, its aims and approach.

Chapter 2 examines definitions of AI, its likely impact on the labour market, and considers how Ireland compares with other countries on AI adoption.

Chapter 3 examines international evidence on the specific and transversal skills that will be needed for AI adoption and deployment.

Chapter 4 analyses survey and workshop evidence to consider what specific and transversal skills will be needed by different groups of people who will use AI.

Chapter 5 looks at the supply channels for skills, both digital and AI skills, namely education, training and migration.

Chapter 6 summarises the findings of the study.

Chapter 7 makes recommendations about what needs to be done to ensure Ireland is equipped with the necessary skills for the deployment, management and regulation of AI.

2

AI: Definition, Impact and Adoption

2.1 Definitions

Ireland's AI strategy, AI Here for Good, and the OECD describe AI as follows.

"Artificial Intelligence (AI) refers to machine-based systems, with varying levels of autonomy, that can, for a given set of human-defined objectives, make predictions, recommendations or decisions using data."[13] Machine Learning, a subset of AI, is software which is able to learn from applicable datasets to self-improve, without being explicitly programmed by human programmers.[14]

The European Commission's Communication on AI, 2018,[15] 12 provides a more detailed definition.

What is artificial intelligence?

Artificial intelligence (AI) refers to systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals.

AI-based systems can be purely software-based, acting in the virtual world (e.g. voice assistants, image analysis software, search engines, speech and face recognition systems) or AI can be embedded in hardware devices (e.g. advanced robots, autonomous cars, drones or Internet of Things applications).

We are using AI on a daily basis, e.g. to translate languages, generate subtitles in videos or to block email spam.

Many AI technologies require data to improve their performance. Once they perform well, they can help improve and automate decision making in the same domain. For example, an AI system will be trained and then used to spot cyber-attacks on the basis of data from the concerned network or system.

13. OECD Council Recommendation on Artificial Intelligence, OECD/Legal/0449, (adopted 22 May 2019).
14. AI Here for Good, p 4
15. European Commission, Communication on Artificial Intelligence for Europe {SWD(2018) 137 final)

2.2 What makes AI Different?

AI is seen as a general-purpose technology[16], like the steam engine, electricity or the internet and, as such, will have broad ranging impacts on the economy and society. AI can contribute to automation of tasks but is likely to complement rather than replace human beings in many cases. While many sectors and job roles will be exposed to AI, this does not mean that these jobs will be lost,[17] rather that jobs will change: some tasks will be automated, and humans will focus more on the things that AI cannot do quite as well.

The AI skills workshop held in June 2021 as part of this study identified a number of themes in this context. Asked what makes AI different from other technologies, participants commented that there may be some popular misunderstanding of what AI is amongst the public, and this could be fed by media and science fiction. Linked to this may be a fear factor that AI will cause substantial job losses. Education is therefore required to spread an awareness of what AI really is, and what are the real opportunities as well as its limitations. Despite this, it remains the case that technology is advancing quickly, and AI is not a future technology, but a current one, with AI assistants, search engine optimisation, spell checkers, and so on, being part of our everyday lives already. The potential for opaque use of personal data, however, fuels concerns for some people around privacy and accountability.

2.3 AI and the Labour Market

According to the OECD[18], AI is not likely to result in net job losses, but it will affect a wide range of jobs. This is consistent with what has been found for digitalisation as a whole[19]. The EGFSN's Digital Transformation report, 2018 finds that "One in three jobs in Ireland are at high risk (a probability greater than 70%) of being disrupted by the adoption of digital technologies. Much of the disruption, however, will result in changes to job roles and tasks performed by individuals rather than job losses."[20]

Whether jobs are transformed rather than replaced will depend, to a great extent, on how well the strengths of AI and the strengths of human beings can complement each other within each job. In general, high-skilled jobs are more likely to see such complementarity while some lower-skilled jobs, more open to automation, may be lost. Ireland's National AI Strategy, AI Here for Good, states that, as with other technologies, AI will create "winners and losers" so the challenge for policymakers will be to ensure that the benefits from the jobs of the future are shared by all workers.

It is likely that many high-skilled jobs will change, with certain tasks being taken over by AI systems, but other tasks, more suited to human intelligence, will continue to be done by people. On the other hand, some low-skilled jobs will be automated by AI, just as jobs have been replaced by other technologies in the past. People in high-waged jobs could therefore benefit more from AI-adoption, potentially leading to increased income inequality. The OECD[21] highlight the need for reskilling and lifelong learning to weather potential job losses and navigate transitions to new jobs.

AI appears likely to increase productivity, but it remains difficult to see this effect in the data.[22] In theory AI should improve productivity by assisting workers in the execution of tedious or physically

16. Examples of General Purpose Technologies (GPTs) range from the domestication of plants and animals, 10,000 years ago, to mass production, the computer, the internet and biotechnology, more recently. General Purpose Technologies have the potential to affect the economy and society very broadly, not just in relation to specific sectors or activities.
17. The Impact of AI on the Labour Market, OECD, p 9
18. The Impact of AI on the Labour Market, 2021, OECD
19. The Anatomy of Employment in Ireland – Goldrick-Kelly, P, et al - Nevin Economic Research Institute Working Paper, April 2021, p 50
20. EGFSN – Digital Transformation: Assessing the Impact of Digitalisation on Ireland's Workforce, 2018, p 7
21. The Impact of AI on the Labour Market, 2021, OECD
22. A so-called 'productivity paradox'. See OECD – The Impact of AI on the Labour Market, Jan 2021, p 27

demanding tasks, while allowing workers to leverage their own uniquely human abilities. How this potential productivity increase will benefit workers – either by increasing demand for labour or driving up wages – may depend on which AI systems are adopted and on how workers can reskill to ensure that AI complements their jobs rather than replacing them. If AI is applied with the singular motivation to cut costs, it could entail significant risks for the work environment.

AI may already be more prevalent in the workplace than many people realise. The German Institute for Economic Research (DIW) recently found that a random sample of workers substantially underestimated how many of their tasks are regularly completed with assistance from AI-based systems. Asked directly whether they "work with digital systems at your workplace that use artificial intelligence or machine learning", 20% answered that they did. However, asked indirectly whether they worked with systems that "recognize and process language or language commands", "recognize and process pictures and photos", recognize and process handwriting, texts, and numbers", or "answer questions about specialized knowledge", 45% of respondents said that they use at least one of these four AI-based systems at least weekly.[23]

2.4 AI Adoption in Ireland

The European Commission's Enterprise Survey on AI, 2020,[24] shows Ireland to be below the EU average for AI adoption with 35% of enterprises using at least one AI technology compared with 42% of firms across Europe. When it comes to those using at least two AI technologies, Ireland is in the bottom three countries in the EU at 14% of firms compared with a 25% average for all EU enterprises. Europe's 'Digital Decade' is to propose that 75% of firms will be using at least two AI technologies by 2030.[25] 52% of Irish firms are not using AI at all and not planning to use it, whereas the EU average is 40% of firms.

Categorised by firm size, all size categories of firms in Ireland lag the EU average for AI adoption. However, micro firms (5-9 employees) are almost on par with the EU27 average, whereas large firms in Ireland (250+ employees) lag the most behind.

Perceived barriers to AI adoption, when compared to all EU enterprises, show Ireland more significantly blocked by "insufficient or incompatible IT infrastructure" and "lack of internal data" rather than a "lack of skills among existing staff".[26] Irish firms also perceive "reputational risks linked to using artificial intelligence"[27] as a much bigger barrier than average for all European enterprises. However, difficulty of hiring new staff was perceived as the biggest barrier to AI adoption by Irish firms in the EU study, as it is for firms across the EU. Irish firms report significant skills gaps in the areas of cloud computing, programming and machine learning or modelling, compared with our European neighbours.

In contrast to the results of the European Commision survey, LinkedIn found[28] that Irland has the highest share of its active labour force with AI skills in the European labour market, and suggest that this may be due to "the strong presence of technology companies in the country". These skills may be highly concentrated within technology multinationals however, and not dispersed across other sectors.

23. Artificial intelligence in Germany: employees often unaware they are working with AI-based systems, by Oliver Giering, Alexandra Fedorets, Jule Adriaans, and Stefan Kirchner - DIW Weekly Report No.48 2021, p373 - dwr-21-48-1.pdf (diw.de)
24. European enterprise survey on the use of technologies based on artificial intelligence, European Commission, 2020
25. See COM(2021) 574, Proposal for a Decision of the European Parliament and of the Council – establishing the 2030 Policy Programme "Path to the Digital. Decade", European Commission, 2021, Article 4, p 23 - resource.html (europa.eu)
26. Enterprise Survey of AI, European Commission, 2020, p 105
27. For example: "unfair or discriminatory algorithms, unreliable or malfunctioning outcomes, misuse of personal or confidential data", and so on – See: Understanding the reputational risks of AI, Charlie Pownall, CPC & Associates: (PDF) Understanding the Reputational Risks of AI (researchgate.net)
28. AI Talent in the European Labour Market, LinkedIn, 2019, p 3

3

Skills for AI - International Evidence

3.1 Categories of Skills Needed

Both technical and transversal skills are needed for AI jobs

The World Economic Forum Future of Jobs 2020 report identifies the typical skills needed for roles in data and AI jobs (based on LinkedIn data)[29] as well as pointing out where the skill gaps have tended to be when people have transitioned to such jobs in the past. Artificial Intelligence was found to be experiencing the largest skills gap among the sixteen skills listed, with other closely associated skills also near the top of the list (see Table 1). The skills gap was defined based on workers moving into these roles over the past five years; where the gap indicates the level of training and learning required between the previous and new role. Hence, many roles in Data & AI require significant investment in upskilling.

Table 1

Skill Gaps for Skills Needed for Data & AI Jobs
(WEF Future of Jobs Report 2020)(1 = Full Gap; 0 = No Gap)

Skills Needed for Data & AI Jobs	Skill Gap (1 = gap; 0 = no gap)
Artificial Intelligence	0.9
Natural Language Processing	0.89
Signal Processing	0.85
Data Science	0.81
Cloud Computing	0.73
Data Storage Technologies	0.59
Scientific Computing	0.59
Development Tools	0.27
Computer Networking	0.22
Management Consulting	0.15
Information Management	0.07
Product Marketing	0
Digital Marketing	0
Advertising	0
Customer Experience	0
Software Development Life Cycle (SDLC)	0

29. Future of Jobs Report 2020, World Economic Forum, p 37

The World Economic Forum[30] has also identified what employers view as the 15 top skills, more generally, for 2025[31], listed in Table 2, below. Only three of these skills are technical (technology use, technology design, systems analysis). The remainder may be considered to be transversal skills. This highlights the diverse range of skills that will be needed by people working with AI. The OECD has pointed out that the skills that people will require in order to adapt to AI will not only be "AI-related skills" but "skills in areas that AI cannot perform so well, such as creative and social intelligence, reasoning skills, and dealing with uncertainty."[32] The development of AI systems themselves will also require a diverse range of transversal skills. For example, AI innovators and users will need organisational and management skills to facilitate the complex, cooperative and iterative nature of developing AI systems. Those developing or employing AI systems must also have a keen knowledge of the ethics involved, in order to avoid any unintended or unwanted consequences that might arise from using AI systems to help make decisions that affect people.

Table 2

Top 15 Skills for 2025
(WEF Future of Jobs Report 2020)

Top 15 Skills for 2025	**Number**
Analytical thinking and innovation	1
Active learning and learning strategies	2
Complex problem-solving	3
Critical thinking and analysis	4
Creativity, originality and initiative	5
Leadership and social influence	6
Technology use, monitoring and control	7
Technology design and programming	8
Resilience, stress tolerance and flexibility	9
Reasoning, problem-solving and ideation	10
Emotional intelligence	11
Troubleshooting and user experience	12
Service orientation	13
Systems analysis and evaluation	14
Persuasion and negotiation	15

30. The Future of Jobs Report 2020, World Economic Forum, p 36
31. Ibid, p 35: "... skills and skill groups which employers see as rising in prominence in the lead up to 2025" – not specific to AI jobs – data collected in the WEF Future of Jobs Survey 2020
32. OECD – The Impact of AI on the Labour Market, 2021, p 9

Additionally, the WEF report[33] lists the top 20 job roles likely to experience increasing demand – see Table 3. AI and Machine Learning Specialists come out as the second ranked job role likely to see increasing demand. However, a number of the other roles in this list can be considered adjacent to, or supportive of, AI adoption, including, for example: Data Analysts and Scientists, Big Data Specialists and Digital Transformation Specialists, for example. The need to fill skills gaps is ever the more important as demand for AI roles increases.

Table 3

Job Roles Likely to Experience Increasing Demand
(WEF Future of Jobs 2020)

Rank	Job Roles likely to experience Increasing Demand
1	Data Analysts and Scientists
2	AI and Machine Learning Specialists
3	Big Data Specialists
4	Digital Marketing and Strategy Specialists
5	Process Automation Specialists
6	Business Development Professionals
7	Digital Transformation Specialists
8	Information Security Analysts
9	Software and Applications Developers
10	Internet of Things Specialists
11	Project Managers
12	Business Services and Administration Managers
13	Database and Network Professionals
14	Robotics Engineers
15	Strategic Advisors
16	Management and Organization Analysts
17	FinTech Engineers
18	Mechanics and Machinery Repairers
19	Organizational Development Specialists
20	Risk Management Specialists

33. Future of Jobs 2020, WEF, p 30

The WEF results discussed above are consistent with job postings analysis by the OECD[34] which found that AI-related skills such as Natural Language Processing and deep learning are becoming increasingly popular, while transversal skills related to communication, problem solving, creativity and teamwork have also gained relative importance over time. The OECD found that skills related to AI appear to be in demand across almost all sectors of the economy, although are most frequently demanded in NACE sectors "Information and Communication", "Financial and Insurance Activities" and "Professional, Scientific and Technical Activities".

3.2 Skills barriers to AI Adoption

Section 2.3 discussed the potential labour market impacts of the increased adoption of AI. Overall, evidence to date points to AI replacing individual tasks rather than whole jobs, while there is also likely to be growth, productivity and competitiveness gains from increased AI-usage. However, in order for any potential gains to materialise, AI first needs to be adopted. The WEF Future of Jobs 2020 report[35] lists nine perceived barriers to the adoption of new technologies – see Table 4, below. The top three barriers involve skills gaps.

Table 4

Perceived Barriers to Adoption of New Technologies
(WEF Future of Jobs Report 2020)

Perceived Barriers to the Adoption of New Technologies	% of Companies Surveyed
Skills gaps in the local labour market	55.4
Inability to attract specialized talent	46.7
Skills gaps among organization's leadership	41.4
Insufficient understanding of opportunities	38.9
Lack of flexibility of the regulatory framework	33
Shortage of investment capital	32.3
Lack of flexibility in hiring and firing	26.3
Lack of interest among leadership	17.9
Other	5.3

34. Demand for AI skills in jobs: Evidence from online job postings, OECD, 2021 3ed32d94-en.pdf (oecd-ilibrary.org)
35. Future of Jobs 2020, WEF, p 35

The EU Enterprise Survey on the Use of Technologies based on Artificial Intelligence 2020 asked over 9,500 enterprises across Europe the perceived barriers to AI-adoption. 85% of the respondents to the EU survey identified the difficulty of hiring new staff with the right skills as a relevant barrier for them. Difficulty of hiring staff was ranked as the most important obstacle, above cost, complexity or IT infrastructure. In terms of specific skills, enterprises identified 'programming skills' as the most needed skill to facilitate AI-adoption, followed by 'big data management skills' and 'machine learning skills'. The results from the survey are found in Table 5, below:

Table 5

Specific Skills Needed by Enterprises for the Adoption of AI
(EU Enterprise Survey on the Use of Technologies based on Artificial Intelligence 2020)

AI Skills Needed	% of Enterprises
Programming skills	52
Big data management skills	43
Machine learning skills	39
Cloud computing skills	33
Robotics skills	31

One final potential labour-related barrier to AI adoption is the underrepresentation of women in the sector. AI Here for Good notes that 75% of workers in AI and data science in Ireland are men. The strategy also points to a 2018 European Commission study on 'Women in the Digital Age' which estimates an annual productivity loss of EUR 16.2 billion to the EU economy due to women leaving digital jobs. It is important that government and firms encourage workers from a diverse range of backgrounds to help fill skill gaps.

4

Skills Demand for AI – Survey and Workshop Evidence

4.1 Survey and Workshop Methodology

A survey and workshop were undertaken as part of the research for this project. The survey was circulated to contacts of Steering Group members and their organisations, stakeholder groups of the Department of Enterprise, Trade and Employment and other Departments, and via social media. The overall response rate to the survey was just over 370. A detailed breakdown of the response cohort can be found in appendix A2.

Every effort was made to circulate the survey as widely as possible, but it was not feasible within the timeframe of this study to survey the whole population of Ireland in a representative manner. As the survey respondents were self-selected, the results may not necessarily represent the opinions of the population at large. For example, 39% of respondents worked in the public sector. Care should therefore be taken when interpreting these survey results and the results should not be accorded the same weight as data from international published studies, referenced elsewhere in this report.

The survey had four sections, targeted at different groups likely to be affected by AI:

1. Users & Innovators
2. Educators
3. The Public
4. Policy Makers, Legislators and Regulators.

The four groups were defined as follows:

Users & Innovators	End-users of AI systems; those who work routinely with AI systems – including, but not only, AI experts ... and ... those who develop new and improved AI systems and applications.
Educators	Teachers, researchers, lecturers, trainers, mentors
The Public	Ordinary members of the public who will use and be impacted by AI in everyday ways.
Policy Makers, Legislators & Regulators	Those in the public sector who must understand AI well enough to legislate, regulate, procure, draft policy, support enterprise, etc.

Respondents could choose which group represented them best and could choose to answer in more than one group, if they wished. Questions were designated either 'Select all that apply' or 'Select the most relevant'. In the latter case, percentages add up to 100%, but in the former case, they will not. In the 'Select all that apply' cases, therefore, percentages should be interpreted as indicating a ranking of the available options.

Also as part of this study, a workshop was organised in June 2021 to explore the issues around AI Skills in detail with a broad group of stakeholders. Workshop attendees were invited in a similar manner to that of the survey. Almost 80 people attended from the public sector, industry and the education and training sectors. The workshop ran for four hours and was structured along the following key themes:

1. Specific Skills needed for AI
2. Demand for Skills
3. Supply of Skills
4. "What are the Big Challenges?"

4.2 Users and Innovators: Survey and Workshop Results

AI Users and Innovators are end-users of AI systems; those who work with AI systems – including, but not only, AI experts. They may work in industry, the public sector, education or research.

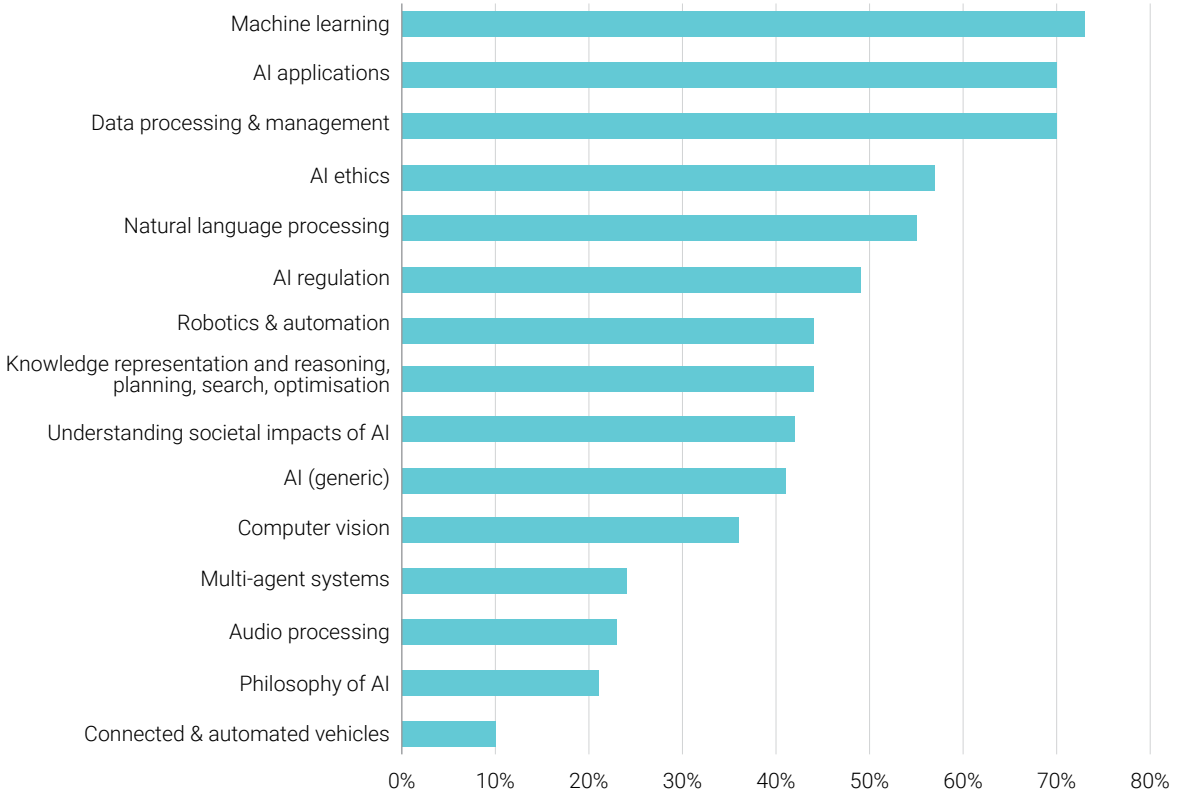
In the survey, Users & Innovators were asked questions about technical AI-related skills as well as the organisational and management skills needed to manage the adoption or development of AI systems.

Firstly, in terms of AI-related technical skills, AI Users and Innovators believe that they most need skills in machine learning, AI applications and data processing and management in order to adopt or expand on their use of AI. A full list of AI-related technical skills is found in Chart 1.

Chart 1

AI-related Technical Skills Needed by Users & Innovators

(DETE AI Skills Survey; n = 162



Question (for AI Users & Innovators):
In order to adopt or expand on your use of AI, what technical skills will your organisation need to make this happen?
(Select all that apply.)

These survey results are consistent with responses from the workshop. Specific skills identified as important for AI innovators during workshop discussions included: software engineering and development, high end data analytics, data engineering, data infrastructure, real-time edge computing, as well as AI engineers and data architects.

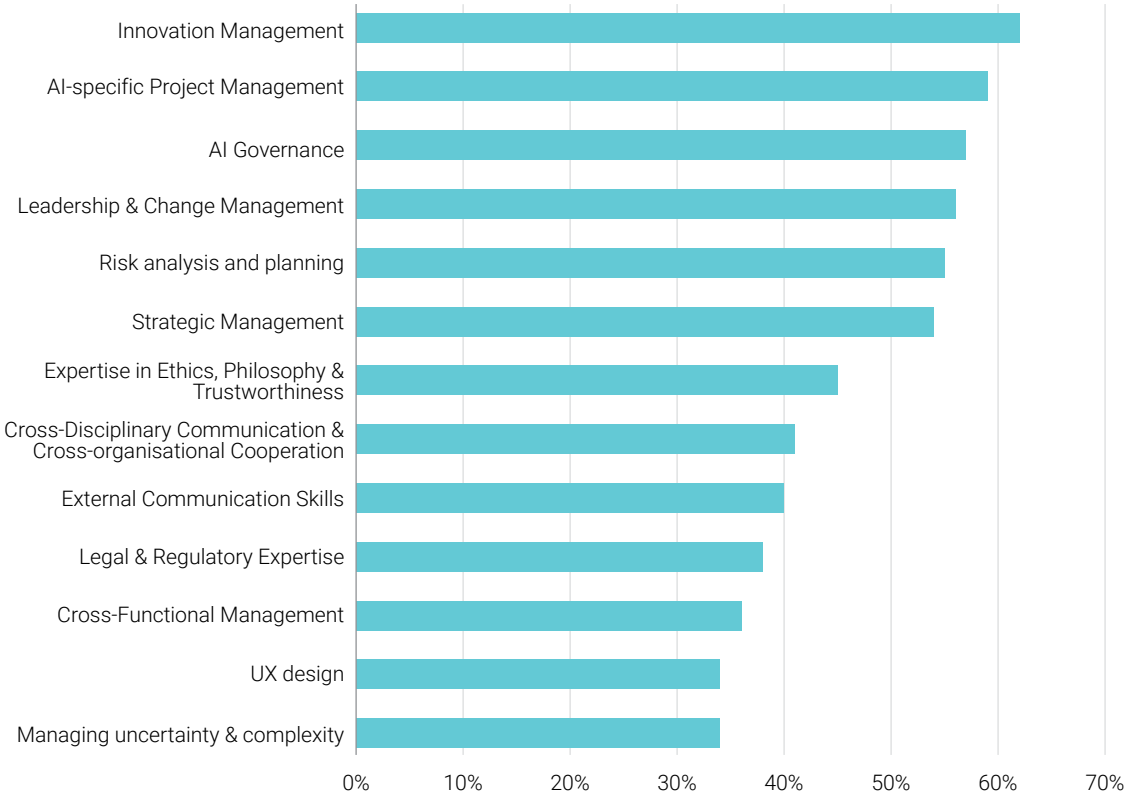
It was suggested in workshop discussions that the necessary level of critical thinking required for some AI projects can only be found at PhD level, once a person has already conducted their own research and hypothesis testing. It was considered unlikely that a new graduate would have all the necessary skills, so an in-house training capacity would be of some importance for those firms who need to develop their employees further. It was proposed that the required skills could alternatively be accumulated through micro-credentials, for example.

It is likely that many of the employees essential to an organisation that adopts AI do not need to be high-level AI experts. Many will just need a basic knowledge of what it is, how it works and what its potential is. To this end, Users & Innovators were also asked what organisational and management skills they would need to adopt AI successfully. Users & Innovators were seen to need a broad range of organisational and management skills, headed by innovation management.

Chart 2

Organisational & Management Skills Needed by AI Users & Innovators

(DETE AI Skills Survey; n = 162)



Question (for AI Users & Innovators):
In order to adopt or expand on your use of AI, what organisational and management skills (excluding technical / ICT skills) will your organisation need to manage this process?
(Select all that apply.)

The organisational and management skills outlined above were also thought of as being key in workshop discussions. Dual-skilling will be an important component for individuals, whereby they combine their domain-specific skills with a knowledge of AI. Developers will need to understand the consequences of their coding, for example in terms of ethics and fairness, regulation, or the environment. Operationalising AI will require both technical and non-technical skill-sets – for

example, risk management and governance. Skills are likely to be required around the growing use of machine learning in software development and IT operations, linking this with regulatory compliance, trustworthiness and transparency. There are also technical and non-technical skills needed around data bias in the context of AI. Future innovators may not need a degree in computer science, so low-code and no-code solutions would facilitate the transition to hybrid roles.

Of some importance here is the question of how to work more effectively in multi-disciplinary teams. The range of skills needed for many AI projects is broad and the whole range of these skills will not be found in any one person. Therefore, an ability to work together cross-functionally is increasingly important. As in other areas, diverse perspectives are needed, bringing, for example, technical and design knowledge to bear on various challenges. The pharma industry provides an example of how this is done in the context of that sector's (non-AI) needs, where training systems are already about the collective skillset – integrating critical thinking, systems engineering, systems thinking, interactions with processes and regulators, etc.

Many workshop participants pointed to the importance of considering smaller companies, particularly those who are not yet AI Innovators. In many of these cases, there are some obstacles that need to be overcome, such as a lack of awareness or basic fear of AI. A new technical person cannot realistically be hired until there is a role for them to fulfil. This means that the organisation and, in particular, the top levels of owners and managers, need a sufficient understanding of what AI can do if they are to make the necessary changes throughout the organisation. There is therefore a need for management to upskill sufficiently to be able to start on the AI journey. Managers need a basic understanding of what AI can bring to their organisation and what the steps are towards making that a reality. Short courses offering micro-credentials may supplement non-AI expert's current skills sufficiently. There are also a number of online resources[36] that many people may find useful.

4.3 Educators: Survey and Workshop Results

Broad Skill Needs for Students and Educators

Throughout this project, Educators were broadly defined as including teachers, lecturers, trainers and mentors. Discussions with workshop participants tended to focus on the skills needed by learners in schools, and therefore the skills needed by teachers.

Educators (with a separate question relating to students) were asked about broad skills with the following categories: (1) awareness and understanding of AI, (2) soft skills (transversal skills) (3) digital skills and (4) AI-specific skills.

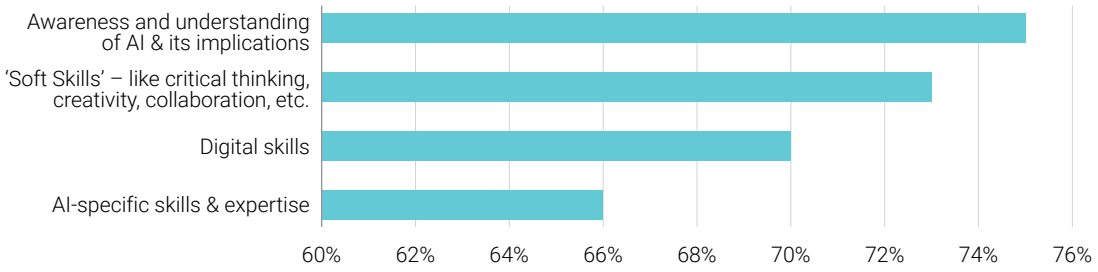
Students were seen to need a relatively even mix of these four skill areas – slightly less for AI-specific skills and slightly more for awareness of its implications. Soft skills come a close second to awareness and understanding for students (Chart 3). Educators meanwhile were seen to need a high level of AI-specific skill and expertise, but fewer soft skills (Chart 4).

36. such as Udacity, Coursera and ed-X, for example, as well as the Elements of AI.

Chart 3

Broad Skills Needed by Students

(DETE AI Skills Survey; n = 146)

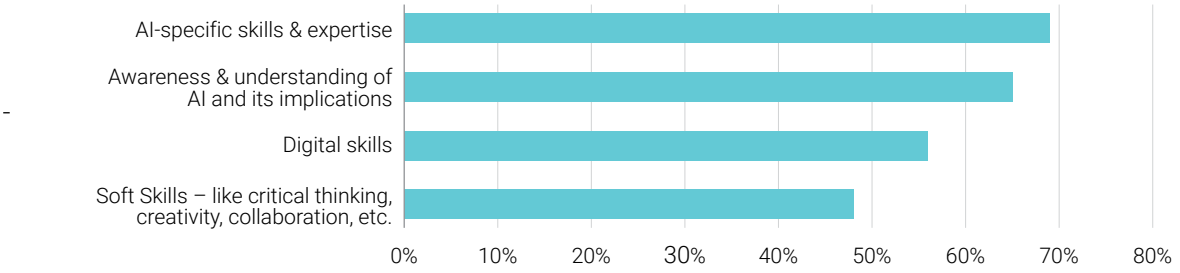


Question (for Educators):
What skills should your organisation be imparting to students / learners / trainees so that they are fully prepared for what AI will bring in the next 5-10 years?
(Select all that apply.)

Chart 4

Broad Skill Areas Needed by Educators

(DETE AI Skills Survey; n = 146)



Question (for Educators):
What skills do you and your colleagues [Educators] need to make this happen [… to impart necessary AI-related skills to students and / or to use AI systems to support the work of teaching]?
(Select all that apply.)

During workshop discussions, some of the key skills that children are seen as likely to need include the following: analytical skills, mathematics, fundamental coding, algorithmic thinking,[37] creative thinking and problem solving. These skills need to be taught in schools so that all children are provided with the opportunity to develop them and can be supported by informal learning outside school. The acquisition of such skills must not depend on a child's access to broadband and computers at home.

37. Can be described as: "Creating a set of ordered steps (sequencing) and then doing them in a particular order to solve a problem or accomplish a task in a way that could be repeated by others (using an algorithm)." -See What is Algorithmic Thinking | IGI Global (igi-global.com)

There are a number of subjects at Senior Cycle that would provide a good grounding for future AI users. However, workshop participants believed that the theoretical approach of some curricula may need to be supplemented with practical applications. It has been suggested that AI can be brought into multiple areas in school, including mathematics, art, history and language classes. There are aspects of AI that relate to each of these. Making AI real is likely to attract more learners to consider STEM and AI-related subjects.

In this context, improving awareness of AI in schools would yield benefits. Visits from experts to schools, either to talk to teachers or students, are seen as very valuable. Ideally, this should be an ongoing activity, not just a one-off initiative around a specific report or strategy. However, how widespread or consistent this practice is needs to be assessed.

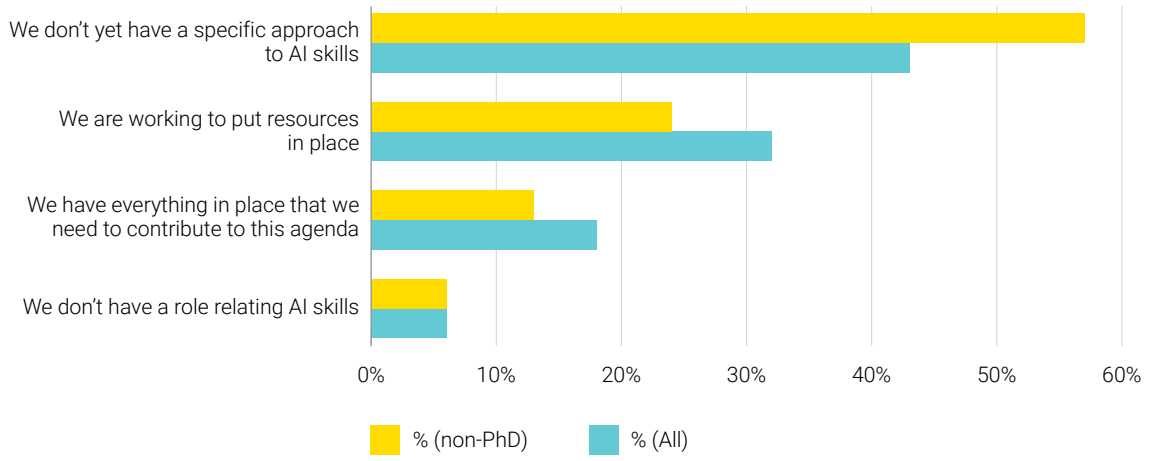
Consistent with survey results, workshop participants believe that teachers in schools do not need to be AI experts but just need an understanding of the core elements of AI. Many of the skills needed by teachers are already available through their existing CPD and some will also be relevant to STEM education.

Preparedness for AI among Educators

During the survey, Educators were asked how well prepared they feel their organisations are for the adoption and deployment of AI. Only 6% of educators said they believed they had no role relating to AI skills. However, 43% said that their organisation did not yet have a specific approach in place. Filtering out those with PhDs as a proxy for Third Level educators, the ranking remains the same and 6% continue to say that they have no AI-related role. However, the proportion who do not have a specific plan in place rises from 43% to 57% for educators not in Third Level institutions (based on this proxy assumption). Overall, 50% of educators state that they either have everything in place or are working to put resources in place. When PhD respondents are removed, 13% have everything in place and 24% are working to put resources in place (adding up to 37%).

Chart 5

Preparedness of Educators for AI (Comparison of those with PhDs with all respondents)
(DETE AI Skills Survey; n = 146)



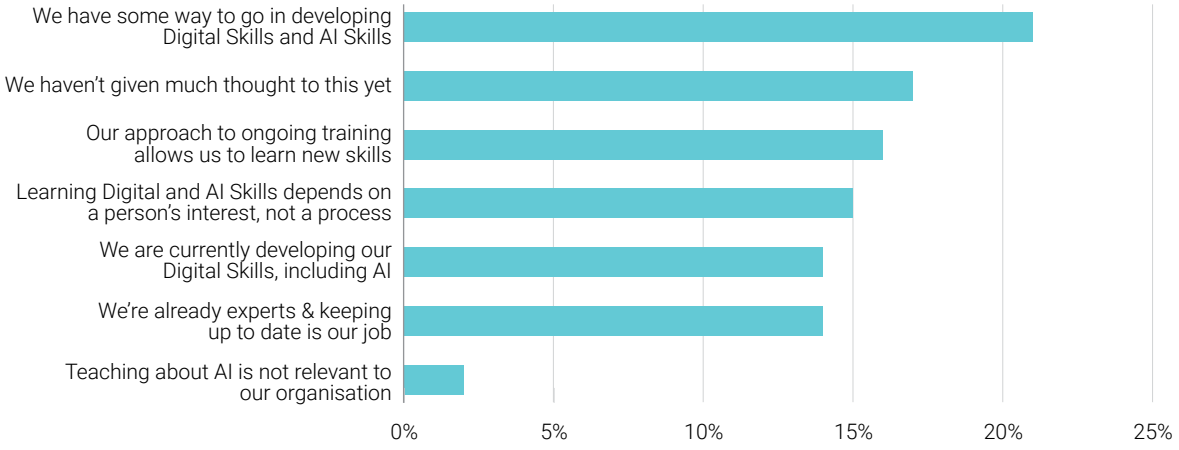
Question (for Educators):
How well prepared is your organisation for the adoption and deployment of AI?
(Select the most relevant.)

Educators were also asked whether they have systems in place to support the necessary upskilling in their organisations. At the extremes of the scale, 21% of respondents stated that they are already experts while 19% responded that they had not yet given the matter much thought or that AI is not relevant to their organisation. Some 15% of respondents believed that the learning of Digital and AI skills depends on a person's interest and is not systematically taught across institutions (Chart 6).

Chart 6

Systems & Preparedness for All Educators

(DETE AI Skills Survey; n = 146)



Question (for Educators):
Do you have a system in place to ensure you can gain the skills you need?
(Select the most relevant.)

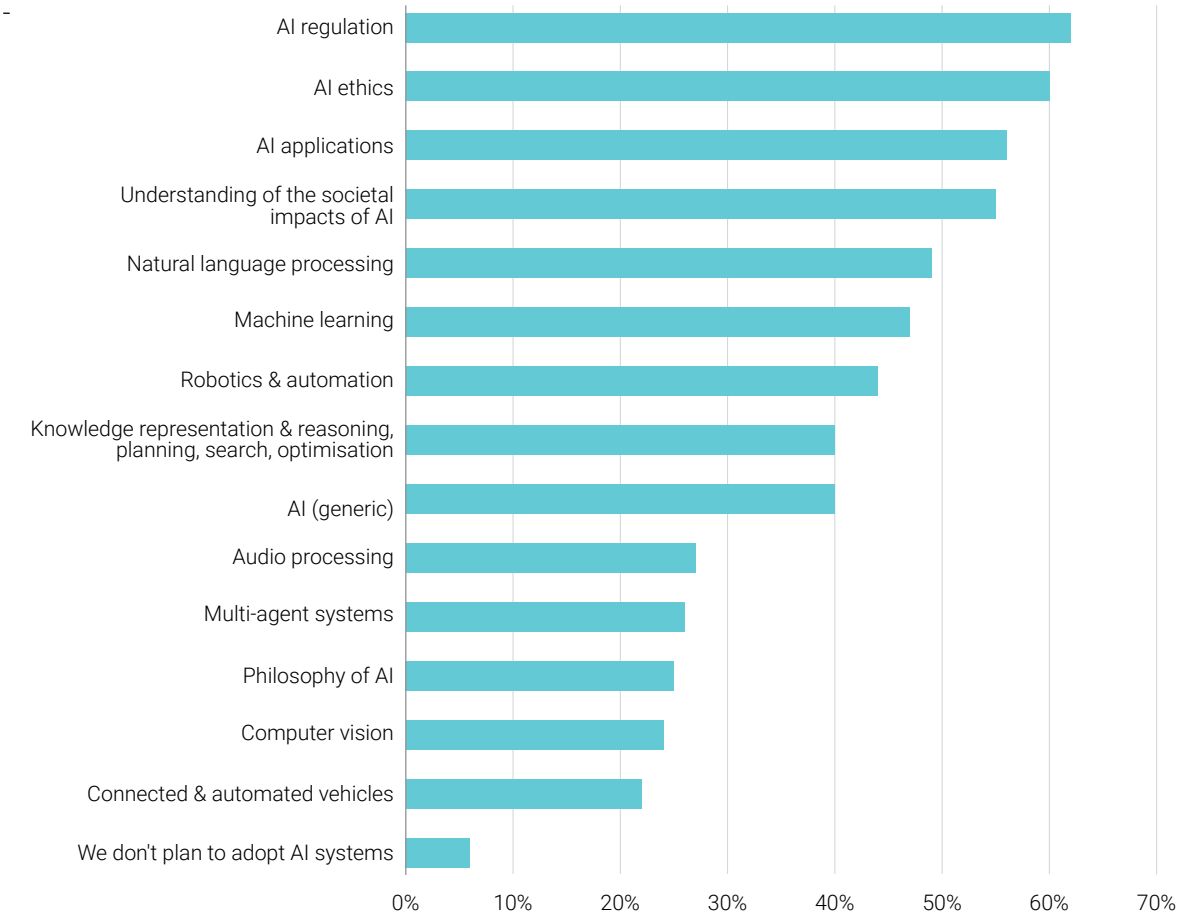
4.4 Policy Makers, Legislators and Regulators: Survey and Workshop Results

For the purposes of this study, Policy Makers, Legislators and Regulators have been defined as those in the public sector who must understand AI well enough to legislate, regulate, procure, draft policy, support enterprise, etc. Survey data suggests that Policy Makers are seen primarily to need skills in AI regulation and AI ethics, as well as AI applications and understanding the societal impacts of AI.

Chart 7

AI-related Technical Skills Needed by Policy Makers, Legislators & Regulators

(DETE AI Skills Survey; n = 89)



Question (for Policy Makers, etc.):
If you plan to adopt or expand on your use of AI, do you know what technical skills your organisation will need to make this happen?
(Select all that apply.)

Participants at the AI skills workshop commented that policy makers need to: understand the difference between basic task automation and AI – otherwise they may regulate for the wrong things; understand the implications of regulation on innovation and consider all the nuances – so need a deeper understanding of the technologies to do that; understand the positives of AI, not just the fear – and regulate accordingly: every technology has multiple uses.

As in the private sector, it is not realistic to expect that one individual will have all the necessary skills for dealing with AI – it is the skills combined with the structure that is important. This should be seen as a skills ecosystem. The focus here should not only be on hard skills, but on other skills required in an AI environment such as ethics and governance.

It is essential that the civil and public service has the required expertise and capacity to lead in this space. The civil and public service should put in place a range of AI skills development building blocks in partnership with educational institutions. Commitments in the Civil Service Renewal 2030 Strategy[38] will be central to this. A knowledge and understanding of AI should be integrated into the 'Digital First' culture envisioned in that strategy, so that those who work with AI systems, in whatever capacity, will have the skills they need to do their jobs effectively.

It is important to remember that the public sector is also a potential user of AI, not only the legislator and regulator. The relevant public servants need to be made aware of the courses that are available and appropriate to their future work. Courses are being developed by the Department of Public Expenditure and Reform and are actively being advertised throughout the Public Service with the first cohort starting in late 2021[39].

In terms of preparedness for the regulation, legislation and policy making around AI, 6% of 'policymaker' survey respondents stated that they are one of the leaders in this space and 33% know they will have a role and are preparing for it. More than half of respondents (51%) did not yet know what their role will be in this context, however, highlighting the need to integrate an understanding of AI into the 'Digital First' culture envisaged by the Civil Service Renewal 2030 Strategy.

38. gov.ie - Civil Service Renewal 2030 (www.gov.ie)
39. Foundations of AI level 8 Certificate Course (TUD award)

4.5 The Public: Survey and Workshop Results

The public here are defined as ordinary members of the public who will use and be impacted by AI in everyday ways. Survey respondents saw **the general public** as needing awareness and understanding of AI's implications above all else, rather than being in need of AI-specific skills.

The public should have trust in AI systems if they are to use and interact with them, and this requires effective communication from Government about relevant regulation, ethics, privacy issues and so on. During workshop discussions, influencers were considered to be an important constituency in terms of informing the public about AI in a way that is clear, intelligible and independent. The recent appointment of Dr Patricia Scanlon as AI Ambassador by Minister Troy is likely to make a significant contribution to how the public are informed about AI over the coming years.

Workshop participants emphasised how people need to prepare as the profile of jobs in the economy changes. Upskilling and reskilling should not wait until people have lost their jobs or after job roles change. It is necessary to connect with hard-to-reach people, those who might not normally engage with lifelong learning, and incrementally change attitudes, helping people to start building their skills.

There will be different impacts on people at different stages of their career, at different ages, and with different levels of education. Initiatives must therefore target early, mid- and late-career workers – there will be different needs at each stage. Additionally, the digital divide needs to be addressed. This means acquiring basic skills, not necessarily those needed for high-tech jobs. At present, 900,000 people in the workforce have NFQ Level 5 certification, or less. There is therefore a need to encourage and support lifelong learning across the board.

4.6 Survey and Workshop Conclusions

The bottom line is: different groups will need different skills depending on how they interact with AI. For many people, basic digital skills plus an awareness of AI may be enough.

Unsurprisingly, **AI Innovators and Users** will need the most technical and high-level AI skills. Dual-skilling will be required, whereby they combine their domain-specific skills with a knowledge of AI. However, beyond this, organisations that use or plan to use AI will need specific organisational and management skills to deal with AI product development, procurement, use, deployment, and so on. It is this combination of technical digital skills with non-digital (including managerial and organisational) skills that may determine the success of an AI project. Because AI systems can be complex and difficult to understand, and can result in unintended or unexpected consequences, they can require a broader approach to management than with some other technologies. This is likely to require technical people with high-level AI skills to interact with managers, data scientists, lawyers, regulators, process auditors, and so on. And it is likely to require those who are not AI specialists to understand more about AI and its implications. In short, it requires multi-disciplinary teams, so the skills needed for AI-related projects should not be seen as the skills needed by any individual, but the broader range of skills needed by the whole team.

Similarly, **Policy Makers, Regulators and Legislators** need to understand AI well enough to draft strategies and laws, to regulate effectively and to procure and manage AI systems such that they work in a trustworthy manner.

Educators can make use of AI systems to support teaching. However, they cannot impart the necessary understanding of AI and its implications to learners until they have undergone the appropriate training and education themselves. Transversal skills, such as critical thinking, creative thinking and data analysis are considered as extremely important for anyone wishing to work with AI during their career. Foundations in these transversal skills start an early age. It is important that these skills are developed through both formal and informal education.

The General Public already interact with AI systems like search engines, voice assistants, bots, and so on. The more exposure people have to these systems, the more important it will be that they have a basic understanding of how they work and what to watch out for. It is important that the public have trust in AI systems and this requires both that the systems themselves are, in fact, trustworthy and that members of the public have sufficient confidence and knowledge to use them in an active and empowered manner.

Many people and organisations have not yet started to prepare for the adoption and use of AI. About half of educators and policy makers have no specific plan for the adoption and use of AI, as yet. Reports suggest that SMEs are often either afraid of adopting AI or do not know what steps to take to make it a part of how they run their firm.

5

Skills Provision (Supply)

5.1 Supply Channels for Skills

The supply of skills can come from training, education or hiring / migration. Hiring works for firms and organisations when the labour market already has the needed skills, and when pay and conditions are sufficient to attract those with the required talents. Talent attraction works for countries in the same way.

The range of skills required for the deployment, management and regulation of AI is so broad that it requires all areas of education and training to be considered. Beyond hiring, firms and public bodies need to provide training and support lifelong learning for their employees. Individuals need to look to the future and assess their own skillset in the light of changes in technology and the labour market.

Though this report is focused on AI skills, it is essential to underline the importance of digital literacy as a foundation not only for high-level AI skills, but also for working with and using AI systems as they become more embedded into our lives, both in work and outside it.

Schools have an important role here, ensuring that learners leave school with a sufficient understanding and proficiency in digital technologies. Learners may decide to choose ICT-related or AI-related fields as they progress, so appropriate courses need to be available at junior and senior cycles and through further and higher education, training, and apprenticeships.

A commitment to lifelong learning is an empowering choice for anyone wanting to become more specialised in their career or to improve their job-market attractiveness, but it could also be a career saving choice for those who may have fallen behind the curve in digital literacy, or those whose roles may be at risk of automation, whether by AI systems or other advances in technology.

5.2 Supply from the Education System

What is already happening: Digital Skills

Ireland's National Skills Strategy 2025 sets out a comprehensive range of Objectives and associated Actions, aimed at making the education system fit for the 21st Century. Many of the Actions are focussed on areas that have been identified as important for AI skills. In relation to STEM, the strategy commits, for example, to increase the level of uptake of STEM at second level and to support the retention of students on higher education courses, particularly in STEM disciplines. Additionally, it commits to ensuring that "assessment supports learning and provides evidence of learning transversal skills and knowledge across the sector" and to promoting "the development of transversal skills at all levels of the education and training system".

The Digital Strategy for Schools to 2027[40] aims to "empower schools to harness the opportunities of digital transformation to build digital competence and an effective digital education ecosystem". Pillar 1 will support teachers "to strengthen their confidence and competence in using digital technologies in teaching, learning and assessment" with the aim of ensuring that "all learners develop the digital skills necessary to navigate a complex digital world". Pillar 2 commits to ensuring that all schools are served with high-speed broadband and other necessary infrastructure. An Implementation Plan with actions will be developed shortly, the first phase of the Plan to run from 2022 to 2024.

40. gov.ie - Digital Strategy for Schools to 2027 (www.gov.ie)

SOLAS has recently published a new strategy for Adult Literacy, Numeracy and Digital Literacy, Adult Literacy for Life, targeting a reduction in the share of adults in Ireland without basic digital skills from 47% to 20%.[41] Additionally, the Skills to Advance [42] initiative, developed and funded by SOLAS, and delivered throughout Ireland by the Education and Training Boards helps both employees and employers with the upskilling needed to adapt to a changing labour market, as new areas emerge. This provides opportunities for workers to gain the mid-level technical and digital skills needed to work successfully in increasingly AI-enabled firms and organisations. Building on recent developments and the ICT traineeships and apprenticeships which are now available, there are opportunities to develop apprenticeships in AI as the expansion of the apprenticeship system continues into new areas.[43]

At a European level, the EU Digital Education Action Plan[44] prioritises developing a high performing digital ecosystem and enhancing digital competences for the digital transformation. Additionally, the Digital Skills and Jobs Coalition[45] brings together Member States, companies and organisations to boost digital skills in Europe and tackle the digital skills gap. The Coalition aims, for example, to train 1 million young unemployed people for vacant digital jobs. In Ireland the Digital Skills and Jobs Coalition[46] aims for improved digital skills for citizens and within the workforce, as well as for modernisation of the education system.

What is already happening: AI-Specific Skills

The HEIs currently provide more than 105 courses[47], from certificate to masters level, in AI and related areas, such as robotics, automation and machine learning. Seven of these courses are available under Springboard+[48] and three operate under the Human Capital Initiative.[49] Many more computer science courses contain modules on AI, data analytics, natural language processing, and so on. Skillnet Ireland currently supports ten AI-related programmes.[50] These are largely provided in association with HEIs around the country. The courses range from 25 days to 4 years' duration. A number of additional courses are planned for the 2021-22 academic year.

Private colleges also provide 17 AI-related courses. For example, Griffith College in Dublin provides degree courses in machine learning, AI and robotics, and big data analytics; and Dublin Business School runs a masters in AI. The development of new apprenticeships led by industry consortia is also addressing emerging skill gaps in AI related areas with courses of variable duration and innovative models of delivery.

Several of SFI's Centres for Research Training programmes have been developed to support AI graduates in applying their skills to real-world AI research and business problems. Four of the CRTs relate to AI[51], and together they involve 9 HEIs, 361 researchers, 208 students (as of 2021, with a target of 499 by 2026) and 40 non-academic collaborations. The programmes include research projects for all students, and both academic and non-academic placements, and they target transversal skills, discipline-specific skills, research skills, cross-sectoral skills, networking and career development.

41. Home | Adult Literacy for Life Strategy
42. Skills to Advance | Solas | Learning Works
43. See www.apprenticeship.ie
44. Digital Education Action Plan (2021-2027) | European Education Area (europa.eu)
45. Digital skills coalition | Shaping Europe's digital future (europa.eu)
46. About – Digital Skills and Jobs Coalition Ireland (digitalcoalition.ie)
47. See Appendix D.
48. HEA - Springboard+ (springboardcourses.ie)
49. Human Capital Initiative | Skills and Engagement | Higher Education Authority (hea.ie)
50. See Appendix D.
51. These are the Machine Learning CRT, Data Science CRT, Digitally Enhanced Reality CRT and Artificial Intelligence CRT. See the SFI website for details: SFI Centres for Research Training

CASE STUDY

Building future skills in AI: SFI Centres for Research Training

The Centres for Research Training (CRTs) are cohort-based PhD programmes that nurture and develop highest-level skills and promote excellence in research and education, adhering to best practice guidelines in doctoral education. The CRT programme was launched in 2019 with an investment of more than €100 million to provide training for approximately 700 postgraduate research students across six newly established centres. By fostering collaboration across a network of Irish Higher Education Institutes (HEIs) and encouraging peer-to-peer learning within the cohorts of postgraduate students, CRTs play a pivotal role in increasing research capacity. The programme was developed under the theme of Data and ICT skills for the future, encompassing the development of innovative software- and hardware-based information and communications technologies (ICT), as well as the diffusion of ICT as a key enabling technology in other relevant areas of science and technology. Four of these six CRTs support the creation of a talent pipeline and building *future skills for AI research and innovation in Ireland*:

SFI Centre for Research Training in Machine Learning https://www.ml-labs.ie/
Funded by SFI and industry partners, the CRT in Machine Learning is a collaboration between University College Dublin, Technological University Dublin, and Dublin City University. The CRT brings together supervisors at the cutting-edge of Machine Learning (ML) to develop future leaders managing the disruption that ML is causing across industry and society, and strengthen the reputation of Ireland as a global hub for ML education, research and application.

SFI Centre for Research Training in Digitally Enhanced Reality https://d-real.ie/
The CRT in Digitally Enhanced Reality - hosted by Trinity College Dublin, Technological University Dublin, Dublin City University, National University of Ireland Galway and University College Dublin, and funded by SFI and contributions of industry partners - will develop digital skills for next generation human-centric media technology encompassing machine intelligence based sensing and advanced digital content understanding, interaction and processing, and its impactful application in multiple industry and societal settings.

SFI Centre for Research Training in Foundations of Data Science https://www.data-science.ie/
The CRT in Foundations of Data Science, funded by SFI and Skillnet Ireland and supported and facilitated by Technology Ireland ICT Skillnet, is a large-scale collaborative initiative between the University of Limerick, University College Dublin, and Maynooth University. It aims to join and blend the fundamentals of applied mathematics, statistics, and machine learning with application areas of national importance to deliver an adaptable workforce with the skills needed for truly innovative and disruptive data science.

SFI Centre for Research Training in Artificial Intelligence http://crt-ai.cs.ucc.ie/
A joint initiative hosted by University College Cork, University of Limerick, Trinity College Dublin, Dublin City University and National University of Ireland Galway and funded by SFI and industry partners, this CRT aims to create an internationally connected and globally recognised centre of excellence for the training of postgraduate students and the upskilling of industry-based staff in key technical topics in artificial intelligence and data analytics, as well as challenges in fairness and transparency of advanced data-driven applications.

The cohort-based model is uniquely fit to equip students with transversal, cross-sectoral and discipline-specific skills, developing a pipeline of future skills and talent. There is close engagement with enterprise in both the design and delivery of the training programmes to address skill needs in the labour market and build a high-value talent pipeline. Moreover, the CRTs expose student to the wider scientific relevance of their research and facilitate necessary network building to enhance their research, employability and leadership potential, particularly through facilitating placements that encourage students to experience diverse research and work environments.

The Education and Training Boards provide AI related courses at levels 5 and 6 on the National Framework of Qualifications in areas such as robotics, cobotics, automation and data analytics. A range of AI-related and digital modules are also incorporated in other programmes. SOLAS and the ETBs are currently collaborating with QQI and enterprise partners to develop a national approach to micro- training and qualifications for the FET sector. The aim is to make available agile and flexible training opportunities for the Irish workforce. A new model of skills development may be needed to give impetus to the development of AI skills across occupations and sectors at a regional level.

The Irish Universities Association is developing a multi-campus micro-credential programme between 2020 and 2025. The goal is to make modules and shorter courses available as stand-alone qualifications or as stackable steps that can accumulate over time into a higher-level award. The programme will make use of modules already being taught within existing courses as well as developing new specific modules.

In terms of public sector training, the Department of Public Expenditure and Reform provides information and support to public servants in relation to Robotic Process Automation and the use of AI systems on their Our Public Service website.[52]

For businesses, Enterprise Ireland encourages the development of AI skills, with a strong focus on building collaboration between researchers and business as many of the companies are developing their skills in the area of AI for the first time. Skills to help drive a culture of innovation, embed design and creative thinking along with building up the technical skills is critical for future business growth. This is done through a range of supports such as the following:

- Marie Skłodowska-Curie Career-FIT PLUS program which helps place AI research specialists within a business. This aids both the researcher and the business through cross sharing of knowledge, upskilling and innovative thinking.

- Work-Ready Graduate Programme: Students with an MSc in AI/Analytics are placed on an accelerated learning program in to drive adoption of AI in business.

- R&D Support: A business is aided to explore and develop capability in AI, which leads to upskilling, cross networking of skills and helps foster and grow the lifelong learning culture within both business and individuals.

52. Our Public Service - Artificial Intelligence (ops.gov.ie)

CASE STUDY

The LMETB Advanced Manufacturing Training Centre for Excellence (AMTCE)

Key to this new model of skills development is the creation of a central resource within regions to raise awareness about AI, and other emerging technologies, to offer a point of contact for networking and collaboration, as well as providing a consistent and relevant supply of upskilling options for employees and employers, assisting them in adopting AI and integrating it into their work processes. This innovative partnership model which explores AI, its technologies, reach and scope alongside its applications in industry, is best exemplified in the innovative work of the recently launched LMETB Advanced Manufacturing Training Centre for Excellence (AMTCE) in Dundalk.This is a National centre for Advanced Manufacturing and Technology and as such, its scale and connectivity with the other 15 ETB allows the Further Education and Training sector to share innovation and developments in the area of AI, data analytics and associated technological areas.

The AMTCE was developed by Louth Meath ETB with support from the Enterprise Ireland Border Enterprise Development Fund and from SOLAS to provide support for collaborative, enterprise capability building projects, to advance entrepreneurship, productivity, and innovation in the Border Region.

Additional funding from the SOLAS Skills to Advance Innovation though Collaboration fund enables the design and delivery of training programmes in advanced manufacturing in response to the identified industry needs in the region to support current manufacturing operations across a range of sectors and those required in industry 4.0 driven operations. Courses include upskilling in Cobotics, Robotic Welding and Machine Learning.

The centre provides an inspiring environment for interchange between industry and Further Education and Training, generating new collaborations to address emerging needs. It combines a showcase for state-of-the-art technological developments with opportunities to connect manufacturing companies, R&D entities, technology vendors and state enterprise and education and training agencies in order to leverage and accelerate the benefits of Industry 4.0 technology adoption.

CASE STUDY

Enterprise Ireland and CeDAR: Work-Ready Graduate Programme

Enterprise Ireland and CeADAR, the Centre for Applied AI, launched the **Work-Ready Graduate Development Programme** in October 2018. The goals of the programme are twofold:

- to enable and encourage companies to mobilise and accelerate their AI ambitions in a supported and cost-effective way. The programme provides graduates for industry with the knowledge, experience and training needed to assume roles in data science which bring immediate business impact;

- to develop the next generation of data scientists by placing, into ambitious EI client SMEs, motivated individuals with an MSc in AI/Analytics who will gain practical knowledge and hands-on experience of AI and analytics in a real-world setting.

One of the many positive impacts for companies on the programme is that they are investing more time and budget into their digital and AI transformation which is leading to market and technological differentiation both nationally and globally.

The CeADAR work-ready graduate programme is an accelerated hands-on learning programme with significant company engagement and secondment. The year-long programme accepts 10 EI client companies along with 10 postgraduates. The programme combines in-house training with external courses. The in-house training concentrates on building up hands-on technical competence via our own courses designed and provided by CeADAR. External courses were selected to develop the graduates into immediately useful employees by providing certified project management and scrum training, GDPR training, data security, DevOps, report writing and project financial planning.

The graduates exit the programme equipped with the latest knowledge, techniques and familiarity with the most widely-used tools in Data Analytics and AI. The graduates also have a thorough grounding and training in modern business and software design best-practices, coupled with the hands-on experience to implement Data Analytics and AI solutions in business production systems.

5.3 Supply from Overseas Talent

One of the main sources of skills for a country is migration. It is not just firms themselves that need to provide attractive jobs; the countries and regions in which those jobs are located also need to ensure that the location itself is attractive for the talented workers that are needed.

Technology Skills 2022 assesses the demand for ICT skills out to 2022. The analysis predicts an increasing demand for ICT skills and shows a widening gap between supply and demand for ICT skills in Ireland. The report states that "as of 2018, indigenous supply is forecast to meet 57% of demand." The National AI Strategy commits to review the criteria for employment permits for critical AI skills. Other employment permit policy, such as the liberalisation of restrictions around spousal working rights should also help to boost initial attraction and retention.

Another highly successful initiative from Enterprise Ireland which began in 2017 is the Career-FIT PLUS Career Development Fellowships. The aim of the programme is to recruit experienced international researchers to work on market-focused research projects in Ireland for 3 years. The competitively awarded programme is co-funded by the EU and each Fellowship is worth approximately €250,000 with no contributory funding required from the industry partner. The scheme is an innovative concept where top global talent and skills are matched with the research needs of enterprises in Ireland.

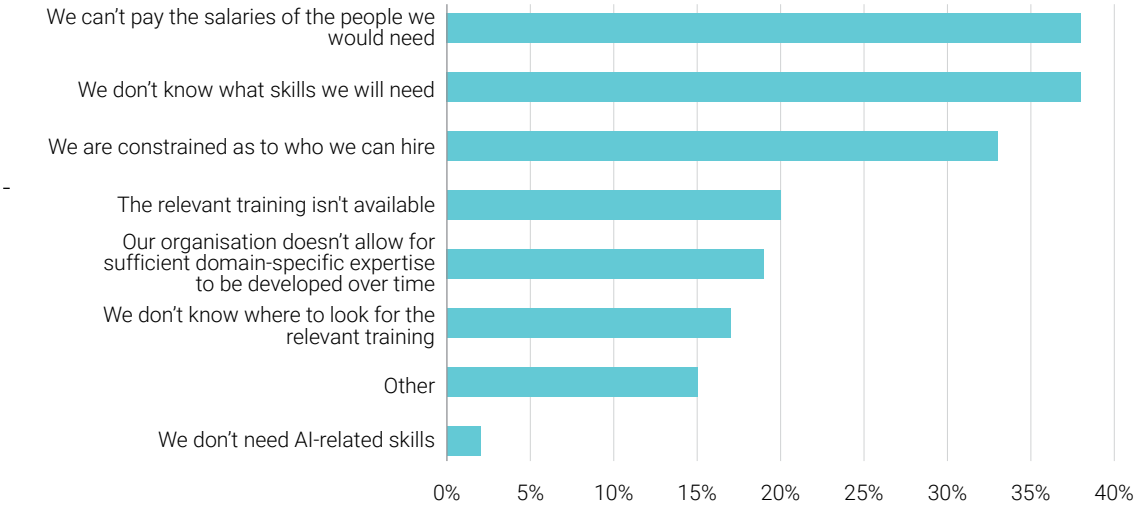
5.4 Challenges and Opportunities to Supply – Survey and Workshop Results

AI Users and Innovators were asked what the main barriers were within their organisations to getting or developing AI skills. The most important barriers were not being able to pay the required salaries and not knowing what skills that would be needed. 20% of respondents said that the relevant training isn't available, highlighting the need for education providers to advertise their courses more broadly.

Chart 8

Barriers to Users & Innovators Gaining AI Skills

(DETE AI Skills Survey; n = 162)



Question (for Users & Innovators):
What are the main barriers to getting or developing these skills [to adopt or expand your use of AI]**?**
(Select all that apply.)

During the workshop participants particularly identified cost and access for SMEs as an issue. Costs of training in terms of both time and money could pose a problem for smaller firms where staff cannot be covered. Many participants suggest that firms need to be incentivised to allow training during work hours. And despite all efforts, many people may still be reluctant to engage in lifelong learning, as where roles are eliminated this may create cynicism towards AI.

There is a perceived need to change the educational model: 2-year programmes provide more flexibility than traditional 4-year programmes. Existing workers could take shorter courses and be awarded certificates. The capacity of third level institutions to deliver the necessary courses is in question, according to workshop participants; some are already struggling to retain current staff or attract new ones. Micro-credentials are seen as a useful addition to the arsenal of courses offered by further education and training and higher education and others.

Traditionally in Ireland apprenticeship programmes have also been four years in duration. Since 2016, with the expansion of the apprenticeship system the consortia-led programmes are of variable duration, lasting between two and three years depending on the programme, with different models of delivery being utilised.

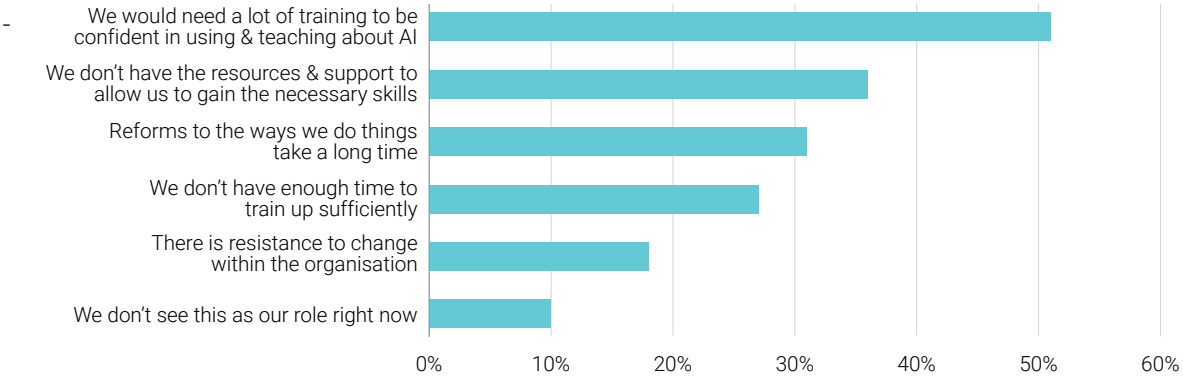
Asked what the biggest barriers are to **the public** gaining the skills they will need for dealing effectively with AI, respondents believed that the issue was not about a lack of available training or about misinformation, but about a general lack of awareness of what the consequences of AI might be. It is clear from all of the preceding analysis that AI will affect many, if not all, sectors of the economy, and the skills required to support this range far beyond the high-level technical skills needed by AI experts.

Educators were asked about the main barriers to making progress in being able to teach about and use AI effectively. The least common answer was that educators don't see AI as their role right now, while the most common was that they would need a lot of training to be confident in using and teaching about AI (Chart 9).

Chart 9

Barriers to Educators Teaching and Using AI

(DETE AI Skills Survey; n = 146)



Question (for Educators):
What are the main barriers to making progress – to being able to teach about and use AI effectively – in your organisation?
(Select all that apply.)

During workshop discussions, participants felt that root and branch educational reform may be needed, and that rote learning and memory are seen as highly stressed in Irish education and the Leaving Certificate, while AI requires more creative thinking and problem solving. Some workshop participants suggested that AI currently has low priority in the education system, overshadowed by more established computer science programmes.

For **Policy Makers, Regulators & Legislators** the most common perceived barrier to developing AI Skills was that policy makers do not know what skills they will need for AI. 38% of respondents answered that they were constrained as to who they can hire, perhaps suggesting a need for more flexibility within the public sector over role creation.

More generally, a number of suggestions were made as to how the supply of skills could be increased. These included the creation of Digital Learning Hubs around the country, as well as the introduction and mainstreaming of micro-credentials and other forms of incremental learning. It may be that some of the required skills already exist in the workforce, but people may not realise that they possess them. There is therefore a need to unlock these latent skills. The creation of a champion programme to illustrate the accessibility of AI may assist in this context.

5.5 Conclusions

Simply put, the supply of skills may be said to arise from three sources: education, training, and attracting international talent. Education covers not only the mid and high-level AI-related skills needed for technical jobs but also the digital education – including the knowledge and understanding of AI – that is provided by the school system. Those who are already working may be provided with training through their employers, but they may also continue their development throughout their careers through lifelong learning. There is a broad range of options available for lifelong learning in Ireland, from Further Education and Training to Higher Education, and including Springboard+, for example.

Schools underpin digital education within the education system, with a number of current and upcoming strategies focussing on strengthening digital literacy among both students and teachers. AI-specific skills may not be relevant at the early stages of education, but some understanding of what AI is and what its implications are is important. Additionally, many 'soft' or transversal skills are needed by those who work with AI, such as critical thinking, creative thinking and collaboration. The foundations of these skills are developed at an early stage of education.

Further Education and Training Boards and Higher Education colleges provide a range of AI-related courses along with modules within broader courses. One consistent theme in discussions about courses at this level is the importance of making ICT and AI modules available to those from other specialisms so that they can work effectively in an organisation that uses or develops AI systems, even if they are not themselves AI experts. Micro-credentials may play a significant role in underpinning this needed flexibility. As we continue to expand apprenticeship provision in Ireland (level 5-10 on the NFQ), consortia of industry representatives may develop specific apprenticeships in AI as a means to further meet the current skills gaps.

Another role of Further Education and Training is in supporting literacy, numeracy and digital literacy for adults. It is important to attract people back into education so that they can have a more active role in their future career development. There is a broad range of options available for lifelong learning in Ireland, from Further to Higher Education, and including Springboard+, for example.

The importance of talent attraction should not be overlooked. Many countries and regions are taking active measures to assist internationally mobile talent to migrate and then settle down in their country, supplementing their labour market with needed skills.

6

Summary of Findings

Theme 1 - AI will have a broad impact on the labour market

- AI is a general-purpose technology and so will have a broad impact on the labour market. AI technologies have the potential to improve efficiency, reduce costs, improve service offerings, and support decision making for firms.[53]

- AI is expected to complement humans in some tasks, while replacing them in others. Whether jobs are transformed rather than replaced will depend, to a great extent, on how well the strengths of AI and the strengths of human beings can complement each other within each job.

- AI may have an impact on more jobs than most people think. A recent study from Germany suggests that more than 40% of workers use AI technologies on a regular basis, though only half this number realise that they are making use of such technology.[54]

Theme 2 - A number of Skills-related Challenges exist

- The European Commission's Enterprise Survey on AI, 2020, shows Ireland to be below the EU average for AI adoption with 35% of enterprises using at least one AI technology compared with 42% of firms across Europe.

- Skills availability has been identified as the number one barrier to AI adoption. Irish firms report significant skills gaps in the areas of cloud computing, programming and machine learning or modelling, compared with our European neighbours.

- Many mid and high-skilled workers will need to adapt to new job roles with a different set of tasks, but some lower skilled workers will need to prepare for a new career if their role is likely to be automated. For lower skilled workers in particular, there will be a need for reskilling and lifelong learning to weather potential job losses and navigate transitions to new jobs.

- The adoption and deployment of AI systems isa complex process that requires;
  a. AI-specific skills,
  b. relevant management and organisational skills,
  c. soft skills, and
  d. an awareness and understanding of AI and its implications.

  Organisations, both public and private, will need a clear and detailed strategy for adopting AI if they are to identify the wide range of skills their staff will need.

- Digital literacy needs to increase across the whole population. According to new EU targets[55], digital literacy among those aged 16-74 in Ireland must increase from its current 53.4% to 80% by 2030.

53. Demand for AI Skills in Jobs: Evidence from online job postings, OECD, 2021, 3ed32d94-en.pdf (oecd-ilibrary.org)
54. Artificial intelligence in Germany: employees often unaware they are working with AI-based systems, by Oliver Giering, Alexandra Fedorets, Jule Adriaans, and Stefan Kirchner - DIW Weekly Report No.48 2021, p373 - dwr-21-48-1.pdf (diw.de)
55. https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_en#the-path-to-the-digital-decade

Theme 3 - Different People, Different Skills

- AI will affect a broad range of jobs, so AI skills will be needed by a broad range of people not just by AI experts and specialists. How closely a person works with AI systems will determine the kinds of AI skills they will need and how they will need to prepare. Everyone in the labour force needs to know how AI is likely to affect and change their jobs, and then they need to take action to prepare for those changes. All individuals should see lifelong learning as an option and an opportunity for them to prepare for the future of work.

- **AI specialists, experts and regular users** will need specific education and training, while those working in organisations that use AI systems will need to be dual-skilled, with digital and AI skills alongside their core area of expertise.

- **Students in full-time education** need at least basic digital literacy. This is a necessary foundation for an understanding of AI and for building AI-specific skills.

- The role of **Educators** is to help prepare students for the future. Educators must prepare for the future even sooner than other groups in developing their digital and AI skills as they are teaching others so that they can embed the use and understanding of digital technologies across teaching, learning and assessment.

- **Policy makers, legislators and regulators** need to understand the subject matter that they work on in order to do their jobs well. Those with such responsibilities in the area of AI need to know how AI systems work, how data are used, how data-related bias can arise, how ethics may be impacted by decisions taken by AI systems, and so on.

- Members of the **general public** need to be able to recognise when they are using an AI system – on their phone or computer, for example – or when a decision is being taken or suggestion being made by an AI system. They need to know how to assess the accuracy of these suggestions and decisions. AI should also be seen to be trustworthy if it is to be deployed and used successfully over the coming years. This trust should be built on knowledge and understanding.

This leads to a range of levels of AI-related skills, as set out in Theme 4.

Theme 4 - Levels of AI Skills

- Depending on a person's level of day-to-day interaction with AI, they will need different levels of skill. A large number of those working in any organisation that uses AI systems are likely to need some understanding of AI and its implications.

- **Specialist AI skills** are needed by AI developers and specialist users. AI specialists and developers will continue to need the kinds of skills developed through specific AI third-level courses, PhD programmes, collaborative research programmes, and so on.

- **Technical and Mid-level Skills** are needed for AI users and technical support staff. Those who work with and use AI systems on a daily basis, as well as those responsible for the installation and maintenance of hardware (such as robots, for example), will need appropriate technical skills.

- **Complementary and Transversal Skills** are needed for people working in organisations that use, procure or adopt AI systems. Those whose primary function or expertise is not AI but who work with or alongside AI experts or systems will need enough understanding of how AI works to contribute meaningfully to their teams and organisations. The importance of critical thinking – as well as creative thinking, collaboration, innovative thinking, and so on – has been emphasised by participants throughout this project. Many of these transversal skills are ideally built from an early age.

- **Management and Organisational Skills** are required by those who manage AI projects. AI projects can be more complex than other ICT projects, so additional management and organisational skills will be necessary in many cases. Skills such as innovation management, AI-specific project management, AI governance, and leadership and change management are important in this context.

- **Digital Literacy** acts as an essential foundation for AI skills for individuals, and digitalisation acts as an essential foundation for AI adoption for firms. People need to know something about ICT before they can effectively learn about AI. Firms need to have a track record of digital adoption and digital upskilling before they can begin to consider the adoption of AI systems, and hiring of AI-literate workers.

- **Skills for Educators** are for educators at all levels. To the extent that each of the above levels of skills require education and training, the educators providing that education and training need to have the expertise needed to impart the necessary knowledge at each level.

7

Broad Objectives and Recommendations

Broad Objectives

To respond to the themes discussed above, many groups and individuals in the economy need to make plans and take action to ensure that the right skills are developed in the right places to support the deployment of AI. Many of the Actions from Ireland's National AI Strategy, AI Here for Good, are relevant to the broad objectives around building AI skills. For convenience, some of the most relevant Actions from that report are referenced in boxes. While implementing these recommendations from AI Here for Good, those responsible should consider the broad objectives set out here.

Education Policy - Schools

Education policy should ensure that digital literacy is embedded as an integral part of education at all levels, as a matter of course. AI skills can then be built upon this foundation of digital literacy. The school system needs to embed digital literacy and AI skills with the goal that no-one leaves school without basic digital skills, and everyone has a basic understanding of AI and its implications. Schools should also focus on the transversal skills needed for AI and for the workplace of the future. Many of the skills required for the future are transversal or 'soft' skills.

It is essential that teachers at all levels have the digital and AI skills necessary to prepare their students for the future. Educators need to assess their own skills in order to prepare for a future where all students will understand AI at a basic level, as well as where digital and AI systems will be used routinely to underpin and facilitate teaching.

Education policy should ensure that teachers have the support, resources, training and encouragement to make this a reality. Digital skills should therefore continue to be included in the continuum of teacher training (initial teacher education[56], induction[57] and CPD) so that all new teachers have sufficient ICT and AI knowledge to teach these topics at primary school level. AI should be included in curriculum reviews at primary and post-primary level to assess where and when it should be taught. The pace of curriculum review needs to match the pace of technological change, so certain subjects may need to be revised more frequently.

Gender balance is also an important consideration in the area of AI, as it is in all STEM subjects. To the extent that attitudes and opportunities at school affect later outcomes, any unconscious biases and structural inequities that may exist should be addressed in a systematic manner. Increasing amounts of interaction between industry and schools should be encouraged so that students can learn about the kinds of jobs that will be available for them when they are ready to join the workforce. The availability and promotion of relevant work placements in AI-related roles is also an important means of ensuring that labour supply meets demand in the future.

Relevant Actions from AI Here for Good

- Consider how AI can be incorporated into future policy for digital learning [D/Education]
- Establish an expert group to develop an action plan to increase the participation of women in related careers [DETE / DFHERIS / D/Education / DCEDIY]

56. The Teaching Council have included the development of digital skills for pre-service teachers as a key component of its revised Standards for Initial Teacher Education Process, Céim, which was published in 2020.
57. The National Induction Programme for Teachers also provides guidance on the effective use of digital technologies.

Education Policy – HE and FET

The HE and FET sectors should be supported in further developing capacity on courses with significant AI content. The FET and HE sector needs to provide both specialised AI courses and shorter, more flexible courses, including micro-credentials. It needs to be as easy as possible for people to gain digital and AI skills as an integral part of their chosen course of study so that, over time, dual-skilling becomes the norm. Such capacity building will require a focus on the recruitment of academic staff with expertise in AI. While educational institutions must decide independently how to allocate existing resources, the question of whether the overall level of resources available to them is adequate in this context is a matter for policy and State investment may be required.

The capacity built in this process must meet the future needs of enterprise. Increasing levels of collaboration between HEIs, ETBs and enterprises, including SMEs, to focus on the design and development of modules, is an important part of ensuring that this result is realised.

PhD programmes and post-doc research are also essential for high-level AI expertise, and collaborative research programmes create a bridge between academia and industry, where theoretical and practical skills can be co-developed.

Away from academia, members of the general public need to assess their careers to identify if AI is likely to change their role in some way over time. They then should engage in lifelong learning in order either to learn how to become more effective in their current role, making use of the AI systems that become increasingly embedded in their jobs, or to change roles where AI (or any other technology) takes their role over or is likely to do so.

In this context, the continued promotion of lifelong learning opportunities broadly to the population is of fundamental importance. This can underpin dual-skilling and complementary skills for those already in the workforce, but also prepare those who may lose their jobs to automation.

Relevant Actions from AI Here for Good

- Encourage Higher Education Institutions to take a coordinated approach to delivering AI education and training informed by the outcome of the EGFSN review [DFHERIS, HEA and HEIs]
- Assist employers to expand workplace-focused AI upskilling and reskilling, including through apprenticeships, SOLAS programmes, Skillnet Ireland training programmes and enterprise partnership schemes [DFHERIS, Skillnet Ireland, HEA, & SOLAS / DETE, Enterprise AI Advisory Board]
- Developing a national AI cluster or platform to drive collaboration between MNCs and SMEs [All actions above for DETE, EI, IDA, LEOs, SFI]
- Establish an AI Innovation Hub, as part of Ireland's planned programme of European Digital Innovation Hubs,conduct a mapping of the AI R&I ecosystem [DFHERIS-SFI] and identify sectors of opportunity for establishing AI testbeds and experimentation facilities [DETE, EI, IDA & NSAI / DFHERIS, SFI, Enterprise AI Advisory Board]
- Promote Irish participation in international AI R&I programmes and relevant EU funding calls [DFHERIS, SFI/ DETE]
- Explore potential mechanisms for all-island cooperation on AI R&I in strategic sectors, for example through the Shared Island initiative [DFHERIS, SFI/ DoT]
- Promote and expand courses which educate the general public about AI [DFHERIS]

Firms and Supporting Bodies (public and private sector)

Firms need to drive their digitalisation journey and then assess the potential for AI to add value to their business. The deployment of AI needs to be seen as not just another IT project; it can be more complex and lead to unexpected and undesired outcomes if not well managed. Managers, in both public and private sectors, need to understand enough about AI and its consequences to allocate the required staff and resources to AI projects such that they lead to ethical and trustworthy outcomes. Industry bodies play a role in emphasising the importance of progress in these areas.

Relevant Actions from AI Here for Good

- Examine and promote ways to help businesses self-assess the trustworthiness of their AI systems, including through development of case studies and toolkits for SMEs [DETE/ EI, IDA / DFEHRIS]

- Publish a Standards and Assurance Roadmap for AI. [DETE-NSAI]

- Establish an Enterprise Digital Advisory Board to advise and work with Government to drive industry adoption of AI and other digital technologies including by:

- Assessing the current spectrum of AI resources available to industry from Government to inform actions to maximise the potential of the existing infrastructure;

- Developing an AI programme for enterprise of targeted funding and advisory measures for AI adoption;

- Raising awareness among businesses of all sizes of the resources available to help with AI adoption;

Public bodies also need to assess where AI will be used, procured, regulated or legislated for by them, and train their staff accordingly. A key source of labour supply for firms, particularly for specialised and high-tech roles, is the attraction of international talent. Policy makers should be aware of where and what skills will be required by firms when reviewing employment criteria for critical AI-related skills.

Relevant Actions from AI Here for Good

- Consider an appropriate mechanism for ensuring a coordinated approach by Irish regulators to Digital, including AI, as part of the forthcoming National Digital Strategy [DOT/ DETE / DECC / D/Justice/ DTCAGSM / DCEDIY]

- The GovTech Delivery Board will consider the adoption of AI by the Public Service, including:

- The approach to developing and promulgating principles for trustworthy AI which will apply to all AI developed for and used by the Public Service

- The development needs for AI talent in the Public Service

- Review the criteria for employment permits for critical AI-related skills, having regard to the research and analysis of AI skills needs that is undertaken [DETE]

- Promote Ireland as a centre for talent in AI R&I as part of Global Footprint 2025 [DFHERIS/ DETE/ DFA]

Communicating AI's Impact

The broad impact of AI on the labour market, the economy and society needs to be communicated clearly. Government communication needs to emphasise that AI skills are not just needed by a handful of developers and experts, but that different levels of skill and knowledge are needed by many, even most, people.

Relevant Actions from AI Here for Good

- Appoint an AI Ambassador to champion AI as a positive force for the economy and society [DETE]

- Open a conversation with children and young people about AI through Comhairle na nÓg the national structure for consultation with children and young people [DETE / DCEDIY]

The EGFSN may consider carrying out a more detailed study of AI skills in the future when quantitative data become available. A governance structure will be put in place by the EGFSN secretariat to monitor progress on these objectives and ensure that skills are properly being taken into account in actions relating to AI deployment.

Relevant Actions from AI Here for Good

- Government will develop a detailed action plan, to drive implementation of the strategy, and this action plan will be updated each year to address emerging challenges and opportunities.

Recommendations

In addition to the actions set out already in the national AI strategy AI: Here for Good, the following 10 recommendations will help to deliver on the key messages of this report.

1 Ensure that Computer Science teachers' CPD evolves with AI developments. (DoE)

2 Enhance digital literacy in the continuum of teacher training (initial teacher education, induction and CPD) so that all new teachers have sufficient ICT and AI knowledge to teach these topics at primary and post primary levels. (DoE, HEIs)

3 Examine the Teaching Council definition of Computer Science teacher qualifications to ensure it has suitable breadth to include the variety of relevant and appropriate recognised qualifications, including industry certifications, necessary for teaching about AI. (DoE, Teaching Council)

4 Support the development of new Apprenticeships in AI (National Apprenticeship Office, HEIs, ETBs, Industry)

5 Make AI-related micro-credentials – at HE and FET levels – available broadly to both learners and workers across the economy. (HEIs, SOLAS, ETBs, QQI)

6 Ensure the review of curricula at primary, junior and senior cycle includes consideration of AI, especially in STEM subjects. Aim to ensure that the review of Computer Science (including AI) curricula keeps pace with technological change. (DoE, PDST, NCCA)

7 Explore the use of AI to support teaching, learning and assessment – eg, blended / flipped learning and personalising feedback delivery.

8 Promote a free online AI course for citizens. (e.g.: the Elements of AI.[58]) Underpin this with similar online courses on basic digital skills. Link the promotion of this with digital literacy courses provided by FET and HE sectors. (SOLAS)

9 Target international AI talent in a pro-active manner through the Tech/Life Ireland programme. (IDA, Enterprise Ireland, DETE)

10. Public servants who may interact with AI as regulators, legislators, users or procurers should seek out a relevant AI course or module through their employer. One or more such courses should be made available and publicised broadly to public servants. (Public Bodies, DPER)

58. A free online introduction to artificial intelligence for non-experts (elementsofai.com/ie)

Appendix A: Survey Methodology

A1. Survey Approach and Methodology

A survey was designed to collect data on the use of AI, preparedness for AI and skills needed for the adoption of AI. The survey was circulated via the project Steering Group and via a broad range of stakeholder groups familiar to the Department of Enterprise, Trade & Employment. In general, these groups include policy makers and legislators, teachers, academics and industry representatives. The survey was also publicised on social media. However, it is unlikely that a large number of the general public were reached.

It was not intended that the survey be a random sample of the population of Ireland. That would require a lot more time and resources than were available for this project. Despite this, a response of more than 370 people is quite reasonable, and significant insights may be said to have been gained into skill needs around AI, and so on.

The survey was anonymous and no personal data or contact details were collected. It was administered using a European Commission Online Survey Tool[59].

Four groups were targeted:
1. Users & Innovators
2. ducators
3. The Public
4. Policy Makers, Legislators and Regulators

The questionnaire was therefore divided into four main sections according to these groups.
Each section had 6-8 questions. There was also a set of background questions designed to yield descriptive statistics about respondents.

Respondents were not restricted to identify as only one of these groups; they could answer the questions relevant to any or all of the groups. A respondent might identify as a User of AI but also an Educator, for example. All of the respondents are, of course, members of the Public. This approach means flexibility for the respondents but means that in interpreting the results, it is not strictly true to say that, for example, 'Educators' say X and 'Policy Makers' say Y. We must interpret the results are saying that 'respondents' say such and such about what skills Educators or Policy Makers may need. That said, the questions are reasonably specific to people who work in the sector being asked about, so it can be assumed that, for the most part, the Educators section was answered by educators and the Users & Innovators section was answered by users and innovators.

Results are reported as percentages – the percentage of respondents who answered each question who chose that option. However, it is important to distinguish between the 'Select all that apply' questions and the 'Select the most relevant' questions. Percentages only add up to 100 in the latter case. In the 'Select all that apply' case, we get an indication of the relative importance of each option provided. In the report, each table or chart provides the text of the question asked and indicates whether it was a 'Select all that apply' question or a 'Select the most relevant' question.

59. EUSurvey - Welcome (europa.eu)

A2. Survey Response Stats

Of the 363 Respondents:	
Location	95% lived in Ireland
Education	Only 4% did not have a degree or higher
Gender	56% were male; 41% were female
Age	none were below 18 years of age
	17% were between 18-34
	49% were between 35-50
	33% were between 50-65
	1% were over 65
Employment	27% worked in industry / the private sector
	39% worked in the public sector
	29% worked in education
	2% were either students, retired or taking care of children or family
Opinion	87% of respondents said they were giving their personal opinion;
	13% on behalf of their organisation.

Response Rate by Groups	No
Users & Innovators	162
Educators	146
The Public	173
Policy Makers, etc.	89

Of the 162 Users & Innovators who responded
There was an almost equal split between those who identified mostly as Users and those who identified mostly as Innovators.
35% of respondents to this section said that they develop AI systems

Appendix B: Survey Questionnaire

AI Skills Survey 2021

This survey is being carried out by Ireland's Department of Enterprise, Trade & Employment in order to understand better what skills may be needed for Ireland to benefit from the adoption and deployment of Artificial Intelligence over the next 5-10 years.

The survey is anonymous. It does not ask for your name or contact details.

The survey is aimed at people, or groups, who may be affected by AI in different ways.

You can pick the group that fits you the best or you can answer more than one section.
The Groups are:
A The Public
B Users & Innovators
C Educators
D Policy Makers, Legislators & Regulators.

As well as choosing which Group(s) you wish to complete, you can also decide if you want to answer on behalf of your organisation or company or give your personal opinion.

If you would like to answer from both of these two perspectives, just answer the survey once from one perspective, and then click into it again and answer it from the other.
(You can choose the same Groups or different ones when you answer from each perspective.)
Within each section, all fields are required apart from the optional comments.
Text fields are optional.

What is Artificial Intelligence?

Artificial Intelligence refers to software and hardware systems that can perform some of the functions commonly attributed to human intelligence.

- ☐ I'm happy with this definition
- ☐ I'd like to see a more detailed definition

Choose your Perspective

* Are you giving your personal opinion or answering on behalf of your organisation, institution or company?

- ☐ I'm giving my personal opinion.
- ☐ I'm answering on behalf of the organisation I work at or represent.

Choose your Group

* Choose the Group(s) you'd like to respond to. Groups
You can respond to more than one. (Select 1 to 4)

- ☐ The Public - Civil Society
- ☐ Users & Innovators
- ☐ Educators - Teachers, Lecturers, Researchers, Trainers, Mentors
- ☐ Policy Makers, Legislators & Regulators

The Groups are defined as follows:

A. The Public
Ordinary members of the public who will use and be impacted by AI in everyday ways

B. Users & Innovators
End-users of AI systems; those who work routinely with AI systems – including, but not only, AI experts ... and ...Those who develop new and improved AI systems and applications

C. Educators
Teachers, researchers, lecturers, trainers, mentors – what skills do they need, what technologies can they use, etc.

D. Educators
Those in the public sector who must understand AI well enough to legislate, regulate, procure, draft policy, support enterprise, etc.

A. The Public – Civil Society

The Public Group is defined as:
Ordinary members of the public who will use and be impacted by AI in everyday ways.

1 **How do you think the general public will be affected by the deployment and adoption of AI over the next 5-10 years?** (select the most relevant)

- ☐ AI will bring net benefits for society
- ☐ AI will bring more problems than solutions
- ☐ AI will bring problems for some and opportunities for others
- ☐ We haven't yet considered this question sufficiently to give a definitive answer

2 **What kinds of skills do the general public need to ensure the best outcomes (empowered customers / citizens, optimal career potential, etc.) as AI is deployed and adopted?** (select the most relevant)

- ☐ AI-specific skills and expertise
- ☐ Digital skills
- ☐ Awareness and understanding of AI and its implications
- ☐ 'Soft Skills' – like critical thinking, creativity, collaboration, etc.
- ☐ We haven't yet considered this question sufficiently to give a definitive answer
- ☐ The general public don't need to have AI-related skills

3 **How should the general public gain this knowledge and understanding and these necessary skills?** (select the most relevant)

- ☐ The education system – Primary
- ☐ The education system – Post Primary
- ☐ The education system – Third Level
- ☐ The education system – Post Graduate
- ☐ Lifelong learning and training
- ☐ Traditional Media
- ☐ The Internet
- ☐ Social Media
- ☐ From Government
- ☐ From Industry
- ☐ Don't know

List any other sources here:

4 **Who will need to gain new skills the most if they are to reap the benefits of AI adoption?** (select the most relevant)

- ☐ Elderly people
- ☐ Older workers
- ☐ Mid-career workers
- ☐ Younger workers
- ☐ People in high-tech jobs
- ☐ People in low-tech jobs
- ☐ The unemployed
- ☐ School kids

5 **Who will need to gain new skills the most if they are to avoid potential negative consequences of AI adoption?** (select the most relevant)

- ☐ Elderly people
- ☐ Older workers
- ☐ Mid-career workers
- ☐ Younger workers
- ☐ People in high-tech jobs
- ☐ People in low-tech jobs
- ☐ The unemployed
- ☐ School kids

6 **What are the biggest barriers to the general public gaining the skills they need about AI?** (select all that apply)

- ☐ Most people aren't aware of what AI is and what its consequences might be
- ☐ People don't know where to go to learn what they need
- ☐ People are afraid that AI is too hard to understand
- ☐ Many people don't even have digital skills, so AI seems very far from their everyday experience
- ☐ People aren't informed sufficiently well by Government and the educational establishment about what education and training is available
- ☐ The relevant training and education aren't available
- ☐ Many people don't have the time or money to invest in learning
- ☐ People get their information through social media, so are potentially being misinformed about AI
- ☐ Don't know
- ☐ Any other barriers not listed here?

List any other barriers here:

B. Users & Innovators

The Usres & Innovators Group is defined as:
End-users of AI systems; those who work routinely with AI systems – including, but not only, AI experts ... and ...Those who develop new and improved AI systems and applications.

Note: this section may be answered by AI Users and Innovators whether they work in business, education or the public sector. Therefore, consider the term 'organisation' to refer to your firm, your college or school, or your public sector body or department.

1 **Are you an AI user or an AI innovator?** (which of the following best describes you)

- ☐ More of a User than an Innovator
- ☐ More of an Innovator than a User

2 **Does your organisation use AI and how much?** (select the most relevant)

- ☐ We develop AI systems
- ☐ AI systems are central to how we deliver
- ☐ AI is integrated into the way we run our organisation
- ☐ AI systems are a useful part of how we run the organisation
- ☐ We need to understand AI to meet our goals
- ☐ It's a new piece of our process that we have developed lately
- ☐ We're working on making it part of how we operate
- ☐ We're exploring how it might help us
- ☐ Our organisation has no concrete plans for adopting or using AI

3 **In order to adopt or expand on your use of AI, what technical skills will your organisation need to make this happen?** (select all that apply)

- ☐ Robotics & automation
- ☐ Natural language processing
- ☐ Machine learning
- ☐ Knowledge representation & reasoning, planning, search, optimisation
- ☐ AI applications
- ☐ Connected and automated vehicles
- ☐ AI ethics
- ☐ Philosophy of AI
- ☐ AI regulation
- ☐ Multi-agent systems
- ☐ Computer vision
- ☐ Audio processing
- ☐ AI (generic)
- ☐ Understanding of the societal impacts of AI
- ☐ Data processing and management
- ☐ Other

If 'Other', please add relevant technical skills here:

4 **In order to adopt or expand on your use of AI, what organisational and management skills (excluding technical / ICT skills) will your organisation need to manage this process?** (select all that apply)

- ☐ Strategic Management
- ☐ Leadership & Change Management
- ☐ Innovation Management
- ☐ Risk analysis and planning
- ☐ Cross-Functional Management
- ☐ Cross-Disciplinary Communication & Cross-organisational Cooperation
- ☐ AI-specific Project Management
- ☐ Legal & Regulatory Expertise
- ☐ Expertise in Ethics, Philosophy &Trustworthiness
- ☐ AI Governance
- ☐ UX design
- ☐ External Communication Skills (including explaining tech to a non-tech audience)
- ☐ Managing uncertainty and complexity
- ☐ Other

If 'Other', please add relevant non-technical skills here:

5 **How do you normally get information on what skills you'll need – including for new technologies like AI?** (select all that apply)

- ☐ We have ongoing connections with industry, academia & / or the research community
- ☐ We are connected to peer networks or clusters
- ☐ We routinely discuss these matters internally
- ☐ We carry out research on the kinds of skills required for our organisation
- ☐ We get advice on our skills needs from consultants
- ☐ We get advice and support from a State body or agency
- ☐ We get advice and support from a business representative organisation
- ☐ The owner / CEO usually decides who to hire
- ☐ We don't have a standard approach for seeking advice about skills
- ☐ Other

If 'Other', please mention other sources for information about skills here:

6 **How are you going to get these skills?** (select all that apply)

- [ ] In-house Training
- [ ] External Training Providers
- [ ] Ongoing Education of Staff
- [ ] Hiring in who we need
- [ ] We're not sure yet how we'll get the necessary AI skills into our organisation
- [ ] We don't need any AI skills in the foreseeable future
- [ ] Other

If 'Other', please mention other ways you will get these necessary skills:

7 **What are the main barriers to getting or developing these skills?** (select all that apply)

- [ ] We don't know what skills we will need
- [ ] We don't know where to look for the relevant training
- [ ] The relevant training isn't available
- [ ] Our organisation doesn't allow for sufficient domain-specific expertise to be developed over time
- [ ] We are constrained as to who we can hire
- [ ] We can't pay the salaries of the people we would need
- [ ] We don't need AI-related skills
- [ ] Other

If 'Other', please mention the other main barriers to getting or developing the necessary skills:

8 **Do you have any further comments about Skills for AI as they relate to your organisation?**

C. Educators – Teachers, Lecturers, Researchers, Trainers, Mentors

The Educators Group is defined as:
Teachers, researchers, lecturers, trainers, mentors – what skills do they need, what technologies can they use, etc.

1 **How important is your organisation in ensuring that Ireland has the right skills to benefit from the adoption and deployment of AI?** (Select the most relevant)

- ☐ We play a central role in AI-related education or research
- ☐ We play a supporting role
- ☐ We haven't considered this very much to date
- ☐ We don't have a specific role in this space

2 **How well prepared is your organisation for the adoption and deployment of AI?** (Select the most relevant)

- ☐ We have everything in place that we need to contribute to this agenda
- ☐ We are working to put resources in place
- ☐ We don't yet have a specific approach to AI skills
- ☐ We don't have a role relating to AI skills

3 **What skills should your organisation be imparting to students / learners / trainees so that they are fully prepared for what AI will bring in the next 5-10 years?** (Select all that apply)

- ☐ AI-specific skills and expertise
- ☐ Digital skills
- ☐ Awareness and understanding of AI and its implications
- ☐ 'Soft Skills' – like critical thinking, creativity, collaboration, etc.
- ☐ Haven't yet considered this in sufficient detail to answer
- ☐ We have no specific role
- ☐ Any other specific skills you believe that students need to be prepared for as world of AI systems?

Please list any other AI-specific skills for students here:

4 **Do you, or could you conceivably, use AI systems to support your work as an educator or researcher?** (Select most relevant)

- ☐ Yes, on a routine basis
- ☐ We are adopting AI systems or planning to adopt them
- ☐ We use sophisticated digital systems, but not AI
- ☐ We haven't yet considered how AI can help us
- ☐ We don't plan to use AI

5 What skills do you and your colleagues need to make this happen? (Select all that apply)

- ☐ AI-specific skills and expertise
- ☐ Digital skills
- ☐ Awareness and understanding of AI and its implications
- ☐ 'Soft Skills' – like critical thinking, creativity, collaboration, etc.
- ☐ Haven't yet considered this in sufficient detail to answer
- ☐ We have no specific role, so have no skills needs relating to AI
- ☐ Any other specific skills you need to help you teach about AI and work with AI?

Please list any other AI-specific skills that you and your colleagues need here:

6 Do you have a system in place to ensure you can gain the skills you need? (Select the most relevant)

- ☐ We're already experts and keeping up to date is our job
- ☐ We have an approach to ongoing training – or a CPD system – that provides us with everything we need to learn new skills
- ☐ We are currently developing our Digital Skills and we believe that AI will be covered under that
- ☐ We have some way to go in developing Digital Skills and AI Skills
- ☐ Learning Digital Skills and AI Skills depends on a person's interest – it is not a systematic process of upskilling across the organisation / institution / group of institutions
- ☐ We haven't given much thought to this yet
- ☐ Teaching about AI is not relevant to our organisation

7 What are the main barriers to making progress – to being able to teach about and use AI effectively – in your organisation? (Select all that apply)

- ☐ We would need a lot of training to be confident in using and teaching about AI
- ☐ Reforms to the ways we do things take a long time
- ☐ There is resistance to change within the organisation
- ☐ We don't have enough time to train up sufficiently
- ☐ We don't have the resources and support to allow us to gain the necessary skills
- ☐ We don't see this as our role right now
- ☐ Other

Please mention any other barriers here:

D. Policy Makers, Legislators & Regulators

The Policy Makers Group is defined as:
Those in the public sector who must understand AI well enough to legislate, regulate, procure, draft policy, support enterprise, etc.

1 Does your organisation have a role in Policy, Legislation or Regulation relating to AI? (Select the most relevant)

- ☐ We have a central role in AI Policy
- ☐ We need to keep up to date with AI Policy
- ☐ Our legislation has potential implications for how AI will be adopted, used & experienced
- ☐ Our regulatory functions will be relevant for aspects of the adoption and use of AI
- ☐ We have not yet explored how our role relates to the adoption and use of AI
- ☐ We have no role that relates to AI

2 How prepared is your Organisation / Unit for the role you will play in devising policy for / legislating for / regulating AI? (Select the most relevant)

- ☐ We're one of the leaders in this space and we have a very clear plan
- ☐ We know we will have a role and we're working on how we will fulfil it effectively
- ☐ We don't know what our role will be in this space
- ☐ We haven't yet considered this question sufficiently to give a definitive answer
- ☐ Our responsibilities have nothing to do with AI policy, legislation or regulation

3 How prepared is your Organisation / Unit for the leading role that Government is likely to play in adopting and deploying Trustworthy AI via Public Procurement? (Select the most relevant)

- ☐ We already procure and use AI systems
- ☐ We are considering how AI systems can help us with productivity improvement and service delivery, etc.
- ☐ We have not yet given the use and procurement of AI systems much consideration
- ☐ We don't expect to use or procure AI systems in the foreseeable future

4 If you plan to adopt or expand on your use of AI, do you know what technical skills your organisation will need to make this happen? (Select all that apply)

- ☐ Robotics & automation
- ☐ Machine learning
- ☐ AI applications
- ☐ AI ethics
- ☐ AI regulation
- ☐ Computer vision
- ☐ AI (generic)
- ☐ Natural language processing
- ☐ Knowledge representation and reasoning, planning, search, optimisation
- ☐ Connected and automated vehicles
- ☐ Philosophy of AI
- ☐ Multi-agent systems
- ☐ Audio processing
- ☐ Understanding of the societal impacts of AI
- ☐ Other
- ☐ We don't plan to adopt AI systems

If 'Other', please mention any other technical skills relevant to the adoption or expansion of your use of AI here:

5 If you plan to adopt or expand on your use of AI, what organisational and management skills (excluding technical / ICT skills) will your organisation need to manage this process? (select all that apply)

- ☐ Strategic Management
- ☐ Leadership & Change Management
- ☐ Innovation Management
- ☐ Risk analysis and planning
- ☐ Cross-Functional Management
- ☐ Cross-Disciplinary Communication & Cross-organisational Cooperation
- ☐ AI-specific Project Management
- ☐ Legal & Regulatory Expertise
- ☐ Expertise in Ethics, Philosophy &Trustworthiness
- ☐ AI Governance
- ☐ UX design
- ☐ External Communication Skills (including explaining tech to a non-tech audience)
- ☐ Managing uncertainty and complexity
- ☐ Other
- ☐ We don't plan to expand on our use of AI systems

If 'Other', please add relevant non-technical skills here:

6 How are you going to get or develop the skills you need for dealing effectively with AI? (Select all that apply)

- ☐ Ongoing education and training – Lifelong learning
- ☐ Specific courses designed to help us understand AI and its implications
- ☐ Hiring in the experts we need
- ☐ Paying consultants to carry out specific projects
- ☐ Getting advice and support from other public sector bodies
- ☐ Getting external advice – from industry, academia, etc.
- ☐ We haven't yet considered this question sufficiently to give a definitive answer
- ☐ We don't need AI-related skills
- ☐ Other

If 'Other', please mention any other ways you intend to develop the necessary skills here:

7 **What are the main barriers to getting or developing these skills?** (Select all that apply)

- [ ] We don't know what skills we will need
- [ ] We don't know where to look for the relevant training
- [ ] Our organisation doesn't allow for sufficient domain-specific expertise to be developed over time
- [ ] We are constrained as to who we can hire
- [ ] We can't pay the salaries of the people we would need
- [ ] We don't need AI-related skills
- [ ] Other

If 'Other', please mention any other barriers to developing these skills here :

8 **Do you have any further comments about Skills for AI as they relate to your organisation?**

Categorical Questions

We have included the following five questions to help us categorise and analyse the data we collect from the survey.

(Note that we are not asking for your name or email address, so there is no way to connect these answers to you, personally.)

1 Which of the following best describes where you work? (Select the most relevant)

- ☐ I work in industry / the private sector
- ☐ I work in the public sector
- ☐ I work in an educational institution
- ☐ I take care of children or family
- ☐ I am a student
- ☐ I am not currently employed
- ☐ I am retired
- ☐ Other

If 'Other', please specify:

2 Which age range do you fit into?

- ☐ < 18
- ☐ 18-34
- ☐ 35-49
- ☐ 50-65
- ☐ >65
- ☐ I'd prefer not to say

3 What is your gender?

- ☐ Male
- ☐ Female
- ☐ Other
- ☐ I'd prefer not to say

4 Which age range do you fit into?

- ☐ PhD
- ☐ Masters
- ☐ Degree
- ☐ Leaving Cert
- ☐ Haven't completed the Leaving Cert
- ☐ Other
- ☐ Prefer not to say

If 'Other', please specify:

5 Do you currently live in Ireland?

- ☐ Yes
- ☐ No

Appendix C: Workshop

C1. Approach to Workshop

A workshop was organised in June 2021 to explore the issues around AI Skills in detail with a broad group of stakeholders. Almost 80 people attended from the public sector, industry and the education and training sectors.

The workshop ran for four hours and was structured around the chapters of this report. Sessions were organised under the following headings: (1) Specific Skills needed for AI, (2) Demand for Skills, (3) Supply of Skills and (4) "What are the Big Challenges?"

Each of the four sessions was kicked off by a presentation from an external expert, followed by 7 parallel breakout groups. Each breakout group was facilitated, and notes were taken of each conversation so that they could be collated together afterwards. Each breakout session was provided with a set of indicative questions to guide the discussion. After each breakout session, a rapporteur from two of the groups reported to the plenary meeting, feeding into a general discussion.

The Zoom meeting was organised and administered by Janet Choi from UCC and was supported by 14 facilitators and note-takers from UCC, DETE, SOLAS and elsewhere.

Insights from the workshop are included throughout the report and summarised in the next section, below. The participants, facilitators, note-takers and administrators who attended and supported the workshop are listed in the following section.

C2. Summary of Themes from the Workshop

Session 1 - Skills Needs

What makes AI different from other technologies? (e.g., Difficult for the majority to understand; potential for black box decisions; potential for unintended consequences, etc.)

- The popular misunderstanding of AI among members of the public fed by media/science fiction has created a scare factor. People fear that it will take jobs, rendering human employees obsolete.
- General education is required to spread awareness of possibilities and limitations of AI. People have the right to make an informed decision AI, which they can't do if they don't understand it.
- AI is dynamic, data-driven, and deterministic – its applications and implications are 'fuzzier' than other technologies.
- The technology is advancing quickly, and is already an accepted part of our lives in many ways (AI assistants, SEO, spell check etc.)
- The technology's opaque use of personal data creates concerns around privacy and accountability. Trust is a key component of any technology adaptation and can be a barrier to entry.
- AI will touch every industry and workplace, there won't be any delineation between jobs that use AI and those that don't.
- This is mirrored by the diverse range of skills that will be required to roll out and adopt AI.

What kind of new skills? What kinds of skills (existing or new) **will we need to reap the benefits** (productivity, innovation, growth, employment, etc.) **of AI?**
(Eg: AI product development requires iterative processes.)

Some suggestions include:

- Mathematical, engineering and ICT skills will be crucial for adoption and rollout
- Interdisciplinary skills such as project management and information security
- Digital Citizenship and lifelong learning of digital skills
- Technical skills for the installation of systems, sensors
- Critical thinking and the ability to question AI decisions
- Legal expertise with an understanding of AI
- ICT support will be crucial, as if AI is fully integrated into businesses, then technical issues and downtime of the apparatus will have to be closely managed to avoid major workflow disruptions
- Data analysis and interpretation
- Data visualisation

What kinds of skills (existing or new) **will we need to ensure that AI is deployed in a trustworthy** (ethical & fair) **manner, avoiding unintended consequences?**

Some suggestions include:

- Emotional intelligence
- Understanding of algorithmic processes
- Critical thinking
- Model Auditing Role
- Risk management and mitigation
- Computer security and data protection
- Data visualisation

Session 2 - Demand for Skills

What sectors or groups in the economy or society will be in need of new or different skills because of AI?

- Almost every sector will require some upskilling/reskilling. Most important will be creating a common understanding of what is AI (and what is not), its abilities and its limitations, across all of society. This could be done through Public Information campaigns, websites, and advertising.
- Mid-high level ICT workers will require lifelong learning as technology continues to develop.
- As AI takes over certain tasks, workers can be trained to take on different roles to mitigate the displacement effect.
- Educators will need to introduce concepts of AI from as young an age as is feasible and will themselves require training.
- Government employees engaged in public policy development will also need skills to understand how to regulate AI.
- AI could be used to guide high-level decision-making in positions in which performance is hard to quantify; e.g., CEOs. Will this increase or decrease trust in these positions?

What skills will be obvious and will be demanded immediately?

- General digital literacy and familiarity with common AI tools. People need to speak the correct 'language' in order to engage with AI.
- Mathematics and computer science.
- Data analysis and engineering.
- Project management skills and the ability to realise value- it will be important to ask the right questions and identify how AI can be applied successfully and profitably.
- Transversal or 'soft' skills such as creative thinking, entrepreneurial activity, teamwork and communication skills.
- Multi-lingual workers will be in demand, not just to overcome language barriers but to translate cultural differences in thought processes.
- Advanced manufacturing will be required for the actual machinery and components of AI, as well as the technical abilities to install the infrastructure such as sensor arrays and servers.

What skills are not obvious, and people / organisations won't realise they need them until things go wrong?

- Companies may be reluctant to spend money on oversight (e.g., bias detection) and regulation (e.g., privacy protection) rather than tech workers who produce a measurable output. Regulation will have to be mandated and overseen by the government; self-regulation will not work.
- Organisations will need in-house experts and will not be able purely to rely on outsourcing workers who may not understand Irish context.
- Fundamentals of behavioural psychology will be needed if AI is used to create systems and schedules that humans will interact with, both as employees and users of services.
- Most companies can't afford to hire a philosopher or to concern themselves with the problems that may emerge over a 5–10-year timescale.

Session 3 - Supply of Skills

How will we get the skills we need for AI? What are the ways (through what channels**) we get skills into our organisations?**

- We need to develop new skills and adapt our existing workforce. Currently high share with high skills and high share with low skills- we need to increase the middle cohort.
- Channels for this include open university courses, Massive Open Online Courses.
- Mapping pathways for AI careers will also be crucial but may be difficult as the field is still developing.
- We also need to attract and retain experts and highly skilled workers from other countries. Advertising and outreach can showcase Ireland as both dynamic in industry and a pleasant place to live.
- AI requires a range of skills at a variety of different levels, so we should train for all of these, not just create programmes that result in a few highly skilled people.
- Incentivise learning through subsidies and grants, tax breaks, support for companies who release employees for training.
- Hybrid degree programmes to create diverse skill groups, e.g., Law and Technology, Computer Science and Ethics.
- Government needs to appoint a Digital & AI Tsar (a technocrat, at cabinet level) with power to direct any public/government body to undertake certain initiatives.

What are the biggest challenges we will face around the supply of necessary skills for AI?

- Cost and access for SMEs which make up a large percentage of Irish economy.
- The science behind AI can seem intimidating, discourages people from a young age, same issues with gender imbalance as many STEM fields.
- Root and branch educational reform may be needed; Rote learning and memory are highly stressed in Irish education/Leaving Certificate, while AI requires more creative thinking and problem solving.
- Teachers also must be trained to provide education in this area.
- University programmes must compete for funding. Currently AI is a low priority, overshadowed by more established computer science programmes.
- The half-life of tech skills must be factored in- some skills may be rendered obsolete by the advancement of technology in the time it takes to learn them.

What are some of the opportunities we have to increase the supply of necessary skills for AI?

- Creation of Digital Learning Hubs around the country, using experience gained through the pandemic to re-orient digital learning platforms.
- Micro-credentials and other forms of incremental learning
- Grants and monetary incentives
- Create modules for university courses similar to UCC's 'Elements of AI' to introduce the concepts and raise awareness among diverse disciplines.
- We may already have some of the skills required in the workforce, but people may not realise that they possess them. Need to unlock these latent skills.
- Companies take promising applicants from secondary level and provide the necessary training, superseding the educational system e.g., Google's Analyst Training Programmes.
- Businesses can also offer support in terms of mentorship programmes.
- Creation of a champion programme to illustrate the accessibility of AI, provide concrete examples of careers in AI.
- Outreach to guidance and careers counsellors to ensure that they are familiar with the pathways associated with careers in AI.

Session 4 - Big Challenges

What are the biggest challenges, or obstacles, we will face when trying to ensure that we have the right skills in the right places for the adoption of AI?

- Raising awareness that AI is not just a field for engineers and mathematicians but requires a wide range of skills.
- Cost of living makes Ireland unattractive; if you can live/work anywhere with AI, why choose here?
- Brain drain takes workers from SMEs to large multinationals.
- Need to change the educational model: 2 year programmes will provide more flexibility than traditional 4 year programmes. Existing workers could take shorter courses and be awarded certificates.
- Students need to be able to pivot and change courses in a much more flexible manner.
- Alternatively, continue to focus on providing high-end broad-spectrum courses. Skills may become out-of-date, but a quality education won't.
- Who takes responsibility for AI, do we need to set up a body to focus on public policy formulation?

What skills challenges (or obstacles) will we face immediately?

- Many companies/SMEs are not even operating at a sufficient level of digital competence.
- SMEs will need ready-made AI programmes (aka 'out of the box') to be able to take advantage of the technology.
- Companies need to be made to understand how AI can benefit them and their businesses, raise awareness of the various, non-obvious ways that AI can be utilised.
- Capacity of third level institutions to deliver the necessary courses is in question, some are already struggling to retain current staff or attract new ones.
- Opportunities for skilled graduates may be limited at first and will not be infinite, possibility of over-supply.
- The presence of numerous large internet multinationals in Ireland means that our Data Protection Office may have an outsized role in setting standards.

What skills challenges (or obstacles) are likely to emerge over time?

- Need for upskilling will be semi-constant, but people's time is limited; incentivise companies to allow training during work hours.
- Despite best efforts people may be reluctant to engage in lifelong learning.
- As roles are eliminated it may result in job losses, which will need to be mitigated and may create cynicism towards AI.
- Potential over-emphasis on STEM education could hurt other disciplines.
- Need to produce graduates with AI knowledge and also domain mastery.
- The global community is unlikely to develop an international regulatory framework for AI- what will the EU's look like vs China or the USA? Will they be compatible and/or transferable?
- Ireland may end up following trends rather than innovating, importing foreign solutions for Irish problems. On a more optimistic note, Ireland was a global leader in terms of the contact tracing app.
- How to build mechanisms that will allow for reskilling and updating of skills throughout a career?
- Who will monitor companies to ensure AI is being applied in an ethical way, how can we identify potential misuses of an emerging technology before they happen?

C3. Workshop Participants, Facilitators and Note-Takers

Participants

	Name	Title/Organisation
1	Aditya Mohan	Standards Officer, NSAI
2	Alessandra Sala	Director of AI and Data Science, Shutterstock
3	Ann Piggott	ASTI
4	Anthony Kilcoyne	Professional Development Service for Teachers, Dept of Education
5	Aoife D'Arcy	CEO, Krisolis
6	Barry O'Sullivan	School of Computer Science & IT, UCC
7	Betty Regan	Dept of Education
8	Brian Mac Namee	Centre Director for the SFI Centre for Research Training in Machine Learning
9	David Moloney	Chief Scientist, Ubotica Technologies
10	Denise Rocks	Regional Skills (West)
11	Don O'Connor	Labour Market & Skills Unit, Dept of Enterprise, Trade & Employment
12	Dr Eamonn Cahill	Director of Trade Licensing and Control
13	Dr Fergal McGrath	Senior Lecturer in Knowledge Management at UL
14	Dr Fionn McGrath	PHD in Philosophy
15	Dr Lisa Wilson	NERI Economic Research Institute
16	Dr Martin Cunneen	Lecturer, Kemmy Business School on MSc AI on Ethics
17	Dr Pepijn van de Ven	Course Director for MSc in AI and on-line educationalist
18	Edward McDonnell	Director, CeADAR, UCD
19	Geraldine Magnier	Idiro Analytics
20	Harry McCann	Trendster Media
21	Harry Molloy	Analyst, Commission for Regulation of Utilities
22	Hilary McPartland	Regional Skills (North-West)
23	Ivan Griffin	Director, Emdalo Technologies
24	Ivica Milicevic	Manager, Active Inclusion, SOLAS
25	James Maher	DFHERIS
26	Jean O'Neill	AP, Intellectual Property Unit
27	Joan McNaboe	Manager, Skills and Labour Market Research
28	Joe Costello	Regional Skills (Midlands)
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35	Kieran McSherry	Senior Director, J&J Vision
36	Lena McLoughlin	Dept of the Environment, Climate & Communications
37	Luke McDonnell	Senior Corporate Communications Manager, Huawei
38	Mark Boyle	J&J Vision
39	Mark Warren	Data Governance Unit, Office of the Government CIO
40	Martin Hayes	Head of The Electronic & Computer Engineering Department, UL
41	Martin O'Flaherty	DETE, Intellectual Property Unit
42	Mary Lyons	Solas
43	Mary Magner	President, INTO
44	Mary O'Donohue	Director, Office of the Government CIO
45	Maysoun Mustafa	Scientific Programme Manager, Science Foundation Ireland
46	Meabh Redmond	Engagement Lead, Accenture Labs Dublin
47	Medb Corcoran	Managing Director Accenture Labs
48	Michael McNamara	Team Leader for Digital Technologies, PDST
49	Nicola Stokes	Technologist, IDA Ireland
50	Patricia Scanlan	CEO, Soapbox Labs
51	Philip McGrath	Dept of Public Expenditure & Reform
52	Prag Sharma	Global Head of AI, Citi
53	Prof Ann Ledwith	Dean of Graduate Studies UL
54	Prof Farrel Corcoran	Professor of Communicatiosn (emeritus) in DCU and former Chairman, RTE
55	Prof John Nelson	Associate Professor, Computer Engineering, UL
56	Rachel Finn	Senior Practice Manager at Trilateral Research
57	Ray Richardson	Global Head of Engineering for Data Analytics, DB Service Centre Ltd.
58	Saoirse Ni Mhathuna	Economist, Department of the Environment, Climate and Communications
59	Sebastian Hamilton	Head of Public Affairs, Ireland, Revolut
60	Tony Devlin	ICT Skillnets, Chair of Industry Board for national MSc AI at UL
61	Yassine Jelassi	Commercialisation Manager of CeADAR, National Centre for Applied Artificial Intelligence.

Facilitators, Note-Takers & Administrators

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1	Alan Power	DETE
2	Niamh Martin	DETE
3	Ruth Morrissy	DETE
4	Michael Hill	DETE
5	Rhodri Lloyd	DETE
6	Jesse Carley	DETE
7	Maedhbh Cronin,	DETE
8	Rachel O'Neill	DETE
9	Dr. Chrys Ngwa	UCC
10	Dr. Long Pham	UCC
11	John O'Donoghue	DPER
12	Don O'Connor	DETE
13	Janet Choi	UCC
14	Shaun Gavigan	UCC
15	Andrea Balogh	UCC
16	Noreen Fitzpatrick	SOLAS
17	Paul Cunningham	Volunteer
18	Barry O'Sullivan	UCC

Appendix D: Supply Data

Springboard+ Courses 2021

Course Type	Course Title	Course Provider	NFQ Level	FT or PT	Credits
Springboard	MSc in Software Design with Artificial Intelligence	Athlone Institute of Technology	Level 9	Part-time	90
ICT	Higher Diploma in Science in Artificial Intelligence Applications	CCT College Dublin	Level 8	Part-time	60
Springboard	Graduate Certificate in the Internet of Things	Dublin City University	Level 9	Part-time	45
Springboard	Graduate Certificate in Artificial Intelligence	Dublin City University	Level 9	Part-time	30
Springboard	Certificate in Drones and SMART Agri Sensors	Galway Mayo Institute of Technology	Level 6	Part-time	20
Springboard	Master of Science in Applied Artificial Intelligence	Institute of Technology Carlow	Level 9	Part-time	90
Springboard	Postgraduate Certificate in Artificial Intelligence	Letterkenny Institute of Technology	Level 9	Part-time	40

HCI Courses

Course Type	Course Title	Course Provider	NFQ Level	FT or PT	Credits
HCI	Higher Diploma in Artificial Intelligence (Concepts and Application)	CCT College Dublin	Level 8	Full-time	60
HCI	Postgraduate Diploma in Engineering in Smart Manufacturing Technology	Limerick Institute of Technology	Level 9	Full-time	60
HCI	Higher Diploma in Science in Computing (Artificial Intelligence/Machine Learning) 1 Year Online	National College of Ireland	Level 8	Full-time	60

All Other HE Provision

Course Name	HEI	Programme Type
Certificate in Robotics and Automation	Athlone IT	Certificate
Postgraduate Certificate in Software Design with Artificial Intelligence	Athlone IT	Postgraduate Certificate
Certificate (SPA) Advanced Industrial Automation	Cork IT	Certificate
Certificate (SPA) Automation and Control Systems	Cork IT	Certificate
Master of Science Artificial Intelligence	Cork IT	Masters Taught (Postgraduate)
Master of Science Artificial Intelligence	Cork IT	Masters Taught (Postgraduate)
Grad Cert in Artificial Intelligence	Dublin City University	Postgraduate Certificate
Grad Cert in Artificial Intelligence	Dublin City University	Postgraduate Certificate
Grad Cert in Image Processing + Analysis	Dublin City University	Postgraduate Certificate
MSc in Computing	Dundalk IT	Masters Taught (Postgraduate)
PGDip in Science in Data Analytics	Dundalk IT	Certificate Taught (Postgraduate)
MSc in Data Analytics	Dundalk IT	Masters Taught (Postgraduate)
BSc(Hons) in Mathematics and Data Science	Dundalk IT	Undergraduate Honours Degree
Bachelor of Engineering in Electrical Services and Automation Engineering	Galway-Mayo IT	Undergraduate General Degree
Certificate in Industrial Automation (Special Purpose Award)	Galway-Mayo IT	Certificate
MSc in Applied Artificial Intelligence	IT Carlow	Masters
HDip in Applied Artificial Intelligence	IT Carlow	Postgraduate Diploma
BSc Honours in Software Development	IT Carlow	Undergraduate Honours Degree
BSc Honours in Games Development	IT Carlow	Undergraduate Honours Degree

All Other HE Provision

Course Name	HEI	Programme Type
MSc in Data Science	IT Carlow	Masters Taught (Postgraduate)
HDip in Data Science	IT Carlow	Postgraduate Diploma
Certificate in Automotive Artificial Intelligence	IT Sligo	Postgraduate Certificate
Certificate in Engineering in Automation and Electronics	IT Sligo	Certificate
Certificate in Engineering in Automation and Instrumentation	IT Sligo	Certificate
Certificate in Mechanical Analysis and Automation	IT Sligo	Certificate
Certificate in Secure IT and Deep/Machine Learning	IT Sligo	Certificate
Certificate in Sensors for Autonomous Vehicles	IT Sligo	Postgraduate Certificate
Master of Engineering in Connected and Autonomous Vehicles	IT Sligo	Masters Taught (Postgraduate)
Postgraduate Diploma in Engineering in Connected and Autonomous Vehicles	IT Sligo	Post Graduate Diploma
Certificate in Industrial Instrumentation and Automation	IT Tralee	Certificate
Certificate in Artificial Intelligence	IT Tralee	Certificate
Certificate in Industrial Instrumentation and Automation	IT Tralee	Certificate
Master Of Science in Artificial Intelligence Research	Letterkenny IT	Masters Research (Postgraduate)
Master Of Science in Big Data Analytics & Artificial Intelligence	Letterkenny IT	Masters Taught (Postgraduate)
Bachelor of Science (Honours) Software Development	Limerick IT	Undergraduate Honours Degree
Bachelor of Science (Honours) Internet Systems Development	Limerick IT	Undergraduate Honours Degree
Bachelor of Science (Honours) Games Design & Development	Limerick IT	Undergraduate Honours Degree
Bachelor of Engineering (Honours) Industrial Automation & Robotic Systems	Limerick IT	Undergraduate Honours Degree

All Other HE Provision

Course Name	HEI	Programme Type
Bachelor of Engineering Industrial Automation & Robotic Systems	Limerick IT	Undergraduate General Degree
BSc in Robotics And Intelligent Devices	Maynooth University	Undergraduate Honours Degree
BSc Bachelor of data science	Maynooth University	Undergraduate Honours Degree
MSc in data science and analytics	Maynooth University	Masters Taught (Postgraduate)
Hdip Higher Diploma in Data Analytics	Maynooth University	Undergraduate Diploma
BSc in Computer Science and Software Engineeing	Maynooth University	Undergraduate Honours Degree
BSC in Multimedia, Mobile, and Web Development	Maynooth University	Undergraduate Honours Degree
Diploma in Automation & Control	National University of Ireland, Galway	Undergraduate Diploma
Master of Science in Computer Science - Artificial Intelligence (FT)	National University of Ireland, Galway	Masters Taught (Postgraduate)
Master of Science in Computer Science - Artificial Intelligence -Online	National University of Ireland, Galway	Masters Taught (Postgraduate)
Postgraduate Certificate in Artificial Intelligence for Managers	National University of Ireland, Galway	Certificate
Speech and Language Processing	Trinity College Dublin	Masters Taught (Postgraduate)
BA (Mod) Computer Science	Trinity College Dublin	Undergraduate Honours Degree
BA (Mod) Computer Science and Business Joint Honours	Trinity College Dublin	Undergraduate Honours Degree
BA (Mod) Computer Science and Linguistics Joint Honours	Trinity College Dublin	Undergraduate Honours Degree
BA (Mod) Computer Science and Geography Joint Honours	Trinity College Dublin	Undergraduate Honours Degree
Computer Science, Linguistics and a Language	Trinity College Dublin	Undergraduate Honours Degree
BA Management Science and Information Systems Studies	Trinity College Dublin	Undergraduate Honours Degree
BA, BAI in Computer Engineering	Trinity College Dublin	Undergraduate Honours Degree

All Other HE Provision

Course Name	HEI	Programme Type
MAI in Computer Engineering	Trinity College Dublin	Masters Taught (Postgraduate)
MSc in Computer Science	Trinity College Dublin	Masters Taught (Postgraduate)
Postgraduate Certificate in Statistics	Trinity College Dublin	Certificate
Bachelor Engineering Tec (Ord) Automation Engineering	TU Dublin	Undergraduate General Degree
Bachelor Engineering Tec (Ord) Control and Automation Systems	TU Dublin	Undergraduate General Degree
Bachelor of Engineering (Honours) in Mechanical Engineering (Automation)	TU Dublin	Undergraduate Honours Degree
Bachelor of Science in Process Instrumentation & Automation	TU Dublin	Undergraduate General Degree
Bachelor of Science in Process Instrumentation and Automation	TU Dublin	Undergraduate General Degree
Bachelor of Science Process Instrumentation and Automation	TU Dublin	Undergraduate General Degree
Certificate in Industrial Automation (SPA)	TU Dublin	Certificate
Certificate in Machine Learning & Artificial Intelligence	TU Dublin	Certificate
MSc in Computer Science (Advanced Software Development)	TU Dublin (City Campus)	Postgrad MSc, full time
MSc in Computer Science (Advanced Software Development)	TU Dublin (City Campus)	Post grad MSc, part time
MSc. in Computer Science (Data Science)	TU Dublin (City Campus)	Postgrad MSc, full time
MSc. in Computer Science (Data Science)	TU Dublin (City Campus)	Post grad MSc, part time
PgCert in Data Science	TU Dublin (City Campus)	Post grad certificate
BSc. in Computer Science (Infrastructure)	TU Dublin (City Campus)	Undergraduate Honours Degree
BSc. in Computer Science	TU Dublin (City Campus)	Undergraduate Honours Degree
BSc. in Computer Science (International)	TU Dublin (City Campus)	Undergraduate Honours Degree

All Other HE Provision

Course Name	HEI	Programme Type
Information Systems and Information Technology	TU Dublin (City Campus)	Undergraduate Honours Degree (part-time)
BSc in Computer Science	University College Cork	Undergraduate Honours Degree
BSc in Data Science & Analytics	University College Cork	Undergraduate Honours Degree
MSc in Computing Science	University College Cork	Postgrad MSc
MSc in Data Science & Analytics	University College Cork	Postgrad MSc
MEngSc Mechanical Engineering (Manufacturing, Process and Automation Systems)	University College Cork	Masters Taught (Postgraduate)
Artificial Intelligence	University of Limerick	Masters Taught (Postgraduate)
Master of Science in Artificial Intelligence	University of Limerick	Masters Taught (Postgraduate)
Robotics	University of Limerick	Certificate
Certificate in Introduction to Automation	Waterford IT	Certificate
Certificate in Robotics and Automation	Athlone IT	Certificate
Postgraduate Certificate in Software Design with Artificial Intelligence	Athlone IT	Postgraduate Certificate
Certificate (SPA) Advanced Industrial Automation	Cork IT	Certificate
Certificate (SPA) Automation and Control Systems	Cork IT	Certificate
Master of Science Artificial Intelligence	Cork IT	Masters Taught (Postgraduate)
Master of Science Artificial Intelligence	Cork IT	Masters Taught (Postgraduate)
Grad Cert in Artificial Intelligence	Dublin City University	Postgraduate Certificate

Science Foundation Ireland Centres for Research Training

The following six involve AI to greater or lesser extents, but do generate PhD-level graduates in artificial intelligence. There are two CRTs specifically addressing artificial intelligence and machine learning

Programme	Awarding Body
SFI CRT on Artificial Intelligence	University College Cork
SFI CRT in Advanced Networks for Sustainable Societies	University College Cork
SFI CRT in Machine Learning	University College Dublin
SFI CRT in Foundations of Data Science	University of Limerick
SFI CRT in Digitally-Enhanced Reality	Trinity College Dublin
SFI CRT in Genomics Data Science	NUI Galway

Skillnet Ireland Courses

Skillnet	Programme Title	Certification Level	Awarding Body
Technology Ireland ICT Skillnet	PhD in Data Science & AI	Level 10	University of Limerick
Technology Ireland ICT Skillnet	MSc In Artificial Intelligence - Year 1	Level 9	University of Limerick
Technology Ireland ICT Skillnet	MSc In Artificial Intelligence Year 2	Level 9	University of Limerick
Technology Ireland ICT Skillnet	Foundation Certificate in Artificial Intelligence	Level 8	TU Dublin
Technology Ireland ICT Skillnet	Foundation Certificate in Artificial Intelligence	Level 8	TU Dublin
Technology Ireland ICT Skillnet	MSc in Computer Science (Artificial Intelligence) Year 1	Level 9	NUIG
Technology Ireland ICT Skillnet	MSc in Computer Science (Artificial Intelligence) Year 2	Level 9	NUIG
Technology Ireland ICT Skillnet	MSc in Computing – Artificial Intelligence Year 1	Level 9	DCU
Technology Ireland ICT Skillnet	MSc in Computing (Artificial Intelligence) Year 2	Level 9	DCU
ICBE Advanced Productivity Skillnet	Certificate in Robotics and Automation	Level 7	GMIT
ICBE Advanced Productivity Skillnet	Robotics & Automation		
Irish Medtech Skillnet	Manufacturing Automation and Robotics L9 5ect	Level 9	LIT
Irish Medtech Skillnet	Data Analytics & Machine Learning L9 5ect	Level 9	LIT

HECA Courses

HEI	Award Title	Type of Programme	Students	Other
Griffith College	BSc (Hons) in Computing Science	Degree	45	Module on Machine Learning (5 ECTS)
Griffith College	BSc (Hons) in Computing Science	Degree	22	Module on Artificial Ingelligence and Robotics (5 ECTS)
Griffith College	BSc (Hons) in Computing Science	Degree	35	Module on Numerical Optimisation (5 ECST)
Griffith College	BSc in Computing Science	Degree	21	
Griffith College	M.Sc. in Big Data Management and Analytics	Masters	85	Module on Data Mining and Techniques (10 ECTS)
Griffith College	Postgraduate Diploma in Big Data Management and Analytics	Postgraduate Diploma	6	
Griffith College	M.Sc. in Big Data Management and Analytics	Masters	83	Information Retrieval and Web Search (10 ECTS)
Griffith College	Postgraduate Diploma in Big Data Management and Analytics	Postgraduate Diploma	6	
Griffith College	M.Sc. in Big Data Management and Analytics	Masters	70	Module on Big Data Analytics (10 ECTS)
Griffith College	Postgraduate Diploma in Big Data Management and Analytics	Postgraduate Diploma	6	
Griffith College	M.Sc. in Big Data Management and Analytics	Masters	82	Module on Applied Data Science (10 ECTS)
Griffith College	Postgraduate Diploma in Big Data Management and Analytics	Postgraduate Diploma	6	
Griffith College	M.Sc. in Computing Science	Masters	40	Module on Information Retreival and Web Search (5 ECTS)
Griffith College	Postgraduate Diploma in Computing Science	Postgraduate Diploma	3	
DBS	MSc in Artifical Intelligence	Masters	21	
CCT	Diploma in Artificial Intelligence and Working into the Future	Diploma	38	60 ECTS / Level 7
CCT	Higher Diploma in Science in Artificial Intelligence Applications	Higher Diploma	64	Full Time 1 year, Part Time over 2 years; Springboard & HCI funded; 60 ECTS / Level 8

Education and Training Board Courses

Course Areas	Education and Training Board (ETB)
Cobotics Control using High Level Programming Approaches	Louth and Meath ETB
Cobotics	Louth and Meath ETB
Introduction to Machine Learning	Louth and Meath ETB
Implementing Automation and Robotics – Intermediate	Louth and Meath ETB
Technical Insight into Automation and Robotics - Introduction	Louth and Meath ETB
Introduction to Robotics - Entry Level	Louth and Meath ETB
Introduction to Innovation in Robotics	Louth and Meath ETB
Engineering Technology & Robotics	Louth and Meath ETB
Automation & Robotics Engineering	Kilkenny and Carlow ETB
Introduction to Robotics - Intermediate Level	Louth and Meath ETB
Cobotics, Programming & Vision Training	Louth and Meath ETB
Digital Systems Engineering - AI and Robotics	Dublin and Dun Laoghaire ETB
Robotic Process Automation Developer Foundation	Limerick and Clare ETB
Electronic Technology - Robotics	Cavan and Monaghan ETB
Robotics Welding	Louth and Meath ETB
Artificial Intelligence / Machine Learning	Louth and Meath ETB

Appendix E:

List of Steering Group Members

Name	Orginsation
Barry O'Sullivan (Chair)	University College Cork
Don O'Connor (Secretary)	Department of Enterprise, Trade and Employment
Betty Regan	Department of Education
Anthony Kilcoyne	Department of Education
Maysoun Mustafa	Science Foundation Ireland
John Durcan	Enterprise Ireland
Nicola Stokes	IDA
Philip McGrath	Department of Public Expenditure and Reform
Mary O'Donohue	Office of the Government Chief Information Officer (Department of Public Expenditure and Reform)
Aditya Mohan	National Standards Authority of Ireland
John Rice	Department of the Environment, Climate and Communications
Mary Lyons	SOLAS
Kieran McSherry	Johnson & Johnson
Sebastian Hamilton	Revolut
Luke McDonnell	Huawei
James Louttit	CPL
Alessandra Sala	Shutterstock
Medb Corcoran	Accenture
Patricia Scanlan	Soapbox Labs
Edward McDonnell	University College Dublin
John Nelson	University of Limerick
Lisa Wilson	Nevin Economic Research Institute
Mary Magner	Irish National Teachers' Organisation

Appendix F:

Acknowledgements

The Expert Group on Future Skills Needs would like to thank all of the project Steering Group members for their time, expertise and enthusiasm through the project. The members of the Steering Group are listed in Appendix E.

In particular, the EGFSN would like to thank the Steering Group Chair, Professor Barry O'Sullivan, who has guided the project and the Group since the outset. Barry has provided tireless encouragement and support to the secretariat throughout the project, not only in terms of the strategic direction but also by way of administrative support for meetings and the workshop.

The EGFSN appreciates the time knowledge offered by a wide range of stakeholders and experts at the June workshop. Additionally, a large number of colleagues from UCC, DETE, DPER and SOLAS supported the workshop by facilitating and taking notes on the day. A list is provided at Appendix C.

In particular, Janet Choi, from UCC assisted materially with the organisation of a number of online meetings, including the workshop, providing invaluable Zoom expertise, without which the events could not have proceeded so smoothly.

Thanks are also due to all of the Steering Group members and departmental officials who assisted in honing the recommendations in the report.

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