Technological University Dublin
ARROW@TU Dublin

Articles | School of Accounting, Economics, and Finance

2023

Automation, AI, and Future Skills Needs: An Irish Perspective

Raimunda Bukartaite
Technological University Dublin, Ireland, raimunda.Bukartaite@tudublin.ie

Daire Hooper
Technological University Dublin, Ireland, daire.hooper@tudublin.ie

Follow this and additional works at: https://arrow.tudublin.ie/buschacart

 Part of the Business Commons, and the Other Computer Engineering Commons

Recommended Citation

Bukartaite, Raimunda and Hooper, Daire, "Automation, AI, and Future Skills Needs: An Irish Perspective" (2023). *Articles*. 63.
https://arrow.tudublin.ie/buschacart/63

This Article is brought to you for free and open access by the School of Accounting, Economics, and Finance at ARROW@TU Dublin. It has been accepted for inclusion in Articles by an authorized administrator of ARROW@TU Dublin. For more information, please contact arrow.admin@tudublin.ie, aisling.coyne@tudublin.ie, vera.kilshaw@tudublin.ie.

This work is licensed under a Creative Commons Attribution-Share Alike 4.0 International License.
Funder: No funding was received for this work.

Automation, AI, and Future Skills Needs: An Irish Perspective

Raimunda Bukartaite and Daire Hooper

School of Management, People and Organisation

Faculty of Business

TU Dublin

Structured Abstract

Purpose: The study explores insights from key stakeholders into the skills they believe will be necessary for the future of work as we become more reliant on artificial intelligence (AI) and technology. The study also seeks to understand what human resource policies and educational interventions are needed to support and take advantage of these changes.

Design/methodology/approach: This is a qualitative study where a sample of highly experienced representatives from a range of small to large Irish organisations, both public and private, provide insights into this important topic.

Findings: Findings indicate participants see a continued need for soft and hard skills as we evolve towards a more technologised workplace, with a need for employees to adopt a life-long learning philosophy. As the knowledge economy in Ireland is well established, experts do not expect mass displacement to occur but differ with respect to the predicted rate of change. Novel HR interventions such as hiring for potential, pooling talent and establishing postgraduate supply contracts are seen as key. Current state interventions were mostly viewed positively but revamping of curricula is needed as well as stronger partnerships with tertiary institutions.

Research limitations: The interpretivist nature of the study limits the generalisability of the findings as they are based on a relatively small sample from one country. Also despite the significant expertise of the sample, it is not possible to predict whether their forecasts will manifest.

Practical implications: This research highlights the need for Irish SMEs to embrace the impacts of automation and AI as many are seen to be slow in reacting to changes in technology. The study also reveals cutting edge talent management interventions for employers to adopt that will insulate them from the challenges technological change presents to recruitment and employee development.

Originality/value: The findings from this paper culminate in the development of a conceptual framework which encapsulates the responsibilities of all parties so that future skills needs will be met. This highlights the interplay between employers, individuals/employees, the Irish government and educational institutions, demonstrating how they are interdependent on one another as we move towards a more technologised future.

Introduction

The advent of the Fourth Industrial Revolution, also known as Industry 4.0 has fundamentally transformed the world in which we live and has created a new genre of economic, social and societal change (Pereira et al., 2023; Sima et al., 2020; Vrontis et al., 2022). It is characterised by a network of advanced technologies such as robotics, the Internet of Things, automation and the application of Artificial Intelligence (AI) to a wide variety of science, technology and business processes. AI, in particular, is seen as the new 'electricity' of Industry 4.0 and is a term often used when discussing machine learning, a unique subfield of AI that is said to become indispensable to business in the future. This paper gains insights into Irish key stakeholders' predictions for the future of work in light of developments in AI and technology. It also explores what interventions are needed to meet future skills needs. The paper addresses the following research questions:

RQ1: How do key stakeholders believe the skills necessary for knowledge workers will change in the future, with respect to developments in automation and AI?
RQ2: What talent management and national educational interventions are necessary to meet future skill requirements?

Literature Review

The Displacement Effect

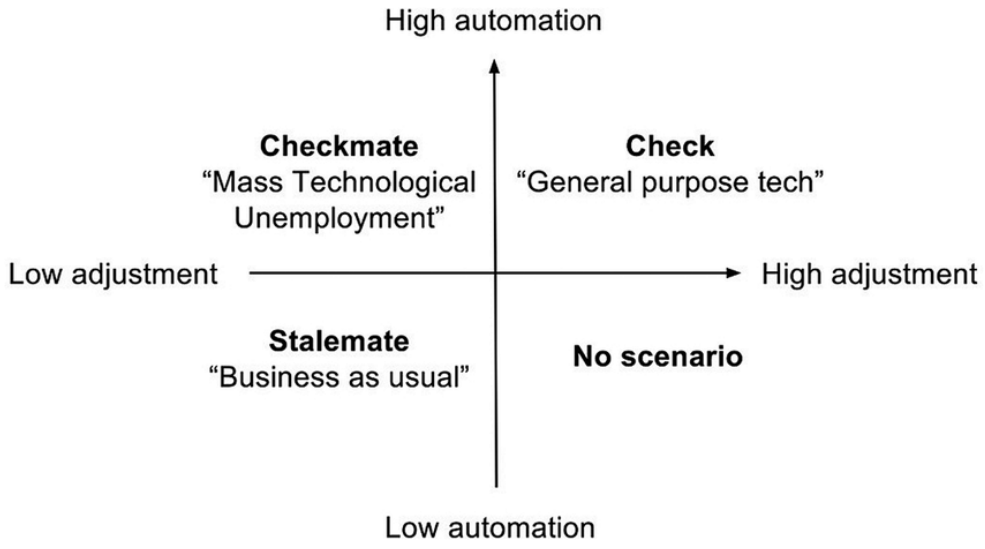
Given the potential of Industry 4.0, there is concern that existing jobs will be threatened (Brynjolfsson & McAfee, 2014; Frey & Osborne, 2017; Vrontis et al., 2022) and it is predicted that in 20-30 years' time, up to 45% of human-performed work will be substituted for robotic labour across most industries (Bruun & Duka 2018, Chui et al., 2015). This shift in labour is known as the displacement effect (Acemoglu & Restrepo, 2018; Georgieff & Hyee; 2022) and is predicted to have far-reaching effects on society. The Covid-19 pandemic highlighted the risks and costs of direct contact between humans and subsequently accelerated the development of the displacement effect through the increased implementation of automation as an alternative to human labour (Korinek & Stiglitz, 2021). Large language models such as ChatGPT are a more recent force that is expected to accelerate this trend with Eloundou et al (2023) predicting

at least half of all tasks for approximately 19% of the US workforce will be affected. These developments put routine tasks which are explicit and codifiable under threat of substitution, with recent employment growth in developed countries focusing on non-routine knowledge work which requires more uniquely human skills (Autor, 2015). However, authors such as Ford (2015) believe automation and AI will move beyond this into non-routine work while simultaneously holding dominance over routine tasks. For some, such as Bruun and Duka (2018), it "represents a situation that has never been witnessed in the history of economic development – a technology that simultaneously threatens jobs across the whole employment spectrum" (p. 4). However, these more extreme views have been tempered by scholars who consider fears of mass unemployment to be overstated (Atkinson & Wu, 2017), with a recent empirical study by McGuinness et al. (2023), finding that as little as 16% of EU workers are impacted by skills-displacing technological change. It is believed that AI is more likely to change the nature and quality of work, rather than replace it, and as long as humans adapt to new opportunities, they will remain valuable to the workplace (Briciu & Briciu, 2021, Lane & Saint-Martin, 2021; Shipley & McGowan, 2020; Thompson & Briken, 2017; World Economic Forum, 2023). As such, roles involving complex problem-solving, creativity, intuition, and persuasion are stubbornly difficult to replace with technology (Autor, 2015; Huang & Rust, 2018) and will remain relevant into the future (World Economic Forum, 2023).

A chessboard analogy has been used by Bruun and Duka (2018) to explain three plausible scenarios of the effects of AI on the labour market by 2038 (see Figure 1 below). 'Stalemate' would suggest that there is little reason for concern, as changes to the nature of work will be far less revolutionary than suggested. Conversely, 'check' proposes changes will not be as significant as anticipated and labour markets can adapt amidst the havoc to create new positions for replaced jobs to keep the human workforce relevant. Finally, 'checkmate' would suggest mass job losses and social instability, as organisations, economies, and individuals struggle to keep pace with the change towards increased automation.

Figure 1: Possible AI Effects on Employment

(Source: Bruun and Duka, 2018)



Experts are highly divided as to which scenario will emerge, with most academics believing the 'stalemate' and 'checkmate' scenarios are most likely to occur (Anderson and Smith (2014), however Bruun and Duka (2018) themselves argue that the real debate is between 'check' and 'checkmate'. Deshpande *et al*. (2021) predict that high-income countries will be better equipped to meet the challenges of automation and AI, with the possibility of positive outcomes for the economy, companies, and employees. These conceptualisations aside, the reality is that in practice, employees are experiencing work intensification, rather than simplification as a result of technology (Brione, 2017). Due to the accelerated use of technology there is often the expectation of greater productivity by management since knowledge workers have more time to contribute to value-adding tasks. By delegating simpler tasks to technology, and taking on more complex tasks, work intensification can become a real challenge for knowledge workers and can have a deleterious impact on employees' wellbeing (Grant et al., 2020).

The proliferation of automation and AI in the workplace has also created some autonomy concerns (Arslan et al., 2022; Chuang 2021; Chuang & Graham, 2018; Morandini, 2023). This parallels Braverman's (1974) Deskilling Thesis, which outlined how the implementation of scientific management in the early 20th century allowed for the routinisation of work but also resulted in the deskilling of employees, making them easily controllable and replaceable. Even

though the main source of business value in developed economies has shifted from labour efficiency to intellectual skills, such as creativity and innovation (Thompson & Briken, 2017), the Deskilling Thesis echoes a power-balance concern that remains relevant in today's debate about automation and AI and may explain the resistance towards emergent technologies (Arslan et al., 2022; Tudoreanu & Kotz, 2020). If employees perceive technological implementation as a threat to their value and wellbeing, internal fear and resistance may emerge which subsequently impedes workers from adapting to new skill requirements.

In the absence of proactive measures, it is predicted that inequality is likely to be exacerbated by the increasing adoption of automation and AI (Zahidi et al., 2020). Employees in jobs that are most at risk of displacement are often at a double disadvantage in that they are limited financially and in terms of job security, while also having lower proficiency in high-demand skills and unequal access to learning and development (Collings & McMackin, 2019). It is anticipated by some that only a minority in society will benefit from the increased use of automation and AI, with a strengthened polarisation of the labour market due to technology, whereby wage gains and crucial skill acquisition are disproportionally experienced by those at the top and the bottom, but not those in the middle (Goos & Manning, 2003; Graetz & Michaels, 2015; Korinek & Stiglitz, 2021). With the correct training and educational support, this polarisation may not last indefinitely, and it is proposed that middle workers can retain their competitive advantage by having a unique combination of both technical and interpersonal skills (Autor, 2015, World Economic Forum, 2023). To add credence to this, an analysis of job descriptors and patents by Webb (2020) finds that, unlike software and robots used for manual tasks, AI is directed at high-skilled tasks, and therefore may have the effect of reducing wage inequality.

Current Skill Demands and the Skill Gap

Due to the accelerated nature of technological change, it is predicted that skill demands will change for the entire workforce, to a greater or lesser extent, even for positions reliant on uniquely human skills with no way to 'robot-proof' any career track (Morandini et al., 2023; Shipley & McGowan, 2020). There is a debate in the skill preparation literature, however, as to which skills should be prioritised to bridge the gap (Rotatori *et al*., 2021). For the last two decades, academics have stressed the importance of Science, Technology, Engineering, and Maths (STEM) skills for the future (Jang, 2016; Smith & White, 2020) and it is believed that

4.5 million job positions in STEM will be vacant by 2030 (Cutler-Knowles & Lewis, 2018), with only 300,000 AI engineers in existence out of the millions needed worldwide (Su *et al*., 2021). Yet despite these predictions, some scholars have challenged the emphasis on hard skills, stating instead that soft skills such as collaboration, teamwork, ethics, and judgement are key (Morandini et al., 2023; Teng *et al*., 2019; Weritz, 2022). In fact, Zahidi *et al*. (2020) find that skill gaps in terms of critical thinking, self-management, and working with people are the number one barrier to the adoption of advanced technologies. Regardless of the type of skills needed in the future, it is essential that employers are cognisant of the negative effect skill shortages and mismatches will have on their business (Brunello & Wruck, 2021) and for those organisations adopting AI systems, reskilling current employees is critical as it allows employees to develop the knowledge to work effectively with these new technologies (Chuang, 2021; Kaliannan et al., 2023; Morandini et al., 2023; Whysall et al., 2019; Wilkinson et al., 2021). Many blue-chip companies are ensuring the future success of new technologies by investing in technical and soft skills training while simultaneously developing AI-powered products and services (Jaiswal et al., 2021). Training initiatives often manifest in the form of corporate learning programmes and industrial academies with specifically tailored curricula aligned to employment schedules (McDonald, 2020). Massive Online Open Courses (MOOCs) such as that provided by third-party platforms like Coursera, edX, and Udacity (Mallon, 2013) allow companies to provide companies with a convenient and cost-effective way of upskilling and expanding their workforce but whether MOOCs are the panacea to the problem (Calonge et al., 2019) in still unclear.

Recruitment Interventions

In the past when companies struggled to recruit the right skills they would try to poach talent from competitors (Amankwah-Amoah, 2018) but this strategy is currently less effective given the necessary skills may not even exist in the system (Whysall et al., 2019). Since some of the most in-demand roles, such as app developers, cloud computing experts and data scientists did not exist ten years ago, there is simply not enough talent in the market from which to recruit (Baldassari & Roux, 2017). For those who manage to attract ideal candidates, critical talent is often under-utilised due to the absence of socially supportive networks to leverage their skills (Amankwah-Amoah et al., 2017). Hence, intensive lateral hiring is not sufficient to meet the talent shortage, rather a more holistic, systems-orientated talent management strategy is required (Whysall et al., 2019).

It has been argued that instead of competing for the limited supply of skills, it would be more advantageous for companies to adopt a 'sharing value' approach, whereby organisations build partnerships to expand the talent pipeline into communities and train people accordingly, while helping to reduce skill inequality in society from a wider corporate social responsibility perspective (Porter & Kramer, 2011). Makarius and Srinivasan (2017) have developed a model of collaborative planning for talent supply chain management (CP-TSCM), where companies and suppliers collaborate with academic institutions, employment agencies and government organisations. This approach relies on contemporary principles of supply chain management, in which there is a thorough needs analysis, a systematic review of suppliers, and the implementation of formal agreements, with a focus on long-term relationship building between the buyer and supplier to minimise risks (Hsu et al., 2008). These formal arrangements would ensure a steady supply of talent with the required skills, since suppliers will have a thorough understanding of the employer's needs and continuously realign their curriculum with industry requirements (Makarius & Srinivasan, 2017).

National Education and Training Interventions - The Collaborative Role of Government

The question as to who is responsible for talent acquisition and development has also been challenged (Makarius & Srinivasan, 2017). There needs to be a shift away from it being the sole responsibility of the HR department but to include the entire organisation, external stakeholders such as government agencies and educational institutions (Cappelli & Keller, 2014; Krzywdzinski, 2017; Wilson, 2013). According to Zavera (2019), although tertiary education met our needs previously, existing systems are not sufficient for Industry 4.0, with employers believing universities to be "confined by long-standing structures and systems, and are not keeping up with the times to adequately prepare students for graduate employability" (Kinash & Crane, 2015 p. 163). Thus the challenge for national governments is to develop relevant content and teaching methods to keep abreast with technological advancements with pedagogy continuously adapted to meet the educational needs of society and business (McDonald, 2020). One pathway to improving the responsiveness of education is for governments to work with industry and academic stakeholders so that they can conduct labour market scans to anticipate changing skills needs (ILO, 2020).

Research Context

Skillset Demands in Ireland

According to Ireland's National Skills Strategy 2025 (DES, 2016), "the convergence of technologies in the design, manufacturing and supply of goods and services is leading to a greater demand for cross-disciplinary knowledge and skillsets" (p. 32) and therefore requires the development of technological skills in collaboration with different disciplines. As previously discussed, it is predicted that technology-related positions across sectors will be particularly difficult to fill, as even though the population is educated, not enough individuals are qualified in the fields with the greatest demand (CEDEFOP, 2020). STEM skills, and particularly digital skills, are considered important across most sectors of the economy (IBEC, 2021; NSC, 2021), yet in 2019, only 7% of further and higher education awards in Ireland were made in science, and 8% in ICT, compared to 37% in social sciences, business, and law, which are in less demand (NSC, 2021). It is therefore common for graduates in humanities to be employed in positions below their skill level (CEDEFOP, 2020) and it has been found that Ireland has the second highest number of overqualified employees in Europe, namely 18% of the workforce (Vandeplas & Thum-Thysen, 2019). This mix of underqualified and overqualified employees highlights quite a divergence in skills match for the country. The National Skills Bulletin (McNaboe et al., 2021) has found that the positions most difficult to fill are software development engineer roles and all IT-related professions, such as blockchain, security analysts, and DevOps engineers. Positions related to data analysis, such as data architects, data scientists and scrum masters are also in great demand but there is also a need for soft skills, which are essential for successful management roles, which includes; leading, motivating, planning, as well as skills related to self-management, such as adapting to change, handling responsibilities, and tolerating stress (McNaboe et al., 2021).

National Training Interventions in Ireland

The national skills strategy (DES, 2016) placed emphasis on lifelong learning, quality and accountability, inclusion and diversity, and infrastructure; planning to offer more STEM education from primary school level onwards, to reform the apprenticeship system for expansion into technology industries, to offer ongoing reskilling and upskilling courses, to establish the technological universities, and to retrain educators to match skilling goals. More

recently, Ireland's AI strategy, titled "AI – Here for Good" (DETE, 2021) has emerged, which encapsulates the government's long-term commitment to keeping pace with developments in automation and AI. The policy contains seven strands, with Strand 6 dedicated exclusively to AI Education, Skills and Talent, estimating that one in three jobs will be affected by digital technologies in the future. The strategy involves studying the implications of automation and AI on skills in the next 5-10 years, delivering tailored AI education and training, expanding workplace-focused AI, reviewing work permits for critical AI skills, an action plan to increase the number of women participating in AI-related careers, and upskilling and reskilling through apprenticeships and Skillnet Ireland - a government agency set up to help organisations and workers be prepared for the future of work, focusing on work design, people development and strategic innovation (DFHERIS, 2021).

Method

Research Strategy

To meet the aforementioned research questions, the current study used a qualitative approach, with semi-structured in-depth interviews chosen as the data collection instrument. Using one-to-one in-depth interviews allowed the researchers to interpret the experiences of the participants and to understand how they construct their world and the meanings they attribute to their lived experiences (Merriam & Tisdell, 2016). The subsequent data generated from these interviews provided the researchers with deep insights into the situation and generated rich data so that a theoretical framework could be developed (Silverman, 1997). An open-ended approach to the interview questions was adopted and followed a hierarchical questioning funnel, where broader questions were asked first to allow the participant to express themselves freely, followed by more specific questions to ensure the necessary information is extracted, if not explicitly provided and developed upon by the interviewee (Schindler, 2019).

Sampling

The following criteria was used for the purposive selection of participants in the sample:

Experienced professionals with:

- substantial knowledge and/or experience of evolving skill demands/talent management in an Irish context, and
- substantial knowledge and/or experience in AI and automation.

The sample includes representatives from small, medium, and large multinational firms operating in Ireland, as well as both private and public organisations, across the education, training, consulting, and recruitment industries, thereby allowing for the formation of a balanced and holistic understanding of the research area.

Twelve interviews were conducted as this was where data saturation was reached (Mason, 2010). At this point no new noteworthy information was found nor were any new themes created (Guest et al., 2006). The final research sample, identified by pseudonyms is presented in Table I.

Table I: Interviewee Descriptions

Interviewee	Position
Carroll	Human Capital Strategist at a government-funded professional training agency in Ireland, and self-employed Organisational Psychologist, with extensive experience working for multinational companies as a talent manager and general manager in software and engineering industries.
Jennifer	Research Manager at the skills and labour market research unit of a state further education and training agency, with over 20 years' experience in skills research, including the effects of emergent technologies on skill development.
Vilma	Human Capital Lead and Partner at a multinational professional services firm with approximately 384,000 employees globally. She has extensive experience in HR transformation, workforce transition, the Future of Work, and the impact of emergent technologies.
Andrew	AI Programme Manager, Chair of Advisory Board for Quantum Computing, and Technical Lead for Future Technologies at a government-funded professional training agency in Ireland specialised in emergent technologies, supporting thousands of companies in Ireland.
Dean	Founder and Director of a HR management consultancy firm, with approximately 20 employees, catering to Irish and multinational companies, with experience in skill development and emerging technologies.
Alan	Principal Recruitment Consultant in an international AI recruitment company, with approximately 45 employees.
Garry	Partner and head of the human capital consultancy department in the Irish branch of a multinational financial services firm employing approximately 260,000 employees globally, with experience talent management strategies, and emergent technologies.

Interviewee	Position
Daniel	CEO of a strategy, innovation and sustainability consultancy business, Founder, Director, and Trainer of a training company, and Senior Consultant at a recruitment firm, employing approximately 3,900 employees globally, with experience in emergent technologies and future skills.
Jason	Head of Talent Management at a national telecommunications company which is a major contractor of the Irish government, with approximately 250 employees. He has extensive experience in skill development and knowledge of automation and AI, especially in relation to training.
Clare	Independent Future of Work consultant, guest lecturer, with extensive experience in HR and innovation at multinational firms, having exposure to skill development in Ireland as well as emergent technologies.
Dan	Managing Director of a multinational recruitment firm with approximately 300 employees, and President of a voluntary recruitment organisation. He has experience in skill development in Ireland, as well as the impacts of automation and AI.
Ron	Senior lecturer, specialising in Digital Transformation, corporate trainer, conference speaker, programme validator of higher education programmes.

Data Analysis

Following the completion of each interview, the recordings were transcribed and prepared for thematic analysis. The interviews were analysed, coded, and developed into themes in accordance with Braun and Clarke's (2012) six steps. These involve the researcher familiarising themselves with the data, generating initial codes, searching, reviewing, and defining themes, and finally, reporting the findings.

Findings

Skill Changes

Lifelong Learning and Shifting Careers

It was predicted that there will be a propensity towards lifelong learning which will lead to much more fluid careers, creating a greater emphasis on transferrable skills which can be leveraged across different roles, industries, and professions:

> "In the long term future for anyone, I think it's going to really be a matrix career. And I think it should be. I think the people who will eventually get to the executive table will be ones that have multiple careers, tested loads and loads of things, loads of different industries, they'll really understand the whole network of an organisation" (Vilma).

Lifelong learning was perceived to be very important to the future of work and was also seen as something companies should encourage as they will ultimately profit from the changing and evolving skillsets of their workforce:

> "I think this thing of lifelong learning, or continuous learning, is really a huge thing… even if we don't think about skills, if we think about mindset" (Clare).

> "If you give people that opportunity for lifelong life-wide learning, you foster a culture of intrapreneurship, so that they can waive their innovation to do things for themselves, and do it for the organisation instead" (Garry).

Due to the changing nature of skills and careers, participants emphasised the importance of having a suitable attitude and learning agility, which could even outweigh the value of specific skills:

> "I questioned why we're specifically looking for people who are skilled in Oracle Primavera P6, because it's just another tool. As far as I'm concerned, if you're an experienced project manager, surely, you can learn a new tool, so it all really depends on our propensity to learn" (Jason).

It was also argued that since "the skillset for the future is going to be broader, wider, more fundamental, with a greater degree of shift" (Clare), job roles and professions are becoming harder to define, and employers are seeking out candidates who are generalists:

> "The main change is just that how much roles are evolving…becoming less clear now than they were before, so it's very much becoming more task-based… companies often need somebody who can do a broad range of things, they don't want a specialist" (Jennifer).

Finally, it may be inferred that the abovementioned changes are the reasons why accurate skill prediction is deemed to be difficult:

> "The one common thread from our research is that… anything that's predicted beyond six to nine months - it's just pure guesswork" (Garry).

Future Skills Needs

The overriding consensus from the participants is that for the employees of today there has been a shift towards an emphasis on soft skills:

> "I think, regardless of what industry you're in, regardless of what role you do, your soft skills will always take priority" (Jason).

Interestingly, no participant stated that hard skills are more important, however several did comment that developing a combination of soft and hard skills from the beginning of one's career is key:

> "You got to do both. Historically, I would have said focus on the hard skills…You had to be almost at a certain age before they could instil some of the softer skills of relationship management, business development, ability to see things slightly differently. But I think that

needs to happen at a much more immediate level now, so much more [sic] expectations from individuals" (Garry).

A summary of the skills identified by the participants as particularly important for future knowledge workers is summarised in Table II.

Table II: Essential Future Skills

HARD SKILLS	
• Programming • Digital/ ICT skills • Data analytics • Cyber security • Technological skills • Digital marketing • Digital transformation • Cloud computing • IoT • AI • Research • Blockchain	• Distributed ledger • Technological application • Compliance • STEM/STEAM *(inclusion of Arts as a science)* • Green skills • Alteryx • Tableau • Power BI • Metaverse • Technical problem-solving
SOFT SKILLS	
• (People) management • Creativity • Communication • Emotional intelligence • Sales skills • Influencing • Trust building • Storytelling • Intrapreneurship • Relationship management • Business development • Innovation • Negotiation skills • Co-creation • Coaching • Mental health support • Proactivity	• Equality, diversity and inclusion • Engaging others • Adaptability • Resilience • Leadership *(through uncertainty / ambiguity)* • Flexibility • Change management • Cyber psychology • Abstract thinking • Trainability • Collaboration • Critical thinking • Decision-making • Design thinking • Life-long learning agility • Strategic problem-solving

Impact of Automation and AI

The Power of Industry 4.0

It was agreed by all participants that "the automation of non-value added processes is a no brainer" (Daniel), and that companies are actively trying to automate all repetitive, simple tasks. Due to this, there is a consensus that jobs which currently involve performing such tasks will face significant modification, or disappear altogether. It was predicted that the power of automation and AI will impact all industries as businesses realise their benefits, as illustrated by the following example:

> "{Company} screen about 250,000 graduates per year…and they had the most successful ever intake when they used AI in the recruitment process… they were able to reduce the amount of cost in terms of manpower for the screening and sifting process. And they were able to improve the quality of hire" (Dan).

However, there were some differences in opinion about the pace of change stemming from Industry 4.0. Some suggest it will be a gradual process, with enough time for Irish businesses to adapt:

> "First of all, it's going to be slow. I mean, we've been talking about Industry 4.0… but most companies are probably at 2.0. There's huge way for companies to go before that starts to take place. And therefore, because there's a long time, companies and people have an opportunity to make the change" (Andrew).

Interestingly, it was also suggested by some participants that the anticipated effects of Industry 4.0 are slightly exaggerated:

> "We're on the verge of something truly fascinating… but I'm not entirely sure that it will change the nature of work to such an extent, unlike the first industrial revolution, which did change how people work and what they do…I do think how we work will totally change and where we work… but do I think it's actually this massive revolution? I'm not sure it is. I don't think it'll have more influence than the internet" (Vilma).

In contrast, other experts believe that Industry 4.0 will, in fact, create significant changes to the world of work, especially in the aftermath of Covid-19. Dan provided an example of possible changes to come:

> "In this one company, a bot was basically performing a credit management role. So, contacting suppliers of the company whose payments were overdue. And the bot actually won Employee of the Month. So a piece of AI was actually awarded employee of the month. You hear some stories like that, and they're kind of headline-catching, but it is indicative of how things are moving along."

However, none of the twelve participants had suggested that the changes would be so significant as to threaten the existence of Irish jobs entirely. It was widely acknowledged that automation and AI are still very far from being able to replicate human soft skills, and may never reach the same level of emotional intelligence as humans:

> "I think those skills, you know - creativity, problem-solving – we will never have a computer that will be able to do that" (Vilma).

Hence, the overall consensus is that AI will not result in mass job losses, but rather disappearing roles will become replaced by new, and often improved ones, allowing humans to leverage their uniquely human skills in collaboration with AI:

> "Because in particular with the likes of AI and automation coming through, people won't necessarily be replaced, but an element of the communication and the humanity capacity of their job has to be, I suppose, maximised" (Alan).

Preparedness of Irish SMEs

According to a number of participants, despite the fact that Ireland is a country that actively encourages, funds, and promotes innovation, Irish businesses are currently lagging behind in the adoption of emergent technologies and in preparing their workforce for the changes to come. This is particularly seen to be the case for SMEs:

> "I would say there is a lack of capabilities and skills in the main… if 30% of industries in Ireland were progressive, I'd say that's probably high" (Daniel).

Interestingly, multiple participants commented that this slow responsiveness is related to the "Irish mindset":

> "The tools are there, it's whether the Irish companies are willing to change and use the tools. And that is always some of the biggest downfalls of Irish companies, it's their willingness to change and evolve" (Alan).

Other reasons suggested were the level of investment that automation and AI requires, especially when the workforce needs to be brought along with that change:

> "Ireland is made up of a lot of SMEs… SMEs do not generally have the financial resources with which to heavily invest in a radical overhaul of skills and technology" (Dean).

However, to counter this statement, Carroll points out that:

> "If an organisation goes to the IDA {Irish Development Authority}and says, 'Look, we need to have 40 people all able to code and be blockchain experts in six months in order to set up this new business or to be able to move with the industry', they actually will get a training grant of 50% of whatever that is. And that could be €1000s".

Hence, a combination of mindset, investment, and perhaps a lack of knowledge about the supports available to companies in Ireland are the reasons why SMEs are currently not adapting to Industry 4.0 at a rapid enough pace.

Talent Management Interventions

Recruitment

The participants acknowledged that competing in the 'war for talent' is becoming increasingly difficult, however they suggested some interventions perceived to be effective in partly bridging the skills gap, including hiring for attitude and learning agility, making use of remote working to tap into a large talent pool, and building an attractive but realistic Employee Value Proposition. A particularly forward-looking suggestion made by several interviewees in the context of recruitment is the concept of sharing talent instead of competing for it, as companies have traditionally done. This would require organisations to be open to forming more partnerships with various stakeholders, and transferring talent, internally and externally, due to the mutual skill gains that come from rotation, as opposed to stockpiling. This changing understanding is already beginning to emerge in some of the larger firms in Ireland. Below are two quotes which provide examples of internal and external sharing of talent:

> "There's generally a little bit of a hoarding aspect with managers and staff…Whereas in {company} the managers put the subordinate's career above the inconvenience of hiring and if everyone did it in a systematic manner, for the staff that you lost, you would have another staff waiting because they'd say, 'Well, I want to leave Sales and go to Marketing'. And the Marketing person might say, 'I want to leave Marketing and go to Sales'. So you're not losing staff. You're just transitioning staff" (Ron).

> "Didn't the guys in {company} set up something with {third level institution}… And the guys said, 'Look, doesn't matter if you work at Google or Facebook, sure work at Facebook for six months, great, because then you're more employable for us, and vice versa'. So at the moment, people are challenging each other for the same talent, where they're saying 'no, no, let's just create a better pool of talent, and we'll all benefit if everyone's learning more and quicker'. So I thought it was kind of innovative in terms of this day and age and the skills challenge that's there" (Dean).

Training and Development

Given the widespread talent shortages, the majority placed emphasis on training and development as the most important areas to focus on for companies. Some suggestions included adjusting the company culture to support lifelong learning, learning from competitors and industry leaders, conducting thorough training needs analyses, and researching available national training and funding support for necessary skill development.

When it comes to methods for upskilling, no consensus was reached on the best way to administer training, however various suggestions were given, including developing programmes in-house, hiring external training companies, engaging in e-learning, funding educational programmes, and even experimenting with virtual reality:

> "We actually used virtual reality technology to train salespeople…we created an immersive experience within the headsets… I think if more companies looked at that, they would find a lot of opportunity, and it would give them a competitive edge over other companies" (Jason).

Multiple participants also commented on the usefulness of Massive Open Online Courses (MOOCs) as an upskilling method, with mixed opinions. Some participants were wary of the quality and effectiveness of such programmes:

> "The issue is quality… You know, what does the QA process look like to say, 'That training is not good, we won't put it on the platform', 'That training is high quality, it's robust, it's assessed, it's constructively aligned'…I'm not seeing that" (Ron).

Carroll, a supporter of MOOCs, nevertheless pointed out that a major issue about using such systems on a mass scale is that they often lack recognition:

> "Look, I actually think they're really useful…but I do think we need to get to a point where the certifications are recognised…because right now we have a cohort of students going through a cybersecurity boot camp from {company}, which is online. And my big worry is, and it's with all of those ones that are online, can you really get a job at the end of it? I think industry have adopted it for their own internal use, but I think they're less open to it when they're hiring in" (Carroll).

Yet committing to an official learning programme is just one part of the upskilling process. Organisations must also consider the coaching and mentoring that is necessary in order to implement the learning effectively:

> "How are you going to provide some level of personal training, some level of e-learning, but more importantly, that on-the-job mentoring and coaching, bringing people along, giving them experiences that they can learn from. Because training and e-learning is only so much, because in many cases, there's many local software capabilities that they have to develop over time and which are not a quick win" (Vilma).

National Training/ Education Interventions

Positive Government Initiatives

The general attitude of participants towards the training and educational initiatives of the Irish government is quite positive, with the majority stating that they are doing more than many other governments in upskilling the workforce. Indeed, Skillnet Ireland has been particularly praised by participants for its effectiveness in bridging skill gaps. According to Carroll, larger companies are realising the benefit of engaging in industry-tailored training, in accordance with the talent-sharing philosophy discussed above:

> "I mean, they wouldn't just go and put a programme in place because one client came along and said they needed it… it really does need to be a scenario whereby the industry in general is looking for it. And I think at this stage, what they're seeing is that industry will say, 'It's good, if we put our staff through the programme, even if we lose somebody, somebody from another company will come into us'. So it's kind of good for the industry overall... If you raise one boat, you're raising all boats".

Furthermore, most participants talked particularly fondly of the Generation Apprenticeship Programme, especially since it has expanded beyond the traditional apprenticeship offerings, such as carpentry, into the knowledge sphere as it incentivises employers by providing them with subsidies for taking on apprentices, and allows employees to upskill while they earn:

> "They rolled out the whole apprenticeship thing as well recently… and that's gone into things like insurance and accounting…which is a new route for people even to change careers by joining, because they're getting paid as they go, which again, was a stumbling block for people to get into, because they didn't have... they couldn't take a year out and not work" (Dean).

While the majority stated that the government should also continue providing national training programmes open for all individuals to join, some participants were more supportive of the existing subsidies and grants offered to companies and industries directly, considering it a better use of resources since the training can be more targeted:

> "I think subsidisation is probably the best given where we are now… I'm not sure we would manage to get programmes in place in the main, where you could start to say, 'That's the set of things that have to be trained', and it's applicable across everyone in the automotive industry. You know, I think there's so many diverse roles in organisations, that I'm not sure how that would work" (Carroll).

Existing partnerships between the government and industry were praised extensively, but participants called for strengthening ties amongst companies, professional bodies, universities, and government in order to meet skill demands accurately:

> "If you take a look at {company}, and {company}, {company}, that's all employers who said 'We have a skills gap and we need both staff internal and stakeholders external to have those skills'…And so yes, they need to partner on it. And I think with the partnership thing, each person needs to be clear about what they're bringing… the government, the colleges, the industry, they are all partnering even more. And I think that's fantastic. These things, however, take years before you can see the benefits of that" (Ron).

Improving Existing Systems

Although the majority of participants had mostly positive perceptions of the existing government training and educational initiatives, most stated that more could always be done. Few provided specific changes they would like to see in the future, but rather emphasised the importance of continued investment and strengthening of existing initiatives, as well as rethinking the current system of education. To support businesses, they suggested consolidating existing national initiatives to enable employers easier access to resources, tailoring third-level education to better meet industry standards, and incentivising companies to invest in the upskilling of their workforce through strategic grants and subsidies, which would allow employees to avail of more learning hours.

Several participants called for a reform in the primary and secondary education systems, and the incorporation of more STEM education, such as programming and computer science as core subjects from primary level onwards, finding the current models in Ireland to be out-of-date compared to international standards:

> "I think our education system is a bit narrow. And sometimes it doesn't really push, particularly the creativity and problem solving. We could do a lot more in that space" (Vilma).

Several participants also commented that third level education is not fully meeting industry needs either, being too subject-based and academic in nature:

> "So many people come out of university with knowledge, but not necessarily applicable knowledge for the work environment…and they have a different view and new views are good, but it means they're not ready to get into the work environment" (Dean).

It is for this reason that many participants favoured apprenticeships, which combine academic and practical knowledge, as well as close working partnerships between companies and universities, which allow for a more accurate understanding of the necessary skills.

Interestingly, several participants also mentioned the rise of company universities, which allow corporations to take control of their talent supply chain and achieve the skills required. Although this was deemed an effective strategy for companies, it raised the question as to whether the privatising of education by corporations will threaten universities and be against the interests of the public:

> "Some organisations might say 'We're not happy with the types of engineers we're getting, so better build our own university'. And what's stopping, if you think about individuals who want to get off the dole and get working straight away, to go and get a Microsoft degree in technology, or a Dyson degree in engineering, or Goldman Sachs degree in financial services? So I think if the government doesn't do something about that, then you might find the private sector taking control of some of the things that might be for the betterment of themselves" (Garry).

Discussion

RQ1: How do key stakeholders believe the skills necessary for knowledge workers will change in the future, in light of developments in automation and AI?

The literature review revealed that skill requirements are expected to change in the future across all industries, to a greater or lesser extent, and the findings confirm this in the context of Ireland as well. Deshpande *et al*. (2021) and Gallagher (2019) reported that automation and AI will lead to a greater emphasis on uniquely human competencies, namely, soft skills, with which the overwhelming majority of interviewees agreed. Although there is some debate in the literature as to whether soft or hard skills should take priority (Rotatori *et al*., 2021), the

majority of participants concurred with Zahidi *et al*. (2020), in that greater emphasis should be placed on soft skills.

While the integration of STEM subjects into the education system from an early age is regarded by both academics (Smith & White, 2020) and policy makers as important training priorities (Jākabsone, 2021), none of the participants here emphasised these skills as more critical than soft skills for the future. This is an interesting observation, given that professions requiring STEM skills such as security analysts, data analysts, and DevOps engineers, are the most difficult vacancies to fill (McNaboe *et al*., 2021). Hence, the emphasis on STEM skills may be overestimated, or perhaps there is a perception that as emergent technologies overtake more of the hard skills, and as individuals upskill on a mass scale due to a combination of individual, employer, and government initiatives, hard skills will become easier to fill, whereas softer skills, which are more uniquely human, will always remain in high demand.

With the move towards shifting and fluid careers, as well as the difficulty in narrowing job roles into specific components, some participants argued that employees will need to balance both soft and hard skills in order to thrive in the future world of work. This is also reflected in the work of Teng *et al*. (2019) and Weritz (2022) who found that changes brought about by Industry 4.0 will require the fusion of both types of skills. The interviewees recommended switching to hiring for attitude and learning agility where possible, and subsequently committing to training the individual in the necessary hard skills in order to bridge the skill gap.

All participants mentioned that automation and AI will lead to changes in the workplace, with a small number predicting these changes will be significant, however some participants perceived the effects of Industry 4.0 to be somewhat exaggerated which is aligned to recent findings (McGuinness et al., 2023; Vrontis et al., 2022) and contrary to predictions that AI will substitute humans on a mass scale (Bruun & Duka, 2018; Chui *et al.*, 2015). The participants' reasoning for this position is based on Ireland's heavy reliance on the knowledge economy and the soft skills that are inherently associated with its structures. In addition to this, Irish SMEs are thought to be behind in the adoption of emergent technologies, and those businesses which are engaging with AI, are doing so on a basic level which led several participants to be of the

opinion that the effects of Industry 4.0 will come to fruition at a relatively slower pace thus allowing companies time to adapt.

The above findings imply that Ireland is on the path towards either a 'stalemate' or 'check' scenario on Bruun and Duka's (2018) chess-board, meaning changes will either be not as momentous as anticipated, or conversely, they will indeed be significant, but companies and the Irish labour market will adjust in time. Notably, no participant hypothesised of a possible 'checkmate' scenario, characterised by mass instability and an inability for business to keep up with the pace of change. While Bruun and Duka (2018) argue that the real debate is between 'check' and 'checkmate', the findings here suggest that practitioners take a more cautious and optimistic view of the effects of automation and AI in Ireland, particularly since Irish SMEs are slow to invest in such technologies. This perception is in line with the prediction that high-income countries, such as Ireland, will be better equipped to overcome the challenges posed by automation and AI, with the possibility of positive economic and social outcomes (Deshpande et al., 2021). Indeed, many participants provided examples to illustrate how AI can improve the quality of work for employees by giving them more time to engage in meaningful, value-added activities. It was confirmed that the future of work will involve greater collaboration between human and AI-powered intelligence which will enable more opportunities for value creation (OECD, 2021).

RQ2: What talent management and national educational interventions are necessary to meet future skill requirements?

Most participants agreed that companies in Ireland are finding it difficult to address current skill needs, especially for SMEs who must compete for talent with large multinational corporations. Many interviewees commented on the importance of finding new ways of overcoming this challenge (Rotatori et al., 2021; Tyszko & Sheets, 2015), suggesting that Covid-19 has created opportunities for companies to attract a greater talent pool through flexible and remote working. Furthermore, participants emphasised hiring for learning agility and trainability, and being less focused on specific hard skills which could be taught by the organisation (Shipley and McGowan, 2020, Lorri, 2013).

A novel approach suggested by some of the interviewees is to engage in internal and external talent sharing, as opposed to competing for scarce skills (Baldassari & Roux, 2017). Indeed, it was discussed that companies should be more open to sharing value externally by co-creating broader pools of talent from which to recruit (Porter & Kramer, 2011). Given the difficulty of recruiting talent, most participants emphasised that upskilling employees internally is a worthwhile investment as it makes companies less susceptible to changes in the labour market (Wilkinson et al., 2021). This would also strengthen the culture of lifelong learning in the company, but training must be done strategically to avoid misdirection and wasted resources. Several participants also spoke about the need for creating new career pathways, instilling transparency in training programmes, and ensuring that employees take ownership over their development and have the choice to pursue their interests. When creating upskilling pathways, employees must, first and foremost, be given the time to engage with the training; it was commented by participants that employers often have unrealistic expectations as to how much time and effort training requires. This has been previously highlighted by Brione (2017) who forewarned that employees are already facing work intensification and lifelong learning cannot be sustainable this way.

Finally, the interviewees shed some much needed light on practitioners' perceptions of MOOCs. Although some participants agreed that MOOCs offer an effective upskilling option for certain employees, there was some reluctance in terms of the quality of material, accommodation of learning styles, and recognition of MOOC certificates. Although Radford *et al*. (2014) argue MOOCs could assist employers with the recruitment of individuals with the right skills, it was not found to be a significant trend amongst Irish organisations, and even cautioned that although employers may be open to using MOOCs for training, they are less keen on hiring employees with MOOC certificates.

All participants agreed that the Irish government and national universities have important roles to play in ensuring that the labour force remains relevant and can contribute effectively to the functioning of the economy. As emphasised by McDonald (2020), and also reflected here, is the challenge for governments to develop relevant and effective education programmes. The general consensus amongst the interviewees was that the state is largely succeeding in doing so as evidenced by the development of Ireland's National Skills Strategy 2025 (DES, 2016)

and a greater focus on STEM education, apprenticeships, Springboard programmes, and the establishment of technological universities. Despite these initiatives, it was also argued that more could be done and that the current educational systems need to be re-evaluated and reformed to meet the needs of Industry 4.0 and ensure that graduates are equipped with the necessary skills and mindsets, mirroring the work of Zavera (2019), and Kinash and Crane (2015). For example, participants called for greater and earlier integration of STEM and digital subjects into primary education, but also for the encouragement of greater soft skills such as creativity and autonomy. Participants also called for increased AI education and the promotion of lifelong learning. It was emphasised that since the current education is primarily based on rote learning, it is only engaging a fraction of learners, usually those who perform best in traditional exams, echoing the concern of student engagement pointed out by Shipley and McGowan (2020). It should be noted, however, that most of these needs have already been included in Ireland's national skills strategies (DES, 2016; DETE, 2021), and time will tell how effectively they are implemented.

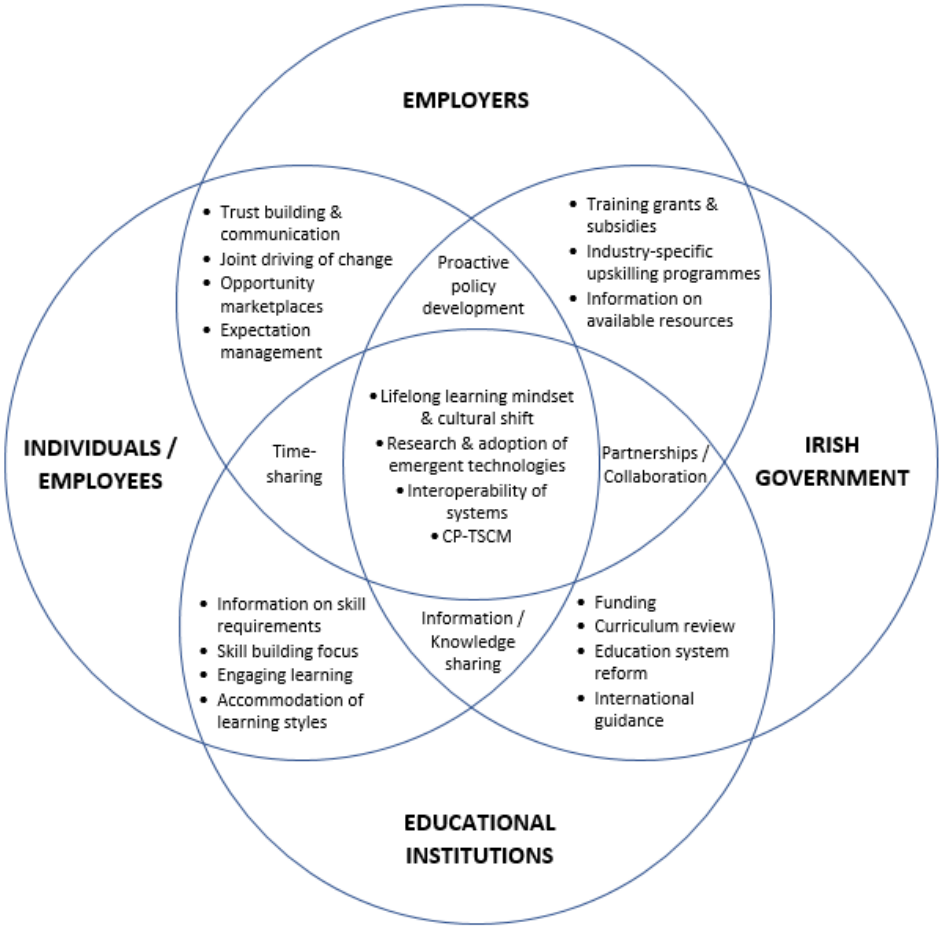
In line with Santos and Reinhard's (2012) interoperability principle, and the ILO's (2020) skill development model, participants emphasised the need for increased collaboration between the government, educational bodies, representative organisations, and companies to improve the effectiveness of education in meeting industry needs. Shah and Burke (2003) have formerly warned that publicly funded training programmes are only effective if the state has a deep understanding of the needs of employers in a particular industry which helps to explain why most participants praised Skillnet, a government agency working closely with industries to develop programmes for their specific needs. Employer incentivisation (Shah & Burke, 2003) is also regarded by a number of participants as key to successful upskilling of employees. However, it was also pointed out that there are many existing incentives in Ireland of which many employers are simply not aware, such as training grants and subsidies. There was praise for the existing Generation Apprenticeship programme, and calls for its continued expansion into additional knowledge industries as an alternative to university education (McGrath, 2020).

Meeting Future Skill Needs: A Conceptual Framework

Based on the findings of this research, the following conceptualisation (Figure 2) suggests a framework for proactively and collaboratively meeting skill needs in light of developments in

automation and AI in Ireland. The framework relies on the concept of close working partnerships between all parties and provides a summary of the responsibilities between the four key skill development stakeholders, highlighting that no party can bridge the existing skills gaps in isolation, but rather within an integrated system based on collaboration.

Figure 2: Conceptual Framework for Collaborative Skill Development



Contribution to Theory

This research provides valuable information about future skills developments for the knowledge workforce in Ireland, as perceived by experienced professionals. It not only explains the current skills situation in the country, but also suggests measures for meeting the skill gap and preparing the workforce of the future, hence shifting research on the transformative effects of automation and AI from reactive to proactive (Howard, 2020). It also contributes to the talent management literature on bridging skill gaps which is currently lagging

behind practice (Calonge et al., 2019; Whysall et al., 2019), by exploring the effectiveness of MOOCs, opportunity marketplaces, and talent sharing. Lastly, it builds upon the concept of partnerships and collaboration for meeting future skill requirements by proposing a conceptual framework in the Irish context.

Contribution to Practice

This research contributes to practice by highlighting the key skills necessitated by employers today, thereby providing guidance for individuals seeking to upskill. Particular skills highlighted by the participants included a range of hard and soft skills; these included digital literacy skills as well as more advanced AI competences as well as people management and creativity skills (see Table II). It also highlights the need for Irish SMEs to prepare more proactively for the impacts of automation and AI as many are lagging behind developments which could enhance their business processes. Furthermore, the paper reveals some novel and practical talent management interventions for employers to adopt such as talent-sharing, while drawing attention to the state-funded support that is available to organisations seeking to upskill their workforce. Lastly, the research provides positive reinforcement of the current government initiatives, however, it also draws attention to areas in need of improvement, such as the current primary and secondary education systems. This will require a rethinking of rote learning and terminal examination approaches which are still commonplace in Ireland, towards more practical problem-solving and creative thinking education. Furthermore, there is a need to reconsider traditional school subjects and integrate technology as a core knowledge area, as opposed to a speciality, from primary levels onwards.

Limitations

A key limitation of the current research is that it is interpretivist, meaning that the findings are unavoidably subjective in nature, and cannot be generalised since they are based on individual viewpoints from a relatively small sample in one country (Bell et al., 2019). In addition, the conceptual framework provides only a general overview of the required areas of collaboration, and it is acknowledged that more detailed policies and strategies are necessary for bridging future skill gaps. Finally, despite the experience and exposure of the interviewees, it is difficult

to predict with a high degree of accuracy how AI and automation will impact skill demands due to the rapidly changing nature of business and technology (Skilton & Hovsepian, 2018). Wilson (2013) states that skill prediction is very speculative, especially when using the qualitative approach. This limitation is exacerbated by the fact that it uses a cross-sectional time horizon, as opposed to a longitudinal one, which makes development over time difficult to measure (Bell et al., 2019).

Future Research

Three areas of further research were identified:

Firstly, given the enthusiasm shown towards the Generation Apprenticeship programme, it would be interesting to study its effectiveness in mitigating skills gaps, particularly in relation to the new apprenticeships targeted towards the knowledge economy. Furthermore, additional research is necessary into the effectiveness and sustainability of the talent-sharing concept (Porter & Kramer, 2011) for companies and educational bodies, and especially how useful this approach would be for Irish SMEs when competing with large corporations. Given the prevalence of the platform economy, there may be room to develop new talent-sharing systems between employers. Lastly, as large, influential companies continue opening their own academies to the public, new research is necessary into the implications of such establishments for students, education standards, and public third-level institutions. More specifically, it is worthwhile exploring what benefits such academies would have for individuals seeking to improve their immediate employability, but also how transferrable these skills would be in the long term. Furthermore, it is important to understand the value of such academies to society and the economy relative to the possible risks of increasing inequality and workers' dependence on private education and training providers.

References

Acemoglu, D. and Restrepo, P. (2018), "The race between man and machine: implications of technology for growth, factor shares, and employment", *American Economic Review*, Vol. 108 No.6, pp. 1488-1542.

Amankwah-Amoah, J. (2018), "Human capital flows in failing organisations: an integrated conceptual framework", *Journal of Intellectual Capital*, Vol. 19 No. 4, pp. 732-746.

Amankwah-Amoah, J., Nyuur, R. B. and Ifere, S. (2017), "A question of top talent? The effects of lateral hiring in two emerging economies", *The International Journal of Human Resource Management*, Vol. 28 No.11, pp. 1527-1546.

Anderson, J. and Smith, A. (2014), *Digital Life in 2025: AI, Robotics, and the Future of Jobs,* Pew Research Centre, Washington DC.

Arslan, A., Cooper, C., Khan, Z., Golgeci, I., & Ali, I. (2022). Artificial intelligence and human workers interaction at team level: a conceptual assessment of the challenges and potential HRM strategies. *International Journal of Manpower*, *43*(1), 75-88.

Atkinson, R. D. and Wu, J. J. (2017), *False Alarmism: Technological Disruption and the U.S. Labour Market 1850–2015*, Information Technology and Innovation Foundation, Washington DC.

Autor, D. H. (2015), "Why are there still so many jobs? The history and future of workplace automation", *Journal of Economic Perspectives*, Vol. 29 No.3, pp. 3-30.

Baldassari, P. and Roux, J. D. (2017), "Industry 4.0: preparing for the future of work", *People and Strategy*, Vol. 40 No.3, pp. 20-24.

Bell, E., Bryman, A. and Harley, B. (2019), *Business Research Methods* (5th ed.), University Press: Oxford.

Braun, V. and Clarke, V. (2012), "Thematic analysis", Cooper H., Camic P.M., Long D.L., Panter. A.T., Rindskopf D. and Sher K.J. (Eds.), *APA Handbook of Research Methods in Psychology. Vol. 2: Research Designs: Quantitative, Qualitative, Neuropsychological, and Biological*, American Psychological Association, Washington DC, pp. 57-71.

Braverman, H. (1974), *Labour and Monopoly Capital: The Degradation of Work in the 20th Century*, Monthly Review Press, New York, NY.

Briciu, V. A. and Briciu, A. (2021), "Covid-19 influence and future perspectives of artificial intelligence on the labour market", *BRAIN. Broad Research in Artificial Intelligence and Neuroscience,* Vol. 11 (2Sup1), pp. 21-28.

Brione, P. (2017), *Mind over Machines: New Technology and Employment Relations*, Advisory, Conciliation and Arbitration Service, London.

Brunello, G. and Wruuck, P. (2021), "Skill shortages and skill mismatch: a review of the literature", *Journal of Economic Surveys*, Vol. 35 No. 6, pp. 1145-1167.

Bruun, E. and Duka, A. (2018), "Artificial intelligence, jobs and the future of work: racing with the machines", *Basic Income Studies. De Gruyter*, Vol. 13 No.2, pp. 1-15.

Brynjolfsson, E. and McAfee, A. (2014), *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*, Norton, New York.

Calonge, D. S., Shah, M. A., Riggs, K. and Connor, M. (2019), "MOOCs and upskilling in Australia: A qualitative literature study", *Cogent Education*, Vol. 6 No.1, pp. 1-19.

Cappelli, P. and Keller, J. R. (2014), "Talent management: Conceptual approaches and practical challenges", *Annual Review of Organisational Psychology and Organisational Behaviour*, Vol. 1 No.1, pp. 305-331.

CEDEFOP (2020), *2020 Skills Forecast Ireland*, European Centre for the Development of Vocational Training, Thessaloniki.

Chuang, S. (2021). An empirical study of displaceable job skills in the age of robots. *European Journal of Training and Development*, Vol. 45 No. 6/7, pp. 617-632.

Chuang, S., & Graham, C. M. (2018). Embracing the sobering reality of technological influences on jobs, employment and human resource development: a systematic literature review. *European Journal of Training and Development*, Vol. 42 No. 7, pp. 400-416.

Chui, M., Manyika, J. and Miremadi, M. (2015), *Four Fundamentals of Workplace Automation*, McKinsey Global Institute, Washington DC.

Collings, D. and McMackin, J. (2019), *Enabling the Workforce of the Future: The Role of Learning and Development*, Skillnet Ireland, Naas.

Cutler-Knowles, A. and Lewis, H. (2018), *Talent for Survival Essential Skills for Humans Working In the Machine Age*, Deloitte, London.

DES (2016), *Ireland's National Skills Strategy 2025*, Department of Education and Skills, Dublin.

Deshpande, A., Picken, N., Kunertova, L., De Silva, A., Lanfredi, G. and Hofman, J. (2021), *Improving Working Conditions Using Artificial Intelligence*, Luxembourg, Policy Department for Economic, Scientific and Quality of Life Policies.

DETE (2021), *AI - Here for Good: A National Artificial Intelligence Strategy for Ireland*, Department of Enterprise, Trade and Employment, Dublin.

DFHERIS (2021), *Transforming Business through Talent: Statement of Strategy 2021-2025*, Department of Further and Higher Education, Research, Innovation and Science, Dublin.

Eloundou, T., Manning, S., Mishkin, P., and Rock, D. (2023), "GPTs are GPTs: an early look at the labor market impact potential of large language models", working paper, arXiv:2303.10130, Cornell University, 27 March.

Ford, M. (2015), *The Rise of the Robots; Technology and a Threat of Jobless Future*, Basic Books, New York, NY.

Frey, C. B. and Osborne, M. A. (2017), "The future of employment: how susceptible are jobs to computerisation", *Technological Forecasting and Social Change*, Vol. 114 No.1, pp. 254-280.

Gallagher, S. (2019), *Peak Human Potential: Preparing Australia's Workforce for the Digital Future,* Swinburne University of Technology, Melbourne.

Georgieff, A., and Hyee, R. (2022). Artificial Intelligence and Employment: New Cross-Country Evidence. *Frontiers in Artificial Intelligence*, *5*.

Goos, M. and Manning, A. (2003), *Lousy and Lovely Jobs: The Rising Polarisation of Work in Britain*, Centre for Economic Performance, London.

Graetz, G. and Guy M. (2015), *Robots at Work: IZA Discussion Papers 8938*, Institute for the Study of Labour, Bonn.

Grant, K., Venz, L., & Bottcher, K. (2020, January 22-23). The dark side of digitalization? A diary study of the impact of digital technologies on work intensification, work-life balance and wellbeing. CIPD Applied Research Conference, Dublin.

Guest, G., Bunce, A. and Johnson, L. (2006), "How many interviews are enough? An experiment with data saturation and variability", *Field Methods*, Vol.18 No.1, pp. 59–82.

Howard, J. (2020), "Artificial intelligence: implications for the future of work", *American Journal of Industrial Medicine*, Vol. 62 No. 1, pp. 917-926.

Hsu, C. C., Kannan, V. R., Tan, K. C. and Leong, G. K. (2008), "Information sharing, buyer-supplier relationships, and firm performance: A multi-region analysis", *International Journal of Physical Distribution and Logistics Management*, Vol. 38 No. 4, pp. 296-310.

Huang, M. H. and Rust, R. T. (2018), "Artificial intelligence in service", *Journal of Service Research,* Vol. 21 No. 2, pp. 155-172.

ILO (2020), *The Digitisation of TVET and Skills Systems*, International Labour Organisation, Geneva.

Jaiswal, A., Arun, C. J. and Varma, A. (2021), "Rebooting employees: upskilling for artificial intelligence in multinational corporations", *The International Journal of Human Resource Management*, Vol. 33 No. 1, pp. 1179-1208.

Jakabsone, M. (2021, June 18), *Ireland – STEM Education Policy*. https://digital-skills-jobs.europa.eu/en/actions/national-initiatives/national-strategies/ireland-stem-education-policy

Jang, H. (2016), "Identifying 21st century STEM competencies using workplace data", *Journal of Science Education and Technology*, Vol. 25 No. 1, pp. 284-381.

Kaliannan, M., Darmalinggam, D, Dorasamy, M. and Abraham, M. (2023), "Inclusive talent development as a key talent management approach: A systematic literature review", *Human Resource Management Review*, Vol. 33 No. 1, pp. 1-23.

Kinash, S. and Crane, L. H. (2015), "Enhancing graduate employability of the 21st century learner", Churchill D., Chiu T. K. F., and Gu N. J. (Eds.), *Proceedings of the International Mobile Learning Festival 2015: Mobile Learning, MOOCs and 21st Century Learning*, Consultants International for Human Capital Development (CIHCD), Hong Kong, pp. 148-171.

Korinek, A. and Stiglitz J. E. (2021), "Covid-19 driven advances in automation and artificial intelligence risk exacerbating economic inequality", *British Medical Journal*, Vol. 3 No. 1, pp 1-3.

Krzywdzinski, M. (2017), "Automation, skill requirements and labour-use strategies: High-wage and low-wage approaches to high-tech manufacturing in the automotive industry", *New Technology, Work and Employment*, Vol. 32 No. 3, pp. 247-267.

Lane, M. and A. Saint-Martin (2021), "The impact of Artificial Intelligence on the labour market: What do we know so far?", *OECD Social, Employment and Migration Working Papers*, No. 256, OECD Publishing, Paris.

Lorri, F. (2013), "Solving today's skill gaps", *Training*, Vol. 50 No. 6, pp. 52-57.

Makarius, E. E. and Srinivasan, M. (2017), "Addressing skills mismatch: utilising talent supply chain management to enhance collaboration between companies and talent suppliers", *Business Horizons*, Vol. 60 No. 4, pp. 495-505.

Mallon, M. (2013), "MOOCs", *Public Services Quarterly*, Vol. 9 No. 1, pp. 46-53.

Mason, M. (2010), "Sample size and saturation in PhD studies using qualitative interviews", *Qualitative Social Research*, Vol. 11 No. 3, pp. 1- 19.

McDonald, M. (2020), *Digital Skills Insights 2020*, International Telecommunication Union, Geneva.

McGrath, J. (2020), *Analysis of Shortage and Surplus Occupations 2020*, European Commission: Brussels.

McGuinness, S., Pouliakas, K., & Redmond, P. (2023). Skills-displacing technological change and its impact on jobs: challenging technological alarmism?. *Economics of Innovation and New Technology*, *32*(3), 370-392.

McNaboe, J., Burke, N., Condon, N., Hogan, A. M., Shally, C. and Walls, D. (2021). *National Skills Bulletin 2021*, National Skills Council, Dublin.

Morandini, S., Fraboni, F., De Angelis, M., Puzzo, G., Giusino, D., & Pietrantoni, L. (2023). The impact of artificial intelligence on workers' skills: Upskilling and reskilling in organisations. *Informing Science*, *26*, 39.

NSC (2021), *Monitoring Ireland's Skills Supply 2021*, National Skills Council, Dublin.

OECD (2021), *Education at a Glance 2021: OECD Indicators*, Organisation for Economic Cooperation and Development, Paris.

Pereira, V., Hadjielias, E., Christofi, M., and Vrontis, D. (2023). A systematic literature review on the impact of artificial intelligence on workplace outcomes: A multi-process perspective. *Human Resource Management Review*, *33*(1), 100857.

Porter, M. E. and Kramer, M. R. (2011), "The big idea: creating shared value. How to reinvent capitalism - and unleash a wave of innovation and growth", *Harvard Business Review*, Vol. 89 No. 1-2, pp. 62-77.

Radford, A. W., Robles, J., Cataylo, S., Horn, L., Thornton, J. and Whitfield, K. E. (2014), "The employer potential of MOOCs: a mixed-methods study of human resource professionals' thinking on MOOCs", *The International Review of Research in Open and Distributed Learning*, Vol. 15 No. 5, pp. 1-25.

Rotatori, D., Lee, E. J. and Sleeva, S. (2021), "The evolution of the workplace during the fourth industrial revolution", *Human Resource Development International*, Vol. 24 No. 1, pp. 92-103.

Santos, E. M. and Reinhard, N. (2012), "Electronic government interoperability: identifying the barriers for frameworks adoption", *Social Science Computer Review*, Vol. 30 No. 1, pp. 71-82.

Schindler, P. S. (2019), *Business Research Methods* (13th ed.), McGraw Hill Education, New York.

Shah, C. and Burke, G. (2003), *Skills Shortages: Concepts, Measurement and Implications*, Monash University - Acer Centre for the Economics of Education and Training, Victoria.

Shipley, C. and McGowan, H. (2020), *The Adaptation Advantage: Let Go, Learn Fast, and Thrive in the Future of Work*, John Wiley and Sons, New York.

Silverman, D.D. (1997), *Qualitative Research: Theory, Method and Practice*, Sage, London.

Sima, V., Gheorghe I. G., Subic, J. and Nancu, D. (2020), "Influences of the Industry 4.0 revolution on the human capital development and consumer behaviour: a systematic review", *Sustainability*, Vol. 12 No. 1, pp. 4035- 4063.

Smith, E. and White, P. (2020), "Moving along the STEM pipeline? The long-term employment patterns of science, technology, engineering and maths graduates in the United Kingdom", *Research Papers in Education*, Vol. 37 No. 4, pp. 457-478.

Teng, W., Ma, C., Pahlevansharif, S. and Turner, J. J. (2019), "Graduate readiness for the employment market of the 4th industrial revolution: the development of soft employability skills", *Education and Training*, Vol. 61 No. 5, pp. 590-604.

Thompson, P. and Briken, K. (2017), "Actually existing capitalism: some digital delusions", Briken, K., Chillas, S., Krzywdzinski, M., and Marks, A. (Eds.), *The New Digital Workplace: How New Technologies Revolutionise Work, Critical Perspective on Work and Employment Series*, Palgrave McMillan, London, pp. 241-263.

Torrington, D., Hall, L., Taylor, S. and Atkinson, C. (2020), *Human Resource Management* (11th ed.), Pearson Education, Harlow.

Tudoreanu, M. and Kotz, D. M. (2020), "Stable jobs or iPhones? The dilemma of innovation in socialism", *Review of Radical Political Economics*, Vol. 52 No. 4, pp. 462-649.

Tyszko, J. and Sheets, R. (2015), *Building the Talent Pipeline: An Implementation Guide*, US Chamber of Commerce Foundation: Centre for Education and Workforce, Washington DC.

Vandeplas, A. and Thum-Thysen, A. (2019), *Skills Mismatch and Productivity in the EU: European Economy - Discussion Papers 2015 – 100*, Directorate General Economic and Financial Affairs (DG ECFIN), Brussels.

Vrontis, D., Christofi, M., Pereira, V., Tarba, S., Makrides, A., and Trichina, E. (2022). Artificial intelligence, robotics, advanced technologies and human resource management: a systematic review. *The International Journal of Human Resource Management*, *33*(6), 1237-1266.

Webb, M. (2020), *The Impact of Artificial Intelligence on the Labour Market*, Social Science Research Network, Stanford.

Weritz, P. (2022). Hey Leaders, It's Time to Train the Workforce: Critical Skills in the Digital Workplace. *Administrative Sciences*, *12*(3), 94.

Whysall, Z., Owtram, M. and Brittain, S. (2019), "The new talent management challenges of Industry 4.0, *Journal of Management Development*, Vol. 38 No. 2, pp. 118-129.

Wilkinson, A., Dundon, T. and Redman, T. (2021), *Contemporary Human Resource Management: Text and Cases* (6th ed.), Sage Publications, New York, NY.

Wilson, R. (2013), "Skills anticipation – the future of work and education", *International Journal of Educational Research*, Vol. 61 No. 1, pp. 101-110.

World Economic Forum. (2023). The Future of Jobs Report 2023. https://www.weforum.org/reports/the-future-of-jobs-report-2023/.

Zahidi, S., Ratcheva, V., Hingel, G. and Brown, S. (2020), *The Future of Jobs Report 2020*, The World Economic Forum: Geneva.

Zavera, I. (2019), *The analysis of the response from tertiary education programs to the challenges of the Fourth Industrial Revolution*", paper presented at the 13th International Conference on Business Excellence, 22-23 March, Bucharest, Romania.