Bridging the AI Skills Gap in Europe: A Detailed Analysis of AI Skills and Roles

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This study provides a comprehensive analysis of the AI-related skills and roles needed to bridge the AI skills gap in Europe. Using a mixed-method research approach, this study investigated the most in-demand AI expertise areas and roles by surveying 409 organizations in Europe, analyzing 2,563 AI-related job advertisements, and conducting 24 focus group sessions with 145 industry and policy experts. The findings underscore the importance of both general technical skills in AI related to big data, machine learning and deep learning, cyber and data security, large language models as well as AI soft skills such as problem-solving and effective communication. This study sets the foundation for future research directions, emphasizing the importance of upskilling initiatives and the evolving nature of AI skills demand, contributing to an EU-wide strategy for future AI skills development.

Keywords:
AI skills, AI roles, Europe, workforce development, mixed-method research

University of Maribor Press

DOI https://doi.org/10.18690/um.fov.4.2024.22
ISBN 978-961-286-871-0

1 Introduction

The fast developing and evolving field of Artificial Intelligence (AI) is reshaping industries and altering the professional landscape at an unprecedented pace (Jan et al., 2023; ARISA, 2023). Characterized by rapid advancements in machine learning, big data, and computing power, AI technologies are now pivotal in driving economic growth, enhancing productivity, and fostering innovation across various sectors (Anagnostou et al., 2022). From revolutionizing medical diagnostics (Kamdar et al., 2020) to propelling the development of autonomous vehicles (Namatherdhala et al., 2022), AI's integration into daily operations and strategic decision-making processes underscores its transformative potential. Recognizing this, the World Economic Forum's Future of Jobs report 2023 highlights AI and related roles among the fastest-growing job sectors, emphasizing the critical need for skills training in these areas (World Economic Forum, 2023).

To fully understand and accurately pinpoint what AI-related skills are needed and what training programs ought to be set up in order to cultivate those skills the ARtificial Intelligence & Skills Alliance (ARISA) Consortium conducted a study with the aims to comprehensively analyze the current AI landscape, emphasizing the critical need for specialized AI roles and skills within the context of the European Union. Drawing on a mixed-method research approach, including both quantitative and qualitative methods, the study explores the demand for AI professionals, the impact of AI on organizational and societal levels, and the pressing need for informed decision-making within this context. As such, the central research question this study seeks to address is as follows:
What are key AI-related skills and AI roles required by organizations in the European Union in the next five to ten years?

By investigating this question, the consortium makes critical contributions to AI research, literature, and European policies by systematically analyzing AI-related skills and roles in the EU and uncovering the essential combinations and patterns of technical and soft skills needed in AI-relevant sectors. Through a mixed-method approach, the findings of the study can provide an improved understanding of current and future demands for AI expertise. In sum, the key contribution of this study is in facilitating the closing of AI-related skills gap as well as setting the stage

for informed policy-making and strategic upskilling initiatives, thereby guiding the evolution of AI skills development within the EU.

2 Research Background

This research aims to investigate the AI roles and the AI-related skills needed for those roles in relation to the current professionals and skills available in the AI sector. This section will clarify the scope of this research and specifies the foundation for the AI roles and skills that are relevant and important.

Lack of skills hinders AI adoption and deployment: besides cost constraint, the lack of skills remains the biggest barrier in AI advancements (IBM, 2022). According to Deloitte's (2022) survey findings, AI technology cannot deliver transformative results unless organizations reimagine operations and how work is structured and executed (i.e., rethinking operations including the business workflow, and within their IT and data science team processes). Therefore, in the current research, it is key to consider the roles and skills for AI professionals with a need for further education in their specific areas of expertise. Moreover, this consideration is also important for non-AI professionals (e.g., decision-makers and managers) who need a basic understanding of AI and skills in implementing AI in organizations.

AI also can and will have a fundamental impact on society in general (Crafts et al. 2018; Deranty & Corbin, 2022; Stanford University, 2023). It is important that good, solidly underpinned decisions are made to make the best use of the possibilities of AI, while limiting the risks associated with it. To achieve these well-informed decisions, decision-makers within organizations and policymakers within (governmental) institutions need to possess AI knowledge and skills. Therefore, this research will also address these target audiences.

Considering AI professionals, the consortium has defined a specific scope of relevant AI-related skills. Stanford University's classification of AI skills served as the foundational structure for this study (Stanford University, 2023). Stanford classification is based on the AI-related skills list and clusters defined by Lightcast (2022) built on extensive analysis of job vacancies and skills taxonomy. The clusters encompass areas such as Artificial Intelligence, Neural Networks, Autonomous Driving, Natural Language Processing, Machine Learning, Robotics, and Visual

Image Recognition. The relevancy of the skills clusters outlined in Stanford University's classification were also verified by reports from OECD (Borgonovi et al., 2023), the World Economic Forum (2023), and by frameworks regarding the most important AI roles from Coursera (2023), Leeds University, (2023), McKinsey, (2022), and Springboard (2023).

Five of the seven clusters proposed by Stanford align with the specific focus on AI skills of this research. Clusters related to specific AI-applications (such as autonomous driving), rather than the skills needed for using these applications, are excluded from the study. However, the skill of processing Data in AI not present among the Stanford (2023) clusters, cannot be overlooked. Acknowledging the role of AI skills in data-related domains, the category 'Data' is therefore added in the classification scheme by the authors. The clusters of AI-related skills in scope of this research are, therefore, as follows: 1) Natural language processing, 2) Visual image recognition (computer vision), 3) Robotics, 4) Machine learning, 5) Neural networks (deep learning) and 6) Data processing and analysis.

With the application of AI in businesses, new AI-related roles emerge as organizations create functions dedicated to the needed AI-skill clusters. The AI-roles related to the above identified AI-skills are included in this study. Namely: 1) Machine learning engineers, 2) Natural language processing engineers, 3) Computer vision engineers and 4) Data scientists, analysts, and engineers.

The research design builds upon the above named AI-skills clusters and related AI-roles, this design is presented in the section below.

3 Research Methods

This section outlines the methodology used to investigate the current and future demand for skills and roles relating to AI. To better understand the fast-changing AI roles and skills, both quantitative and qualitative data were collected. Given the broad scope of the research topic, a mixed-method approach is particularly appropriate as this approach integrates various methodologies enhances the understanding of complex issues (Molina-Azorin, 2016). The study consisted of an EU-wide industry questionnaire, expert focus groups and a job vacancy analysis. More specifically, the questionnaire was used to collect data from industry on their

current needs for AI roles and skills as well as in the future. The current need was further investigated by performing a job vacancy analysis using an AI-driven tool. To enrich and expand upon the insights derived from the industry questionnaire and the job vacancy analyses, expert focus group sessions were conducted. The integration of industry questionnaires, job vacancy analyses, and focus groups was strategically employed to enhance the robustness and comprehensiveness of the research findings. This methodological approach, incorporating both quantitative and qualitative data and the use of multiple research methods, was designed to ensure a multidimensional understanding of the AI skills landscape, improved research reliability and validity, ultimately augmenting the study with diverse perspectives and deepening the analysis. An overview of the data collected is shown in Table 1.

Table 1: Research methods Data collection in numbers

Research method	Data collected
Industry questionnaire	409 Responses, 12 EU countries, collected from October to December 2022
Job Vacancy analysis	2563 Job advertisements, 11 EU countries, posted from November 2022 to May 19th 2023
Expert focus groups	145 Participants, 12 focus groups of policymakers and 12 focus groups of industry experts, 12 EU countries, collected from September 2022 to January 2023

Industry questionnaire

The industry questionnaire was developed to gather data from industry stakeholders working in sectors which apply AI to their operations or at early stages of AI adoption. The main aim was to determine current, urgent and emergent demand for AI roles within industries adopting or planning to adopt AI, and whether these roles have a "business" focus or a "technology" focus. Therefore, the consortium formulated the industry questionnaire to capture both technical (e.g.: data management, machine learning, etc.) and transversal skills (e.g.: soft skills) that are perceived as important currently as well as in the near future based on the organizations' projections. These foci and objectives guided the formulation of the specific questionnaire items used in the industry questionnaire. The questionnaire included items to measure the demand and motivation for considering AI adoption and usage (sample items: "rate the strategic importance of AI and Analytics to your

organizational growth and development"; "what is your motivation for considering AI within your business? ") and the focus for AI skills within the organization (sample items: "where is your greatest demand for AI business skills within your organization?" and "how would you rate the level of the following skills within your organization today?"). Based on the Advanced Technologies for Industry - AT Watch (Cattaneo et al., 2020), a list of sectors was chosen as target groups. Each ARISA consortium partner electronically distributed the questionnaire to the potential respondents fitting the recruitment criteria defined by the consortium (e.g., organizations who are actively adopting or supporting the adoption of AI within the commercial sector). A total of 409 organizations participated in the industry questionnaire between October to December 2022. A detailed overview of the participating organizations is shown in the Results section.

Job vacancy analysis

To complement the insights obtained from the industry questionnaire, a comprehensive job vacancy analysis was conducted, using an AI-driven tool.
A commissioned and specialized organization used this tool to capture and analyze job vacancy advertisements across job platforms across 11 EU countries. Data sources included both National Public Employment services (e.g., Jobtech and Tyomarkkinatori) and Private Job Portals (e.g., Indeed and Hellowork). The extraction of the job vacancy data was done via authorized Application Programming Interfaces (APIs), fully complying with regulatory frameworks put in place by these data sources as well as other relevant regulatory bodies. To identify the most in-demand AI skills and roles, a total of 756,076 job advertisements posted within the EU area between November 2022 and May 2023 were examined through the Headai Dynamic Ontology (Headai, 2024). Headai Dynamic Ontology (HDO) is a specialized analytical methodology anchored on Natural Language Processing (NLP) techniques and has been used by scientific researchers in the conduct and publication of multiple research studies (Aunimo et al., 2021; Okkonen et al., 2020). This HDO methodology was utilized in this study to scan and analyse job vacancies. Overall, this process involved identifying relevant job titles, extracting skills from job advertisements, mapping these skills to a standardized classification system, and filtering based on exact skills to focus on the specific requirements of AI-related job vacancies.

Focus groups with experts

Focus group sessions were conducted with policy and industry experts. These focus groups were categorized into two types: those involving experts from the policy domain and those involving experts from industry. Totaling 145 participants, 12 focus groups of policymakers and 12 focus groups of industry experts were held, across 12 EU countries. The focus groups took place from September 2022 to January 2023. The policymaker focus groups aimed to gather information specific to AI-related skills for policymakers. The aim of the policymaker focus groups was to collect specific insights on AI-related skills necessary for policymakers while the sessions with industry experts served to validate and supplement the findings from the industry questionnaire. The objective for both sets of focus groups -- policymakers and industry experts -- was to validate the information gathered through questionnaires and to enrich it with detailed qualitative insights from the focus group sessions.

4 Results

Industry Questionnaire

A total of 409 organizations completed the industry questionnaire. The geographical coverage was based on the consortium partner countries. Of the 409 organizations, 53% were categorized as large-scale entities with more than 250 employees; approximately one-fourth of the organizations represented in the sample employed fewer than 50 individuals; 21% employed between 50 and 249 individuals. As such, the sample's constitution fully represented both large-scale organizations and small-to-medium-sized enterprises (SMEs). The results from the Industry Questionnaire provided significant insights into the evolving needs of organizations concerning AI roles. In terms of AI roles, Data Scientists, Machine Learning Engineers, and Data Engineers emerge as preeminently sought-after technical positions (see Figure 1). The prominence of these roles underscores their indispensable contribution to the efficacious use of AI technologies by organizations. Further analysis of the variances in demand for these technical roles between the current landscape and the future reveals discernible fluctuations.

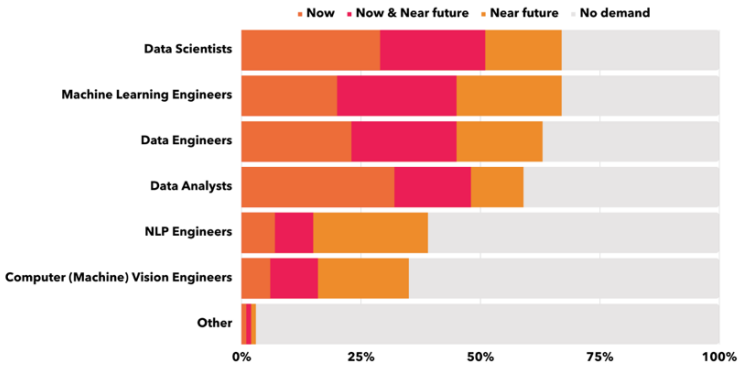

Figure 1: Technical AI roles (now and future)

Source. From AI skills needs analysis: An insight into the AI roles and skills needed for Europe. (ARISA, 2023, p. 22. CC 4.0)

In terms of non-technical, managerial decision-making roles that necessitate proficiency in AI skills, the results showed that Project Managers, Product Managers, and Business Unit Managers were identified by the sampled organizations as the positions demonstrating the most pronounced levels of demand and significance. Moreover, the roles of Financial Managers, Auditors, and C-level Executives (CxOs) have been observed to manifest a significant increase in reported demand. This trend shows a growing acknowledgment of the essential role these decision-making positions occupy in the incorporation of AI technologies into financial management, auditing practices, and executive-level strategic determinations (see Figure 2).

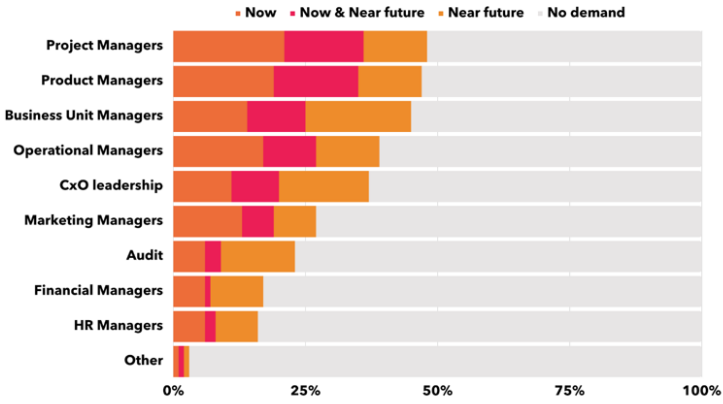

Figure 2: Managerial decision-making roles requiring AI skills (now and future)

Source. From AI skills needs analysis: An insight into the AI roles and skills needed for Europe. (ARISA, 2023, p. 23. CC 4.0)

Concerning AI skills, the results of the Industry Questionnaire revealed that individuals possessing the competence to understand business opportunities arising from AI implementation are greatly needed. Recognizing and utilizing the advantages of AI technologies for organizational benefit is key to guiding strategic decisions and improving competitive positioning. Additionally, the importance of individuals who can source high-quality data is emphasized. The skills required to collect, manage, and organize data critical for the success of AI applications and models are vital for producing reliable and actionable intelligence. Lastly, there is an essential demand for securing AI knowledge and expertise. Attracting individuals with a thorough understanding and skill in AI technologies is essential for efficiently managing the challenges associated with AI development, deployment, and upkeep. A detailed visualized breakdown of the above-mentioned AI skills is shown in Figure 3.

The Industry Questionnaire included a series of questions regarding the soft skills necessary for the effective implementation of AI within organizations. Analysis of the answers revealed the specific soft skills considered crucial by organizations for managing the intricacies of AI deployment. Specifically, problem-solving, critical thinking, effective communication, and an innovative mindset were identified as the key soft skills by the sampled organizations (see Figure 4). Of these, problem-solving was rated as the most important, indicating its pivotal role in overcoming complex issues and crafting viable solutions in environments driven by AI. Additionally, critical thinking was also highly ranked by the respondents for its importance, reflecting the role critical thinking would play in fostering analytical thought and rational judgement in AI-related decision-making scenarios.

Figure 3: AI skill requirements

Source: From AI skills needs analysis: An insight into the AI roles and skills needed for Europe. (ARISA, 2023, p. 24. CC 4.0)

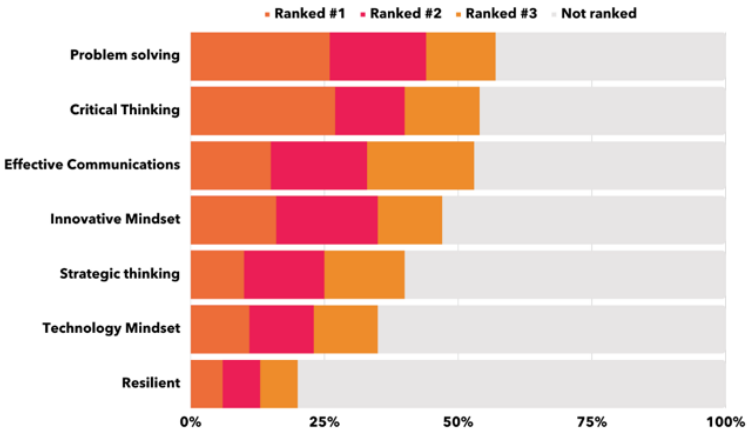

Figure 4: Soft skills for AI success

Source: From AI skills needs analysis: An insight into the AI roles and skills needed for Europe, by ARISA, 2023, p. 25. CC 4.0

Analysis of Job Vacancies

Using the above mentioned HeadAI Dynamic Ontology (HDO) method, this research identified and analyzed, among the 756,076 job vacancies, 2,563 AI-specific job advertisements to deduce the skills demanded within the sector. The search query was based on job roles that were sourced from policy papers and forecast reports (such as IBM, 2022), on exact skills ('unsupervised machine learning') software industry experts and also ESCO classification system.

HDO's innovative interactive interface facilitated the exploration of these skills, showcasing their interconnections and relevance to various roles within the AI domain. The skills extracted from the job vacancies are grouped into five primary clusters: general technical skills, big data & data analytics, machine learning & deep learning, cyber and data security, and large language models. These clusters were generated based on the frequency and closeness of links between various skills identified from the dataset. Using this methodology, the researchers were able to provide illustrative visualizations of the present and future skill demands in the AI field by grouping skills into relevant categories and showing the interactions and overlaps between these groupings (see Figure 5).

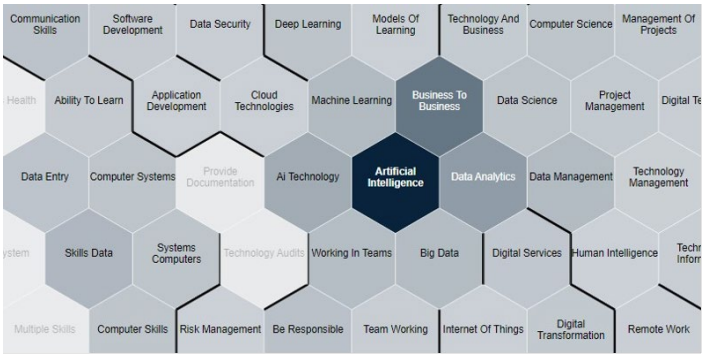

Figure 5: HDO interface showing AI roles and skills
Source: From AI skills needs analysis: An insight into the AI roles and skills needed for Europe, (ARISA, 2023, p. 27. CC 4.0)

General technical skills

The analysis underscored the importance of a broad skillset encompassing both generic and specific technical skills. High demand was observed for skills in programming languages such as Python, Java, JavaScript, and C++, indicating the multi-disciplinary nature of AI. Additionally, traditional ICT skills, including structured query language (SQL) and Big Data, continue to hold significant value in the job market. The findings suggest a need for comprehensive training that spans beyond current buzzwords to include a wide array of technical topics and soft skills like teamwork.

Big data and data analytics

This cluster, closely associated with data science, machine learning, data management, and security, is central to AI. The analysis revealed a strong emphasis on the business application of data analytics, including business intelligence, systems architecture, process automation, and the integration of technology with business strategies. Additionally, the significance of security and renewable technology within this context was highlighted, pointing towards a broad scope of relevant skills.

Machine Learning and Deep Learning

As the most expansive and interconnected skill cluster, machine learning and deep learning are deemed essential for understanding AI. These areas are fundamental to data literacy within AI, underscoring the necessity for these topics to be at the core of AI training and education across all job roles and industries.

Cyber security and data security

The importance of cyber and data security spans the entire ICT sector, with a specific emphasis on AI. The analysis stressed that understanding AI security involves more than just knowledge of protocols or certifications; it requires a comprehensive grasp of how security mechanisms are integrated within AI systems.

Language Models

The emergence of language models, particularly Large Language Models (LLMs), has introduced a rapidly growing demand for skills in natural language processing (NLP), deep learning, and neural networks. The dynamic nature of LLM applications necessitates focused attention in education and training, highlighting the fast-paced evolution in this area.

Role-specific insights

The analysis also provided insights into specific roles, such as data scientists and data engineers, illustrating the different skill emphases between closely related positions. For data scientists, a combination of technical skills and soft skills like team collaboration, business development, and project management was highlighted. In contrast, data engineers' skill sets were noted to focus more on technical aspects, such as mathematics, statistics, and machine learning algorithms.

Focus Groups

The results from the expert focus groups have yielded critical insights into the evolving landscape of AI skills requirements and policy-making strategies across the European Union. The following findings are derived from focus group discussions with 41 policymakers and 104 industry experts across various EU countries.

Policymakers' AI skills needs

- *Roles and levels of policymakers*

The focus groups underscored the necessity for AI skills among policymakers at both national and European levels. It was identified that not only policymakers but also their advisors need to be equipped with relevant AI knowledge to make informed decisions impacting society at large. The discussions and discourse during the expert sessions highlighted the importance of upskilling a wide array of policymakers, including those in non-technical fields such as education, environment, health, and the economy. A significant emphasis was placed on the roles of national chief information officers (CIOs) and government ministers, alongside their ministries and advisors, as crucial targets for AI skills enhancement.

- *AI skills and knowledge*

The discussions revealed an urgent need for basic AI knowledge among policymakers to address legal, ethical, and technical challenges posed by AI technologies. Quotes from participants such as *"We cannot wait. The future is now and affects everybody"* and *"One of the problems we face in the near future is that policymakers know too little about how it really works"* underline the immediate need for upskilling in AI. The focus shifted towards the significance of comprehensive training in AI for policymakers, emphasizing the integration of legal experts, ethical advisors, and strategic technology advisors in policy formulation processes.

Organizational AI skills needs

- *Skills for decision-makers*

The need for organizational decision-makers to adapt to AI developments through change management skills was particularly noted. Skills in understanding the relevance of data and data science, managing risks, and formulating digital strategies were deemed essential. The importance of fostering an organizational culture conducive to AI adoption was also highlighted, with quotes such as "*fostering a culture of experimentation*", and "*culture is important for change*".

- *Skills for AI professionals*

Technical AI skills such as data science, data analysis, machine learning, and deep learning emerged as highly valuable. The discussions highlighted the necessity of not only technical but also soft and business-related skills for AI professionals. Quotes like "*There is a strong need for soft skills*" and "*AI practitioners need skills such as understanding business processes, ability to present and sell a product, customer relations, conflict management*" illustrate the multifaceted skillsets required for AI roles.

In sum, the expert focus groups have elucidated the critical areas of AI skills needs among policymakers and organizational decision-makers. The urgency for AI education and training, coupled with the necessity for a diverse set of skills ranging from technical to soft skills, underpins the recommendations for bridging the AI skills gap. The insights drawn from these discussions will be instrumental in shaping future policies and strategies for AI skills development across the European Union.

5 Discussion, Conclusions, and Implications

The objective of this research was to identify and pinpoint essential skills and roles in the area of AI. Through analyzing job vacancies, conducting focus group sessions, and administering an industry questionnaire, this study uncovered significant insights into the prevailing needs and demands for these AI-related skills and roles in Europe.

Results show that there is a strong demand for AI professionals -- data scientists, machine learning engineers, and data engineers, while the need for data analysts may be experiencing a potential decrease. Additionally, managerial roles including project managers, product managers and business unit managers have been identified as crucial positions requiring knowledge and skills relating to AI. These results are broadly in line with and further refine previous work (e.g., Bukartaite & Hooper, 2023; Cramarenco et al., 2023; Sofia et al., 2023) and highlight AI development directions in Europe for the future.

The findings of this research highlight the complex landscape of AI related skills demands. On the one hand, five main clusters of technical AI-related skills that are needed are underscored, namely 1) general technical skills, 2) big data & data

analytics, 3) machine- and deep learning, 4) cyber- and data security and 5) language models. In these skills, one can recognize the need for strong technical foundations. Additionally, soft skills such as effective communication and ethical considerations also emerged in this research, identified as necessary to effectively collaborate and essential to understand both end-user needs and to continuously consider possible downsides. On the other hand, this research places an emphasis on the critical importance of basic AI-knowledge and skills for policymakers and organizational decision-makers, ensuring AI-fundamentals are taken into account in the decision-making and policy-making process of organizations utilizing and regulating AI.

The findings of this study have impactful implications for businesses and industries, governmental institutions, and society at large. On the governmental front, the creation of supportive policy frameworks is essential to facilitate the rapid development of AI skills. This includes foundational AI literacy for those in policymaking and decision-making positions to enable informed governance and strategy formulation. Investing in upskilling programs, particularly those addressing urgent skill gaps in AI, will be crucial for maintaining Europe's competitive edge in the global AI arena. Moreover, governments must craft regulations that ensure ethical AI usage, balancing the drive for innovation with considerations of privacy, security, and ethics.

For citizens and society at large, adopting a mindset geared towards lifelong learning is imperative in the age of AI, with an emphasis on acquiring both technical and transversal AI skills. The ethical implications of AI necessitate broad engagement, advocating for technologies that are inclusive, equitable, and beneficial to all. Community engagement with educational institutions and industries is vital to ensure the equitable distribution of AI benefits and to make skill development opportunities accessible to a diverse population, thereby fostering an inclusive approach to AI advancement in Europe.

In summary, this study casts light on the vital need for key AI-related skills and roles as well as a collaborative and adaptable approach to advancing AI skills in Europe, underscoring the importance of keeping pace with the rapid innovations in AI technology. Researchers are encouraged to integrate these findings into broader strategic efforts aimed at mitigating skill shortages through a variety of initiatives. Future research should prioritize the design and assessment of pilot projects that

directly tackle the identified skill shortages, alongside efforts to share knowledge and best practices to continue addressing the AI skills gap in Europe. This work will be instrumental in informing an EU-wide strategy for AI re-skilling and upskilling, reflecting a comprehensive approach to equipping the workforce with the necessary skills to navigate the challenges and opportunities presented by continued AI development.

Acknowledgements

This paper presents the findings of a European research initiative undertaken within the framework of the ARtificial Intelligence & Skills Alliance (ARISA) project's Needs Analysis Work Package. The individuals credited as authors of this paper have contributed in various capacities, including research, writing, and editorial roles, to the development of the ARISA Needs Analysis Report. It is important to recognize that the Needs Analysis Report and the research conducted also benefited greatly from the contributions of other researchers affiliated with the ARISA Project Consortium. The authorship and editorial teams of the Needs Analysis Report are fully listed as follows:

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Editors & Reviewers: Mateja Baebler (CCIS), Bálint Gyires-Tóth (Budapest University of Technology), Jose Martinez-Usero (DIGITALEUROPE), Kerli Saarelaid (BCS Koolitus), Ants Sild (BCS Koolitus), Katarzyna Udala (DIGITALEUROPE), Willemijn van Haeften (University of Applied Sciences Utrecht), Blaz Zupan (University of Ljubljana).

The ARISA Needs Analysis Report has been made accessible to the public under the Creative Commons license 4.0. For further information and to view the report, please visit the official website of the ARISA Project at www.aiskills.eu. The ARISA project has received funding from the European Union's Erasmus+ Programme under grant agreement No 101056236.

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