AI4VET4AI

AI-powered next generation of VET

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D2.2: Transnational research report: Regional and national AI-related skill gaps

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SEN	Sensitive (limited under the GA conditions)	
CLASS	EU classified, confidential	

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1. Executive Summary

1.1. General recommendations

- Two key frameworks exist that support AI adoption and curricular development
  - DigComp 2.2: The Digital Competence Framework for Citizens
  - AI competency frameworks for school students and teachers
- AI Observatories play a critical role in ensuring stakeholders remain informed as to the latest developments in AI
- There is a clear need to train specifically on how to deal with technologies responsibly in all sectors and organisations to have a data steward role
- Need to develop curricula focussing on AI related cybersecurity, especially in relationship with the AI Act
- Curriculum design should focus particularly on knowledge clusters 'computer use' (0611) and 'information and communication technologies not elsewhere classified' (0619) in the ESCO 1.2 framework.
- Key skill clusters for curricula include 'accessing and analysing digital data' (S5.5) and 'using digital tools for collaboration, content creation and problem solving' (S5.6)

1.2. Sector Specific Recommendations

- Sectors chosen specifically for their economic contribution in terms of employment levels and potential for innovation
- Agriculture and Telecommunications excluded from the selection process due to the specific challenges and opportunities already under way in these sectors, as well as consortium capacity to engage these sectors during later project stages

1.2.1. Professional, Scientific and Technical Activities

- Key Professions covered: Accounting, bookkeeping and auditing activities; tax consultancy; Advertising; Market research and public opinion polling
- Focus curricula on including the following skills: Image Generation; Audio Analysis; Cross Area - Ethical Literacy; Statistics; Data Analytics; Human-In-The-Loop Process Design; Image Recognition; Image Analysis; Speech Recognition; Language Model; Cognitive Computing; Manage intellectual property rights; Problem-Solving Skills; Machine Learning; Model Validation And Testing; Sentiment Analysis; Critical Thinking; Context Analysis;
- Examples of AI use cases include:
  - Enhanced Audit Processes: AI can improve the quality of tax audits by analyzing large volumes of transactions and identifying discrepancies
  - Compliance and Regulation Summaries: AI can interpret complex regulations and provide summaries, aiding accountants in staying compliant
  - Personalized Advertising Campaigns: AI can create highly personalized advertising campaigns by analyzing consumer behavior and preferences, leading to higher engagement and conversion rates

1.2.2. Wholesale and Retail Trade

- Key Professions covered: Wholesale of household goods; Retail sale in non-specialised stores
- Focus curricula on including the following skills: Machine Learning; Build Data Pipelines (Use IT Tools)

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- Sector is dominated by proprietary software vendors who provide comprehensive training for specific AI needs associated with their software
- Examples AI use cases include:
  - Inventory Management: AI systems optimize inventory levels, reducing overstock and stockouts, and managing supply chain more efficiently
  - Fraud Detection: AI tools detect and prevent fraudulent transactions by analyzing patterns and anomalies in transaction data
  - Supply Chain Optimization: AI enhances supply chain visibility and predicts disruptions, allowing for proactive management

1.2.3. Human Health and Social Work

- Key Professions covered: Hospital activities; Medical and dental practice activities
- Focus curricula on including the following skills: Communication Skills; Ethical Literacy; Prompt Engineering; Autonomous System; Principles Of Machine Learning (Neural Networks And Deep Learning); Rule-Based Expert Systems; Understand How Ai Works And Its Limitations; Human-In-The-Loop Process Design; Activity Recognition; Automation; Evidence-Based Medicine; Training on Operational Procedures; Instruct Others; Problem-Solving Skills; Information Retrieval; Data For Ai – Interpretation; Medical Ai Development Workflows; Custom Scripting; Analytical Decision-Making Skills; Clinical Decision Support; Critical Reflection On Information; Analytical Thinking;
- Examples AI use cases include:
  - Prescription Auditing: AI systems minimize prescription errors by auditing medication orders and ensuring they are appropriate for the patient's condition
  - Natural Language Processing for Clinical Documentation: AI-powered NLP systems help in transcribing and organizing clinical documentation, reducing the administrative burden on healthcare providers
  - Enhancing Mental Health Services: AI tools support mental health services by providing early diagnosis, personalized therapy recommendations, and monitoring treatment progress

1.2.4. Education

- Key Professions covered: Primary, Secondary and Tertiary Educators
- Focus curricula on including the following skills: Data Curation And Organisation; Learning Analytics; Ai Models – Computer Science Prerequisites; Prompt Engineering; Data Analytics; Computational Thinking; Computer Programming; Data Science; Technical Curiosity; Problem-Solving Skills; Data Literacy.; Creative Inquiry; Critical Thinking;
- Examples AI use cases include:
  - Intelligent Textbooks and Curriculum: These are customizable digital learning assets that adapt to the learning pace and style of each student

1.2.5. Accommodation and Food Services

- Key Professions covered: Accommodation; Food and beverage service activities
- Key industry affected by COVID-19 pandemic
- Focus curricula on including the following skills: Prompt Engineering; Software-In-The-Loop; Dialog Systems; Question Answering; Human-In-The-Loop Process Design; Activity Recognition; Conversational User Interface; Training on Operational Procedures; Instruct Others; Education science; Intelligence Data Handling; Machine Learning;

- Examples AI use cases include:
  - Inventory Management: AI algorithms to predict stock levels and automate ordering processes
  - Customer Feedback Analysis: Using natural language processing to understand guest reviews and improve services
  - AI in Food Preparation: Monitoring food safety standards and ensuring consistent quality across outlets

Statement on the use of AI in report generation

During the recommendations development process, we worked with generative AI.

In our pursuit of excellence and efficiency in research, we have embraced the capabilities of generative AI, not as a data processor, but as a support for descriptive text. This AI specialises in crafting notes around the standards, guidelines, and protocols essential to assembling recommendations from disparate sources.

1.3. List of tables

1.4. List of figures

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2. Introduction

Artificial intelligence (AI) is one of the most important technologies of the 21st century, and is already on its way to be a key economic driver of change in the immediate future. The objective of this report is to help understand how the skills required for empowering AI adoption varies between regions, countries, and sectors withing the EU. To achieve this, the report starts with an overview of AI, including definitions, the economics significance of AI, an understanding of how AI will impact on the VET sector and how this filters on to broader implications for the future of work in the EU.

The report then outlines the several methods of inquiry undertake as part of the AI4VET4AI project (Work Package 2), to help understand what the current skill gaps are in the VET educational space. The search for converging evidence helps provide a robust research framework, the intersections of which form a robust mixed-methods analysis. Finally, this report concludes with a detailed discussion, accounting for a number of different perspectives, on what skills are required for a future AI enabled workforce.

2.1. Key Definitions

Artificial Intelligence (AI) can be defined as "the ability of a machine to display human-like capabilities such as reasoning, learning, planning and creativity" (European Parliament, 2023).

An **AI related skill** is any skill that is required to understand, interact with, and leverage artificial intelligence technologies in a professional setting.

2.2. The growing significance of AI in the EU:

In the European Union, artificial intelligence (AI) related skills is the foundation for AI to be a key driver of economic growth and innovation. Research from the European Commission highlights that AI technologies have the potential to contribute significantly to the EU's GDP. Current estimates suggest that the European Union (EU) has seen significant investments in artificial intelligence (AI), which are expected to contribute to its GDP growth (European Parliament, 2024). In 2023, the EU and the United Kingdom (UK) together attracted €9 billion worth of private investment in AI. Between 2018 and the third quarter of 2023, almost €32.5 billion was invested in EU AI companies. The overall global AI market, valued at over €130 billion in 2023, is anticipated to grow substantially by 2030, reaching nearly €1.9 trillion. These investments in AI are likely to drive innovation, efficiency, and economic growth within the EU, contributing to various sectors such as health, high-tech, and banking through advancements in generative AI and other AI technologies.

The exact contribution of AI to the EU's GDP can vary based on a range of factors, including technological adoption rates, regulatory environments, and the integration of AI across different industries. However, the significant investments and the expected market growth indicate a positive outlook for AI's contribution to the EU's economy.

Importantly, a number of policy papers, such as the European AI Strategy (*AI Act | Shaping Europe's Digital Future*, 2024; *European Approach to Artificial Intelligence | Shaping Europe's Digital Future*, 2024), emphasize the need for upskilling and reskilling the workforce to meet the demands of the digital economy, with a specific focus on AI competencies. A number of key issues can be identified from the AI policy environment in the EU.

These include:

- Excellence and Trust: The strategy aims to make the EU a world-class hub for AI, ensuring that AI systems are developed and used in ways that are safe and respect existing laws and values.
- Research and Industrial Capacity: Boosting research and industrial capacity in AI to strengthen Europe's potential to compete globally.
- AI for People: Ensuring that AI works for people and is a force for good in society, enhancing well-being and inclusiveness.
- Strategic Leadership: Building strategic leadership in high-impact sectors and enabling the development and uptake of AI from the lab to the market.
- Risk-Based Regulatory Framework: The AI Act, part of the strategy, is the first-ever legal framework on AI, aiming to provide clear requirements for AI developers and deployers and addressing the risks of AI. It categorizes AI systems into different levels of risk and sets out corresponding requirements and obligations.
- Banning Unacceptable Risks: Certain AI practices that pose clear threats to safety, livelihoods, and rights will be prohibited, such as social scoring by governments.
- High-Risk Applications: The strategy identifies high-risk applications, such as those used in critical infrastructures, education, and employment, and sets specific obligations for their deployment.
- Governance Structure: Establishing a governance structure at both European and national levels to ensure compliance with the regulatory framework.
- Innovation and Investment: The strategy includes measures to support European startups and SMEs in developing trustworthy AI, leveraging assets like supercomputing infrastructure, and fostering an innovative AI ecosystem.
- International Cooperation: The strategy emphasizes the importance of international cooperation to ensure that AI development aligns with European values and global standards.

With respect to these points, it's important to then understand how this impacts specifically on one of the key educational pathways for an AI enabled workforce.This is where the intersection of AI and the Vocational Education Training (VET) sectors interact.

2.3. Impact on Vocational Education and Training (VET) Sector in the EU:

The VET sector in the EU is pivotal in preparing individuals for the changing world of work, including the integration of AI skills. The International Standard Classification of Education defines vocational programmes as education programmes that are designed for learners to acquire the knowledge, skills and competencies specific to a particular occupation, trade, or class of occupations or trades. VET programmes may have work-based components (e.g. apprenticeships and dual-system education programmes). Successful completion of such programmes leads to vocational qualifications relevant to the labour market and acknowledged as occupationally oriented by the relevant national authorities and/or the labour market.

This is important in the landscape of peoples digital literacy skills and the future adoption of AI. According to data from Eurostat, there is a large variation in above basic information literacy skills across the EU. In Figure XXX, we can see that the nordic countries, along with Ireland and the Netherlands have well developed above basic information data literacy skills. However, this is not necessarily applicable to other states, including Germany, where VET is a crucial part of the education system as a whole.

Studies like Cedefop's reports on skills anticipation underline the necessity of aligning VET programs with the evolving skill needs, including AI competencies. This rapidly developing intersection already has several initiatives underway. For example, the European Skills Agenda aims to strengthen VET systems across EU member states to ensure they are equipped to deliver the necessary AI skills to the workforce.

Research studies by Eurostat reveal the existing skills gap in AI-related fields across EU countries, with a growing demand for professionals proficient in AI technologies. Reports from the European Centre for the Development of Vocational Training (CEDEFOP) indicate a shortage of workers with AI skills in various sectors, highlighting the urgency of integrating AI competencies into VET programs.

Integrating AI skills into VET programs in the EU offers numerous benefits, including enhanced employability of graduates, improved productivity in industries embracing AI technologies, and a more competitive workforce in the global market. Studies from the European Parliament emphasize that fostering AI skills through VET can lead to increased innovation, entrepreneurship, and job creation within the EU.

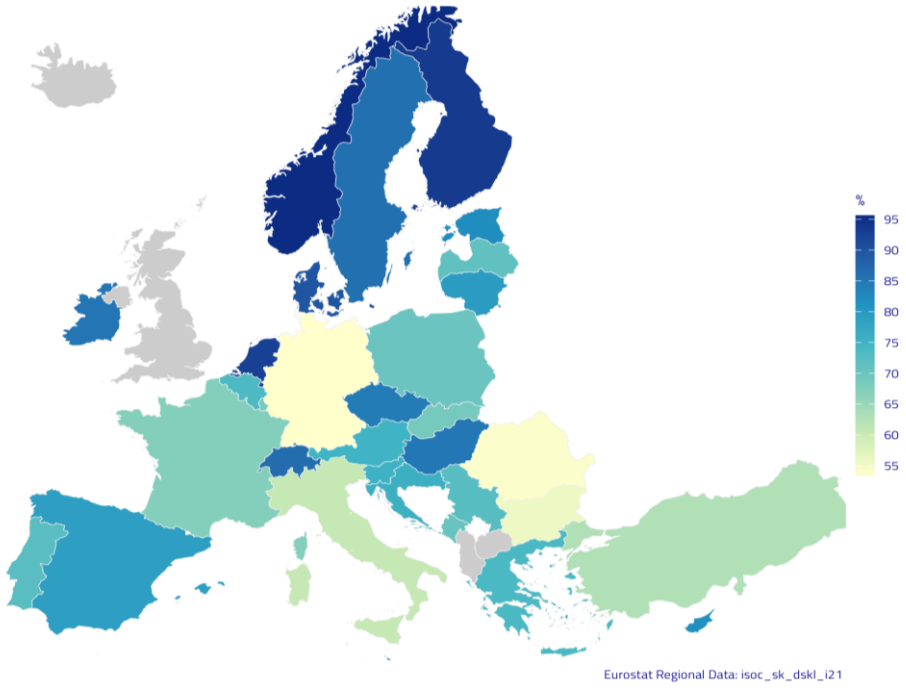

Figure 1: Individuals with above basic information data literacy skills(2023)

However, there are a number of challenges in integrating AI skills into VET programs in the EU, which includes ensuring the quality and relevance of AI training, addressing the digital divide among learners, and adapting curricula to rapidly evolving AI technologies. Opportunities lie in leveraging EU funding programs such as Erasmus+ and Horizon Europe to support the development of AI skills in VET, establishing partnerships between education institutions and industry stakeholders, and promoting lifelong learning initiatives.

2.3.1. Cybersecurity

In that regards, cyber security is paramount and a key component of supporting the development of AI in the future workforce. Safety is an issue because the technology is new and complex. However, though there is little comfort for those involved in accidents, there are already opportunities to automate repair.

AI's relationship with cybersecurity is complex. AI has a dual purpose. On the one hand, it can protect your organisation, spotting anomalous behaviour and reacting appropriately. On the other hand, it can act as a perpetrator via social engineering attacks, creating fake news and producing simplified instructions for human actors who wish to get into your bank accounts.

Known as the AI butterfly effect, a small amount of Garbage in to AI can generate a large amount of garbage out. The uses of data and privacy issues, the biases in the data, the methods of training the AI and the explainability of the decisions create undeniable problems that society needs to reflect in how humans use AI and the training the human co-worker requires.

Legislators have ratified the AI Act to address risk and unleash the European Economic engine. Therefore, specific legally binding artefacts in the business process will increasingly become more critical, such as risk assessments and the need to explain algorithmic decisions.

Researchers have explored the landscape of cybersecurity curriculums at Universities. Different approaches to teaching are possible. The cybersecurity training landscape is detailed and well thought out. The question is more than the curriculum details but rather the experience scale within the teaching profession. Time and again, we see that the teaching profession is bearing the brunt of the need for AI-centric professionalisation to transfer their experiences to the students. Immersion with AI from an early age requires scaling up of support via training. Researchers are designing curriculums and practices for high school students to address these training issues. However, generational differences make it difficult for teachers to connect with students.

The newness aspect provides an immense window of vulnerability around AI, which we can quantify via the AI incident database. Let's briefly review automated driving as an illustration associated with the retail trade sector. Consider this a proxy for Robotics in the supply train in general.

AI watch noted that Artificial Intelligence in Automated Driving the cybersecurity aspect of automation. "An analysis of safety and cybersecurity challenges: The breakthroughs achieved by AI systems in automated driving are contrasted by their higher complexity and opacity, potentially leading to safety and cybersecurity risks. The growing digitalisation of vehicle systems increases the potential for cybersecurity attack surfaces. It can lead to stronger impacts if automation mechanisms are compromised. Biases in and lack of generalisation of AI systems and data may cause vehicles to malfunction in natural conditions or as a result of a cyber-attack, putting the lives of passengers and road users at risk. Vehicle testing procedures need to consider the specificities of AI to ensure that safety and cybersecurity risks are properly addressed. Addressing AI safety and cybersecurity challenges by design is key to securing the many benefits automated driving can bring society."

Between rapid technological change, the newness and legislation, the generational differences between teachers and students, the implementation of new learning strategies, and AI attack vectors. Europe will need to scale the cybersecurity knowledge and experience of teachers and explore new approaches. Over the coming decade,

implementing and deploying cybersecurity hygiene, ethics, training at scale requires a great deal of care and thought from policymakers and Educational practitioners.

2.4. What we are researching

The AI4VET4AI project reviews the **impact of Artificial Intelligence on AI literacy** within European Vocational Education and delivers recommendations. It does so through a focus on a skills gap analysis based on Sector and Regional differences. The velocity and impact of AI on society across demographics, regions, industries, and cultures are complex, and only later historians will genuinely understand. Therefore, the authors triangulated their study through a series of methodologies to identify converging evidence using a mixed methods approach and formulate recommendations for future curricula from this accordingly.

The original research questions were:

RQ1: What are the current skill gaps at the intersection of AI related skills and VET?
RQ2: What AI skills are in increasing demand from 2020 onwards, for VET students or graduates in the labour marketplace?
RQ3: Which occupations are going to need an AI skilled, VET qualified workforce, the most in the next 10 years?
RQ4: What skills belong to the AI literacy skill set?
RQ5: Are there any country or regional differences in the AI skills gap by occupation?
RQ6: What methods can be implemented to provide ongoing and adaptive recommendations for the development of state-of-the-art AI skills curricula?
RQ7: What are the most effective methods for disseminating AI teaching materials?

To provide a focus we refined the Research Questions into three themes:

1. **AI skills gap analysis:** This theme is related to RQ1, RQ2, RQ3, and RQ5. These questions aim to identify the current and future skill gaps at the intersection of AI and VET and how they vary by occupation, country, or region. The theme can help understand the demand and supply of AI skills in the labour market and the challenges and opportunities for VET students or graduates.
2. **AI literacy skill set:** This theme is related to RQ4. This question aims to define the skills of the AI literacy skill set, which are essential for understanding, using, and interacting with AI systems and applications. This theme helps establish a common framework and standard for AI education and training.
3. **AI teaching methods:** This theme is related to RQ7. This question explores the most effective methods for disseminating AI teaching materials, such as online platforms, courses, modules, or workshops. This theme can help to improve the accessibility and quality of AI learning resources and experiences.

2.5. Methods

Methodology was detailed: As you read in detail the methodologies in the technical manual, you will realise how much of an operation it has become to keep track of AI Skills and provide recommendations for AI literacy at the regional level per industry within Europe. We have strived to deliver relevant content, but due to the size and extent of the Big dataset of resources available on the Internet, we have yet to capture all the available value. However, by having a methodic set of search strategies that triangulate our intended goals, we have minimised the loss and delivered within the resources and time allotted to the task.

The approaches included:

1. Skills gap survey
2. Delphi method. A discussion with experts
3. Systematic Literature
4. Review of skills demand in the job market via Job market intelligence that, in the end, requires the analysis of a Big set of online Job advertisements
5. Systematic data review of available sources of data. Later, a number of the discovered data sources are used to support the recommendations

Through these methods, we establish well grounded recommendations supported by multiple sources. We recommend specific skills and curriculums for AI literacy. For the systematic literature review, ten researchers narrowed an initial intake of 11335 research papers down to 102 of high quality, highly specific to the theme of AI literacy.

There is a limitation with the freshness and quality of research and the provision of recommendations. This is driven by competition in improving AI architecture and an arms race for improving models through training of virtually the whole text on the Internet. The ease of use of AI accelerates impact across all industries with the future being felt by the workers faster than other industries. Change leads to increasing capabilities and a wide range of ever-improving techniques and de facto design patterns for service delivery.

The authors launched a systematic data review to help answer the question of freshness of advice. **How do we update advice promptly?** Research papers take time to be published; at the National level, data from traditional survey methods takes time to collect, analyse and publish.

The velocity of change limits the quality of datasets and information related to AI literacy. Sources get old very quickly. The method used to define the minimal level of quality was Chain of Trust. Our initial selection of papers was those that have passed peer review. We then trusted the quality of the sources mentioned and those cited by the selected sources.

Table 1: We defined a six-part taxonomy after a studious selection of research papers and a discussion within the authoring team (TIB and UvA).

Table 1: Taxonomy Count

Domain	Description	Count
DATA	A specific, actionable dataset	63
OBSERVATORY	A curated set of AI evidence that is regularly updated. The Observatories are normally setup to keep track of evolving themes of concern for a region or governance body	30
DATAHUB	A central repository of many datasets.	23
REPOSITORY	An uncurated set of publications with a subset of relevant publications	21
PERIODIC	Reports or other sources of information that are published periodically, such as every year	11
OER	OER resources. Just a few sources that example the potential	2

The highest valued resource was observatories, which were set up mainly by governance or standards bodies to observe specific trends around the impact of AI: experts and the analysis of a gold standard curate the content. Not all observatories have the word observatory in their title, but many groups are effectively an observatory.

The second level of value is relevant reports that international organisations generate periodically. The insights and data sources are valuable for policymakers and the triangulation of recommendations. Links to the observatories and periodic reports are provided in appendices 6,7 within the technical manual.

The primary source of regional data from the review was Eurostat, the statistical office of the European Union. Eurostat collaborates with National Statistical Institutes and other national authorities of E.U. Member States through a partnership known as the European Statistical System (ESS), including the statistical authorities of the European Economic Area (EEA) countries and Switzerland.

Two qualities of the Eurostat dataset that affected the recommendations were: One, the freshness of the datasets and two the geographical resolution of the datasets. For example, there needed to be more regional information at the level of resolution required for our recommendations, and Eurostat covered only some regions for each selected dataset. For more details on these limitations, please review the technical manual.

To provide focus, we chose specific industries and regions for analysis that aligned with current economic data and the AI4VET4AI consortium capacity. The industries were selected by the 27 partners within the project and displayed in Table 2. We selected the regions in Table 3. based on the frequency of responses per region of a survey of experts.

Table 2: Selected NACE Sectors and Subgroups

Code	Description
G	WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES
46.4	Wholesale of household goods
47.1	Retail sale in non-specialised stores
I	ACCOMMODATION AND FOOD SERVICE ACTIVITIES
55	Accommodation
56	Food and beverage service activities
M	PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES
69.2	Accounting, bookkeeping and auditing activities; tax consultancy
73.1	Advertising
73.2	Market research and public opinion polling
P	EDUCATION
85.2	Primary education
85.3	Secondary education
85.4	Higher education
Q	HUMAN HEALTH AND SOCIAL WORK ACTIVITIES
86.1	Hospital activities
86.2	Medical and dental practice activities

Table 3: Identified NUTS 2 Regions for Additional Analysis

Rank	Country	Region
1	Greece	Dytiki Elláda
2	Turkey	Kırıkkale, Aksaray, Niğde, Nevşehir, Kırşehir
3	Ireland	Eastern and Midland
4	Slovenia	Vzhodna Slovenija
5	Slovenia	Zahodna Slovenija
6	Turkey	Gaziantep, Adıyaman, Kilis
7	Croatia	Grad Zagreb
8	Italy	Campania
9	Austria	Tirol
10	Spain	Comunidad de Madrid
11	Croatia	Sjeverna Hrvatska
12	Austria	Wien
13	Spain	Andalucía
14	Croatia	Panonska Hrvatska
15	Germany	Niederbayern
16	Austria	Oberösterreich
17	Germany	Oberbayern
18	Austria	Kärnten
19	Austria	Steiermark
20	Greece	Attiki

2.6. Final Comments

The methodology presented in this chapter enabled us to conduct a comprehensive and rigorous analysis of the AI skills landscape in Europe. It also allowed us to identify the gaps and mismatches between the supply and demand of AI skills, as well as the best practices and recommendations for addressing them. In the next chapter, we will report the results of the systematic literature review, which provides an overview of the current state of the art in AI skills research and development.

3. Systematic Literature Review[1]

The main aim of the systematic literature review was to scour the extant research literature for methods and outcomes pertaining to AI related skills gaps identification. The core focus of the research was to track emerging skills related to AI that could complement the skills listed in ESCO version 1.12. Specifically, the authors performed a systematic literature review of articles published between 2021 and November 7th, 2023 (the query search date).

To provide a focus for coding the full text of papers, we refined these Research Questions into three themes:

1. **AI literacy:** Defining the skills that belong to the AI literacy skill set, which are the essential skills for understanding, using, and interacting with AI systems and applications. AI literacy is occupation a-specific and may form a prerequisite for more advanced AI education and training.
2. **AI skills** gap analysis: Identifying current or future unmet skill demand associated with the proliferation of AI, In particular at the occupational level. The misfit can be between: Educational curricula and specific occupation or job candidates and specific occupations.
3. **AI teaching methods:** Innovative (e.g., gamification) and interactive online teaching methods (including means of content development) that are leveraged to upskill or reskill individual VET students.

We cast a wide net to capture papers through different search engines relevant to these research questions using a query with the following general structure.

(AI) AND (Skills) AND (Labour Market) AND (Education)

The initial set of papers discovered was 11.335. After deduplication, we screened the titles and abstracts of the 7.420 papers that remained, yielding 1.050 papers that went through a more rigorous review. An important contribution to the literature review process was identified during this process, which is the paper by Pinski, Benlian (2024). This paper provided a comprehensive review of AI literacy for users, and conducted a similarly scaled literature review which addressed our first research objective. Rather than conducting additional work, we have included their work into our final list of skills where appropriate. We would highly recommend reading this original research.

As such, to contribute to achieving D2.2 and D2.3 it was decided to focus our initial effort on retrieving those skills identified in articles that had been classified as addressing RQ2. Hence, we selected papers for full-text coding only if they met the following criteria: The experts labelled documents for RQ2 (AI Skills Gaps Analysis), Contribution level 3 and Methodology was greater than 0. At the end of the filtering, a domain expert who was not involved in the initial screening task provided an extra 12 based on a more targeted search for methodologically rigorous means of identifying AI related skills gaps. The final count was 108 papers for full text analysis.

[1] Next to the TiB and UvA project teams, we gratefully acknowledge Alenka Pandiloska, Serdjan Verbić, Stephan Schloegl, Willemijn van Kooten, Janez Kolar, Monika Rohlik Tunjić, Maja Brkljačić,Leo Mršić, Annika Gnädinger, and Silvia Cosimato for their contributions to conceptualization, screening, and coding.

Table 4: Literature Review Results

Title	Authors	Skills	Sector	Occupation	Region / Country
Applications of 3D reconstruction, Augmented reality and 3D printing in Modern Surgical Education	Schulze F.E. And Fayez Hassouna M. And Chand M.		R	Medical Students, Junior Surgeons	
Assessment of educational needs and factors influencing the level of digital skills of TR/RTTs - a stakeholder perception	Barbosa B. And Oliveira C. And Bravo I. And Couto J.G. And Antunes L. And Mcfadden S. And Hughes C. And Mcclure P. And Dias A.G.	Treatment Planning; Management And Research; Computer Programming; Artificial Intelligence Tools Development;	R	Therapeutic Radiographers/Radiation Therapists	Portugal
Using a collaborative approach to identify ways to strengthen enhanced care practices in a general hospital while building research capacity	Daly L. And White P. And Harris E. And Carroll A.F. And Murphy A.		R		
Improved Prediction of Surgical-Site Infection After Colorectal Surgery Using Machine Learning.	Chen, Kevin A And Joisa, Chinmaya U And Stem, Jonathan M And Guillem, Jose G And Gomez, Shawn M And Kapadia, Muneera R		R	None	US
AI-Powered Chatbots in Medical Education: Potential Applications and Implications.	Ghorashi, Nima And Ismail, Ahmed And Ghosh, Pritha And Sidawy, Anton And Javan, Ramin		R	Medical educators	US
Teaching artificial intelligence as a fundamental toolset of medicine.	Otles, Erkin And James, Cornelius A And Lomis, Kimberly D And Woolliscroft, James O	Data Summarization; Data Visualisation; Statistical Modelling; Machine Learning; Simulation; Optimization; Infomration Retreival; Critical Refelction On Information; Information Integration;	R	Medical educators	US
From an Empty, to an Almost Full, and Eventually to a Never Full Glass: The Evolving Challenges of Medical Education	Koufakis, Theocharis And Gouveri, Evanthia And Doumas, Michael And Papanas, Nikolaos		R	Medical educators	
Development of the "Scale for the assessment of non-experts' AI literacy" – An exploratory factor analysis	Laupichler, M.C. And Aster, A. And Haverkamp, N. And Raupach, T.	Machine Learning; Deep Learning; Rule Based Systems; Explainability; Data Privacy ; Data Ethics; Data Security; Ai Tool Selection; Problem		Mixed, non-technical	UK, South Africa, US, Australia, Canada

		Definition; Ai Evaluation; Critical Reflection			
From "Ban It Till We Understand It" to "Resistance is Futile": How University Programming Instructors Plan to Adapt as More Students Use AI Code Generation and Explanation Tools such as ChatGPT and GitHub Copilot	Lau, S. And Guo, P.		Q	Programming educators	US
Artificial intelligence literacy teaching in social studies education	Yetişensoy, O. And Rapoport, A.		Q		Turkey
Booklet-Based Design Fiction to Support AI Literacy	Xie, S. And Solyst, J. And Ogan, A. And Hammer, J.				US
The Impact of Generative AI like ChatGPT on Digital Literacy Education in University Libraries	Gong, F.				
What Is AI-PACK? – Outline of AI Competencies for Teaching with DPACK	Lorenz, U. And Romeike, R. And Pellet J.-P. And Parriaux G.	Ai Related Knowledge (Ai-K); Ai Related Pedagogical Knowledge (Ai-Pk); Ai Related Content Knowledge (Ai-Ck)	Q	Teachers	NA
Research on ChatGPT's Strategy to Promote the Digital Transformation of Education	Yinping, Z. And Yongxin, Z.		Q	Teachers	China
Leading teachers' perspective on teacher-AI collaboration in education	Kim, J.	'Competency To Work With Ai', An Ability To Think, Make A Judgment And Express Themselves To Ai; Competency To Lead A Future' Through Creating Innovative Solutions With Ai; Data Literacy.; Identifying A Problem Of Practice And Framing A Question; Collecting Data; Analyzing Data; Decision Making; Outcomes Evaluation; Developing Collegiality With Ai	Q	Teachers	China
Artificial Intelligence in K-12 Education: eliciting and reflecting on Swedish teachers' understanding of AI and its implications for teaching & learning	Velander, J. And Taiye, M.A. And Otero, N. And Milrad, M.	An Understanding Of How Digitalisation Impacts Society And The Individual;	B	Teacher and Teacher Educators	Sweden

		An Understanding And Use Of Digital Media; An Ability To Critically And Responsibly Relate To Digital Technology; An Ability To Actualise These Ideas Using Digital Technologies; Ai Literacy: Knowing And Understanding Ai, Applying Ai, Evaluating And Creating Ai And Ai Ethics; Technological Knowledge; Technological Content Knowledge; Technological Pedagogical Knowledge; Attitudes And Perceptions Of Ai; Ethics			
It's Only a Bot! How Adversarial Chatbots can be a Vehicle to Teach Responsible AI	Weiss, A. And Vrecar, R. And Zamiechowska, J. And Purgathofer, P.	Knowledge Of Ethics And Responsible Design	K	Computer science students	Austria
Digital applications in mental health: Status, challenges and perspectives	Mouchabac, S. And Bourla, A. And Geoffroy, P.-A. And Micoulaud-Franchi, J.-A. And Misdrahi, D. And Petauton, D. And Samalin, L. And Conejero, I. And Schwan, R. And Bonnot, O.		R	None	None
Linking Higher Education to Patterns of Job Mobility and Emergent Technological Change	Buasuwan, P. And Orsuwan, M.		U	None	Thailand
MaCuDE IS Task Force Phase II Report: Views of Industry Leaders on Big Data Analytics and AI	Lyytinen, K. And Topi, H. And Tang, J.	Fundamental Environmental Competencies; Data, Information, And Content Management; Systems Design Competencies	K	IT	US/Europe
Promoting AI Trustworthiness through Experiential Learning	Fong, A. And Carr, S. And Gupta, A. And Bhattacharjee, S.		U		US
Communication training for pharmacy students with standard patients using artificial intelligence	Nakagawa, N. And Odanaka, K. And Ohara, H. And Kisara, S.		R	Pharmacists	Japan
Artificial Intelligence (AI) for Sustainable Institutional Food Systems: Implementation of AI Tools for	Camaréna, S.		I	School food authorities	USA

School Nutrition Program Management in the United States of America					
Educating the Healthcare Workforce to Support Digital Transformation	Davies, A.C. And Davies, A. And Abdulhussein, H. And Hooley, F. And Eleftheriou, I. And Hassan, L. And Bromiley, P.A. And Couch, P. And Wasiuk, C. And Brass, A. And Otero P. And Scott P. And Martin S.Z. And Huesing E.	Imple,Enting Machine Learning Into Clinical Practice	R	Health Care workforce	UK
Influence of High-Tech Society on the Development of Modern Educational System	Abylkasymova, A.E. And Shishov, S.E. And Kalney, V.A. And Ryakhimova, E.G.	Clinical Practice; Stability Under The Influence Of Volatility; It Skills That Help To Cope With The Increasing Information Flow; Communication Skills That Ensure Effective Interpersonal Interaction; Emotional Intelligence	Q	Educators	Russia
Artificial Intelligence Education for the Health Workforce: Expert Survey of Approaches and Needs	Gray, K. And Slavotinek, J. And Dimaguila, G.L. And Choo, D.	Ethical Implications Of Ai; Evaluate Suitability Of Large Data Sets For Ai Applications; Principles Of Machine Learning (Neural Networks And Deep Learning); Human-Machine Interaction In Clinical Settings; Specific Diagnosis And Treatment Applications Of Ai; Rule-Based Expert Systems; Specific Health Knowledge Management Applications; Specific Patient Engagement And Adherence Applications; Physical Robots; Nlp; Rpa	R	Medical professionals, nurses, and other registered health practitioners	Australia
Needs, Challenges, and Applications of Artificial Intelligence in Medical Education Curriculum	Grunhut, J. And Marques, O. And Wyatt, A.T.M.	Widespread Knowledge Of Basic And Clinical Medicines Along With Data Science; Biostatistics; Bioethical Implications Of	R	Medical students and future physicians	NA

		Ai; Evidence-Based Medicine; Ability To Distinguish Correct Information From Rhetoric; Understand How To Create And Disseminate Thoroughly Validated Trustworthy Information For Patients And The Public; Understand How Ai Works And Its Limitations;			
Competency Model Approach to AI Literacy: Research-Based Path From Initial Framework to Model	Faruqe, F. And Watkins, R. And Medsker, L.	Ai Literacy; Recognizing Ai -Distinguish Between Technological Artifacts That Use And Do Not Use Ai; Understanding Intelligence -Critically Analyze And Discuss Features That Make An Entity "Intelligent", Including Discussing Differences Between Human, Animal, And Machine Intelligence; Ethics -Identify And Describe Different Perspectives On The Key Ethical Issues Surrounding Ai (I.E. Privacy, Employment, Misinformation, The Singularity, Ethical Decision Making, Diversity, Bias, Transparency, Accountability; Programmability – Understand That Agents Are Programmable."; Knowledge Of Ai And How To Use Ai Systems In	Q	Mentions various sectors but focuses on the educational sector and its role in preparing students and workers for AI literacy	NA

		Hybrid (I.E., Human-Machine) Teams;			
Interdisciplinary and Transferable Concepts in Bioinformatics Education: Observations and Approaches From a UK MSc Course	Johnston, I.G. And Slater, M. And Cazier, J.-B.	Basic Familiarity With Command-Line Tools For Operating Systems Usage; Data Curation And Organisation; Fundamentals Of Programming In Python Including Loops, Conditionals, And Functions; Fundamentals And Data Structures In R; Primer On Version Control With Git; Collaboration; Communication; Ethuiics;	Q	MSc students amd future professionals in bioinformatics	UK
The Scope of Human Resource Development: Both an Academic Discipline and Professional Practice	Yorks, L. And Abel, A.L. And Rotatori, D.	Soft Skills; Analytical Decision-Making Skills;	R	Medical professionals in general and physicians	NA
Identity Threats as a Reason for Resistance to Artificial Intelligence: Survey Study With Medical Students and Professionals	Jussupow, E. And Spohrer, K. And Heinzl, A.	Lifelong Learning; Ability To Navigate Uncertainty; Cognitive Agility;	Q	HRD (Human Resource Development)	NA
Machine Learning and Artificial Intelligence in Healthcare Systems: Tools and Techniques	Shaikh, T.A. And Hakak, S. And Rasool, T. And Wasid, M.	Effective Understanding, Application, And Amalgamation;	R	Healthcare professionals, researchers, and students of industrial engineering, systems engineering, biomedical, computer science, electronics, and communications engineering.	NA
Audiovisual media in the universities of Russia: typology and analysis of the content	Urazova, S.L. And Gromova, E.B. And Kuzmenkova, К.Е. And Mitkovskaya, Y.P.		J	ournalists, editors, PR-managers and marketers	Russia
Self-Adaptive Feedback E-Learning Scheme for Elementary Math in Kuwait	Al-Anzi, F.S.	Arithmetic Skills;	Q	Educators	Kwait
Doing more with less: Using AI-based Big Interview to combine exam preparation and interview practice	Fulk, H.K. And Dent, H.L. And Kapakos, W.A. And White, B.J.	Job Interview Skills;	Q		NA
Machine Learning, Artificial Intelligence and the Future of Work: Impact on HR, Learning and Development Professionals	Kyriakidou, N. And Trem, K. And Ogbemudia, J. And Mahtab, N.	Hr Management;	Q	HR managers	UK

A GAME-BASED APPROACH TO DEVELOP ENGINEERING STUDENTS' AWARENESS ABOUT ARTIFICIAL INTELLIGENCE ETHICAL CHALLENGES	Hardebolle, C. And Kovacs, H. And Simkova, E. And Pinazza, A. And Di Vincenzo, M.C. And Jermann, P. And Tormey, R. And Dehler Zufferey, J. And Jarvinen H.-M. And Silvestre S. And Llorens A. And Nagy B.V.	Critical Thinking Skills; Problem-Solving Skills;	Q	engineers	NA
The Role of AI in the Education and for the Education	Pesek, I. And Nosovic, N. And Krasna, M.	Social Skills;	Q	educators	NA
A SYSTEMATIC REVIEW OF RESEARCH ON THE USE OF ARTIFICIAL INTELLIGENCE IN ENGLISH LANGUAGE TEACHING AND LEARNING (2015-2021): WHAT ARE THE CURRENT EFFECTS?	Sharadgah, T.A. And Sa'Di, R.A.	Language Skills; Translation Skills; Listnening Skills; Grammar Skills; Writing Skills;	Q	educators	NA
Challenges of Radiology education in the era of artificial intelligence	Gorospe-Sarasúa, L. And Muñoz-Olmedo, J.M. And Sendra-Portero, F. And De Luis-García, R.	Interpretive Skills; Clinical Skills; Communication Skills;	R	Radiologists	Spain
Seven principles to ensure future-ready accounting graduates – a model for future research and practice	De Villiers, R.	Accounting Gradutes Skills; Business Skils; Technological Skills; Hard And Soft Skills; Organizational Skills; Communication And Interpersonal Skills; Problem-Solving Skills;	N	accounts	NA
Fostering design thinking in transdisciplinary engineering education	Kuo, J.-Y. And Song, X.T. And Chen, C.-H. And Patel, C.D. And Newnes L. And Lattanzio S. And Moser B.R. And Moser B.R. And Josip S. And Wognum N.	Engineering Education; Esign Thinking Skills;	Q	Engineers	NA
Artificial intelligence as augmenting automation: Implications for employment	Tschang, F.T. And Almirall, E.	Cognitive Skills; Creativity ; Synthesis; Sensemaking;	C	Sectors: Manufacturing, Human Health; Occupations: Radiologists, Programmers, Data Scientists	NA, examples from UK
Ethics and standards in the use of artificial intelligence in medicine on behalf of the Royal Australian and New Zealand College of Radiologists	Kenny, L.M. And Nevin, M. And Fitzpatrick, K.		R	Clinical Radiologists, Radiation Oncologists	Australia, New Zealand
Project-based learning for scaffolding data scientists' skills	Martinez-Plumed, F. And Hernandez-Orallo, J.	Curiosity; Innovation; Autonomy; Teamwork; Resourcefulness; Proactivity; Abstract	N	Data scientists	NA

		Thinking; Formative And Non-Punitive Assessment; Critical Thinking; Communication; Leading A Team			
Agriculture 4.0: Is sub-Saharan Africa ready?	Jellason, N.P. And Robinson, E.J.Z. And Ogbaga, C.C.	Ict Skills; Data Management; Operating Sophisticated Technologies; Collect And Manage The High Volume Of Data Used To Improve Decision-Making ;	A	Farmers	Sub-Saharan Africa
Learning to work in a materials recovery facility: Can humans and machines learn from each other?	Kyriacou, H. And Ramakrishnan, A. And Whitehill, J.	Cognitive Skills; Perceptual Skills; Motor Skills;	E	Workers in Materials Recovery Facilities (MRFs)	NA
How to design a competence-oriented study program for data scientists?	Sedelmaier, Y. And Landes, D. And Erculei, E. And Klinger T. And Kollmitzer C. And Pester A.	Mathematics; Machine Learning; Ai; Statistics; Databases; Optimization, Along With A Deep Understanding Of The Craft Of Problem Formulation To Engineer Effective Solutions; Understand Digital Technologies Of The Future Technology; Think In A Process-Oriented Way; Ask Meaningful Questions / Question Things; Understand Digital Future Competences -- Ethical Implications; Deal With Technologies Responsibly	N	Data scientists	NA
Use of artificial intelligence and virtual reality within clinical simulation for nursing pain education: A scoping review	Harmon, J. And Pitt, V. And Summons, P. And Inder, K.J.	Communication; Clinical Skills; Clinical Reasoning Skills; Teamwork; Decision-Making;	R	Nurses	NA
High-level strategy for implementing artificial intelligence at the Saudi Commission for Health Specialties	Housawi, A. And Alsaywid, B. And Lytras, M.D. And Apostolaki, A. And Tolah, A.W. And Abuzenada, M. And Almehda, M.H.		R	Healthcare professionals, Trainees	Saudi Arabia

Smart Customer Experience of ESG Education Capability Building Roadmap for Smart Consulting, Reporting and Engaging for Carbon Peak and Carbon Neutrality Goals	Zhou, X. And Pan, C.-L. And Feng, Y. And Bu, M.		R	ESG consultants, Business managers, Accountants	China
Review and Outlook of Data Visualization Literacy	Huo, C. And Lu, X.				
3D animation and virtual reality integrated cognitive computing for teaching and learning in higher education	Kumar, A. And Dey, R. And Rao, G.M. And Pitchai, S. And Vengatesan, K. And Kumar, V.D.A. And Hemanth D.J. And Elhosney M. And Nguyen T.N. And Lakshmanan S.		Q	Undergraduate and postgraduate students	India
Survey of Resources for Introducing Machine Learning in K-12 Context	Sanusi, I.T. And Oyelere, S.S. And Agbo, F.J. And Suhonen, J.	Foundational Skills; Building Useful Mental Models; Understanding Ai Concepts; Programming;	Q	Educators	NA
Teaching AI Ethics to Engineering Students: Reflections on Syllabus Design and Teaching Methods	Tuovinen, L. And Rohunen, A. And Koskinen J. And Rantanen M.M. And Tuikka A.-M. And Knaapi-Junnila S. And Knaapi-Junnila S.		N	Engineering students	NA
An Intelligent Assessment System of Teaching Competency for Pre-service Teachers Based on AHP-BP Method	Zhang, J. And Shi, J. And Liu, X. And Zhou, Y.		Q	Teachers, pre-service teachers	China
Using Artificial Intelligence (AI)-interfaced robotic toys in early childhood settings: a case for children's inquiry literacy	Kewalramani, S. And Kidman, G. And Palaiologou, I.		Q	Early Childhood Educators	Australia
Developing a medical artificial intelligence course for high school students	Huang, C.-J. And Wu, T. And Lu, J.-T. And Lin, B. And Chang, D. And Wang, P. And Wang, M.-C. And Lee, P. And Wang, W. And Chang R.-F.		R	High school students	Taiwan
Learning Methods Based on Artificial Intelligence in Educating Engineers for the New Jobs of the 5th Industrial Revolution	Modran, H.A. And Ursutiu, D. And Samoila, C. And Chamunorwa, T. And Auer M.E. And Rüütmann T.		N	Engineers, Engineering students	NA
Gender Differences in Cognitive Load when Applying Game Based Learning with Intelligent Robots	Chen, B. And Hwang, G.-H. And Wang, S.-H.		Q	Elementary School Teachers	Taiwan
Scientific discovery in the age of artificial intelligence	Wang, Hanchen And Fu, Tianfan And Du, Yuanqi And Gao, Wenhao And Huang, Kexin And Liu, Ziming And Ch And Ak, Payal And Liu, Shengchao And Van		N	Scientists	NA

	Katwyk, Peter And Deac, Andreea And Others				
Comparative analysis of professions in the field of artificial intelligence based on the competence approach	Gurtov, Va And Pitukhin, Ea And Shchegoleva, Lv				
The impact of artificial intelligence on skills at work in Denmark	Holm, Jacob Rub{\Ae}K And Lorenz, Edward		U	NA	Denmark
Artificial intelligence in Germany: employees often unaware they are working with AI-based systems.	Giering, Oliver And Fedorets, Alexandra And Adriaans, Jule And Kirchner, Stefan		U	NA	Germany
Generative AI in the European social sector.	Na				
Home-Tutoring Services Assisted with Technology: Investigating the Role of Artificial Intelligence Using a Randomized Field Experiment.	Kim, Jun Hyung And Kim, Minki And Kwak, Do Won And Lee, Sol		T	Service Employees (Tutors)	South Korea
Insights of Big Data Analytics in Education-Challenges & Opportunities: A Review Paper.	Manocha, Sanjay And Saini, Pankaj		Q	None	NA
The Ethical Implications of Artificial Intelligence (AI) For Meaningful Work.	Bankins, Sarah And Formosa, Paul		U	None	NA
A policy primer and roadmap on AI worker surveillance and productivity scoring tools.	Hickok, Merve And Maslej, Nestor		U	None	NA
Implementing artificial intelligence education for middle school technology education in Republic of Korea.	Park, Woongbin And Kwon, Hyuksoo		U	None	Republic of Korea
Artificial Intelligence, Computational Simulations, and Extended Reality in Cardiovascular Interventions.	Samant, Saurabhi And Bakhos, Jules Joel And Wu, Wei And Zhao, Shijia And Kassab, Ghassan S And Khan, Behram And Panagopoulos, Anastasios And Makadia, Janaki And Oguz, Usama M And Banga, Akshat And Fayaz, Muhammad And Glass, William And Chiastra, Claudio And Burzotta, Francesco And Ladisa, John F Jr And Iaizzo, Paul And Murasato, Yoshinobu And Dubini, Gabriele And Migliavacca, Francesco And Mickley, Timothy And Bicek, Andrew And Fontana, Jason And West, Nick E J And Mortier, Peter And Boyers, Pamela J And Gold, Jeffrey P And Anderson, Daniel R And Tcheng, James E		R	NA	NA

	And Windle, John R And Samady, Habib And Jaffer, Farouc A And Desai, Nihar R And Lansky, Alex And Ra And Mena-Hurtado, Carlos And Abbott, Dawn And Brilakis, Emmanouil S And Lassen, Jens Flensted And Louvard, Yves And Stankovic, Goran And Serruys, Patrick W And Velazquez, Eric And Elias, Pierre And Bhatt, Deepak L And Dangas, George And Chatzizisis, Yiannis S				
A smarter perspective: Learning with and from AI-cases.	Ossa, Laura Arbelaez And Rost, Michael And Lorenzini, Giorgia And Shaw, David M And Elger, Bernice Simone		R	Healthcare professionals	
Artificial Intelligence-Based Assessment in Education (book chapter)	Fang, Ying And Roscoe, Rod D. And Mcnamara, Danielle S.		Q	teachers and instructors	
Integrating Data Science and the Internet of Things Into Science, Technology, Engineering, Arts, and Mathematics Education Through the Use of New and Emerging Technologies	Liston, M. And Morrin, A.M. And Furlong, T. And Griffin, L.		Q	elementary school teachers	Ireland
Effect of Immersive Virtual Reality on Post-Baccalaureate Nursing Students' In-Dwelling Urinary Catheter Skill and Learning Satisfaction	Chang, C.-L.		R	Nursing	Taiwan
To Tend or to Subdue? Technology, Artificial Intelligence, and the Catholic Ecotheological Tradition	Labrecque, C.A.		T	Religion (Catholic)	
Digital Fit Workforce is the Enabler to Digital Transformation	Al Ameri, W.S. And Kohinoor, S. And Al Awadhi, K.		O	human resource managment	UAE
The Fourth Industrial Revolution (4IR) in the Heart of the SDG Agenda: The Role of Education in Zimbabwe	Yingi, E. And Hlungwani, P.M. And Nyagadza, B.		Q	General education	Zimbabwe
Exploring the Effectiveness and Moderators of Artificial Intelligence in the Classroom: A Meta-Analysis	Lin, R. And Zhang, Q. And Xi, L. And Chu, J.		Q	General education	
Evolution of data science and its education in iSchools: An impressionistic study using curriculum analysis	Urs, S. And Minhaj, M.		Q	Higher education	Worldwide (iSchools)
A Study on Artificial Intelligence for Economic Renaissance in India	Rao, M.S. And Podile, V. And Navvula, D. And Samishetti, B.		O	Government Stratgy	India

Interest in technology among medical students early in their clinical experience	Avidan, A. And Weissman, C. And Zisk-Rony, R.Y.		R	Medicine	Israel
Research on the Requirements of Artificial Intelligence on Applied Talents Cultivation	Liu, W.				
Study on the Application of Artificial Intelligence Technology in Empowering Education Taking "Intelligent Learning Partner" as an Example	Li, X. And Ma, Z. And Tu, Y. And Du, Y.S.				
Trends, impacts, and prospects for implementing artificial intelligence technologies in the energy industry: The implication of open innovation	Dudnik, O. And Vasiljeva, M. And Kuznetsov, N. And Podzorova, M. And Nikolaeva, I. And Vatutina, L. And Khomenko, E. And Ivleva, M.				
Smart University and Artificial Intelligence	Mohanach And Ran, D.K. And Yap, C.T. And Ismaili, Z. And Govindarajo, N.S.				
Smart Pedagogical Knowledge Management Model for Higher Education	Chergui, M. And Chakir, A. And Mansouri, H. And Sayouti, A. And M.B., Ahmed And D., Santos And A.A., Boudhir And I.R., Karas And O., Sergeyeva				Marocco
AI: Potential Benefits and Concerns for Libraries.	Breeding, Marshall				
TEACHING DIGITAL LITERACY IN THE CONTEXT OF AI TEXT-TO-ART GENERATORS.	Dixon, Neil				
Use of generative artificial intelligence in the training of journalists: challenges, uses and training proposal.	Lopezosa, Carlos And Codina, Lluís And Pont-Sorribes, Carles And Vállez, Mari		J	Journalism	Latin America
Business students' perceptions of Dutch higher educational institutions in preparing them for artificial intelligence work environments.	Hanna Rahma Abdelwahab, Abdul Rauf And Dadi Chen		O	business students	The Netherlands
Artificial intelligence and jobs: Evidence from online vacancies. Journal of Labor Economics	Daron Acemoglu, David Autor, Jonathon Hazell, Pascual Restrepo				US
The demand for AI skills in the labor market.	Alekseeva L., Azar J., Giné M., Samila S., And Taska B.		U	many sectors - jobs that demanded at least one AI related skill	US
Evaluation of the trends in jobs and skill-sets using data analytics: A case study.	Alibasic A., Upadhyay H., Simsekler M.C.E., Kurfess T., Woon W. L. And Omar M. A.		D		
Skills requirements across task-content groups in Poland: What online job offers tell us. Technological Forecasting and Social Change	Arendt L., Galecka-Burdziak E., Nunez F., Pater R. And Usabiaga C.		U	many sectors	Poland

The digital skills divide: Evidence from the European tourism industry.	Carlisle S., Ivanov S. And Dijkmans C.		I	TOURISM general	8 European countries (UK, Italy, Ireland, Spain, Hungary, Germany, the Netherlands and Bulgaria).
Skill sets and wage premium: A network analysis based on Chinese agriculture online job offers.	Min D., Yali H., Binzhe Z., Chi C., Yufan S., Yingzi L., Tao T.			-	-
Fine-grained extraction and classification of skill requirements in German-speaking job ads.	Gnehm A., Buhlman E. And Buchs H.		U		German speaking ADs
The short-term effects of generative artificial intelligence on employment: Evidence from an online labor market	Hui X., Reshef O. And Zhou Luofeng				
What skills pay more? The changing demand and return to skills for professional workers.	Josten C., Krause H., Lordan G., Yeung B.				
Why Learn This? Visualizing Pathways between CS Course Topics and Careers	Levine S. And Bourgeois A.		Q	computer studies students	US
Enhancing skills demand understanding through job ad segmentation using NLP and clustering techniques	Mantas Lukauskas 1,* , Viktorija Šarkauskaite˙ 2 , Vaida Pilinkiene˙ 3 , Alina Stundžiene˙ 3 , Andrius Grybauskas 3 And Jurgita Bruneckiene˙ 3				Lithuania
Uncovering the skillsets required in computer science jobs using social network analysis	*Mehrdad Maghsoudi1*		K		Iran/Middle East
Unravelling the skills of data scientists: A text mining analysis of Dutch university master programs in data science and artificial intelligence.	Mathijs J. Mol1, Barbara Belfi2, Zsuzsa Bakkid		Q		Netherlands
Mapping business analytics skillsets with industries: Empirical evidence from online job advertisements	Qin, H., Koong, K., Wen, H., & Liu, L.		K	business analytics	US
An investigation of skill requirements in artificial intelligence and machine learning job advertisements.	Amit Verma, Pratibha Purohit, Timothy Thornton, And Kamal Lamsalty		K	AR/VR	US
An examination of skill requirements for augmented reality and virtual reality job advertisements	Amit Verma, Kamal Lamsal, And Payal Verma		K	AI and machine learing	US
Economics of chatgpt: A labor market view on the occupational impact of artificial intelligence	Ali Zarifhonarvar				

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4. Sectors for AI Enhancement

Five sector reports are developed as part of the analysis. These sectors are defined using the Eurostat NACE2 framework for classifying economic activities. The five sectors selected include (1) Professional, Scientific and Technical Activities; (2) Wholesale and Retail Trade; (3) Human Health and Social Work; (4) Education; (5) Accommodation and Food Services. The five sector reports are intended to be stand alone reports, developed using a mixed research methods approach which is part literature review, part data review, and part skills survey.

The multilingual 'Future Occupations and Skills Survey' (See Appendix) received a total of 965 responses from across 13 countries, Unlike other AI related surveys that look at labour market disruption and displacement, the objective of the survey was to identify occupations and skills that can be enhanced by AI. The survey aimed to sample both educators (supply side) and employers (demand side) on the skills that are currently required or provided in their respective domains. As such, the respondents needed to ensure they had sufficient organizational knowledge to address the questions meaningfully.

The geographic dispersion of the respondents is provided in the form of a map, covering the locations indicated by respondents.

Figure 2: Geographic dispersion of the respondents

While the survey asked respondents several questions, two questions were most relevant to the development of answers that are summarised in the following sector reports. These were:

- **Question 5:** Which skills do you think will support the uptake of artificial intelligence (AI) and AI related tools in the workplace?
- **Question 6:** What is an occupation in your organisation which could be enhanced by AI and AI related tools?

Finally, to identify the most relevant geographic regions, we analyse the responses based on location. As such, AI adoption should be a focus within these sectors.

4.1. Professional, Scientific and Technical Activities

Table 5: NACE2 Professions - Group M

Group M - NACE2 Code	PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES
69.2	Accounting, bookkeeping and auditing activities; tax consultancy
73.1	Advertising
73.2	Market research and public opinion polling

4.1.1. Sector Overview

The story for this industrial sector is the loss of low-skill jobs and the enhancement of higher-valued skills.

In general high-skill labourers, especially analytical workers with advanced degrees, frequently see their compensation grow as they take on tasks that complement AI and automation. These labourers "work on machines" instead of "working for machines," which raises their productivity, elevates their value and lifts their wages. While workers with lower skill levels suffer head-to-head competition with machines, as their work is easily automated. Their wage growth is similarly limited and they are more likely to be displaced. A systematic review notes that automation's impact on traditional bookkeeping and data entry processes is transformative, ushering in an era where machines seamlessly handle mundane tasks, allowing accountants to shift their focus to more strategic responsibilities.

The future of Jobs report Page 6: The (world wide) largest losses are expected in administrative roles and in traditional security, factory and commerce roles. Surveyed organizations predict 26 million fewer jobs by 2027 in Record-Keeping and Administrative roles, including Cashiers and Ticket Clerks; Data Entry, Accounting, Bookkeeping and Payroll Clerks; and Administrative and Executive Secretaries, driven mainly by digitalization and automation.

However, there are mixed signals and global differences in demand In the US the employment of accountants and auditors is projected to grow 4 percent from 2022 to 2032, about as fast as the average for all occupations. Eurostat reported in a Business Survey (Data extracted in March 2023) that the professional, scientific and technical activity sector accounted for 19.2 % of the total number of enterprises in the EU in 2020. The sector also accounted for 8.8 % of the total number of persons employed.

The sector can be divided into seven sub sectors at the NACE division level. Among these, according to the data available for 2020, there were big differences in their contribution to value added and employment. Three subsectors, namely legal and accounting activities (Division 69), activities of head offices; management consultancy activities (Division 70) and architectural and engineering activities; technical testing and analysis (Division 71) provided in total almost 80 % of EU sectoral value added and around 75 % of its employment in 2020. Veterinary activities (Division 75) was the smallest sector in both value added and employment terms, with 1.6 % and 2.0 % respectively.

Within the EU, the **lowest levels of apparent labour productivity** among the sub sectors were recorded for other professional, scientific and technical services (€36 400 per person employed), the veterinary activities (€41 100 per person employed) and **advertising and market research** (€44 400 per person employed).

There are documented concerns around automation, with disagreements about how AI will affect the accounting profession, such as financial accountants, management accountants, and auditors. They worry that AI could make their jobs useless, but others think technology could help improve the accounting business.

The focus on responsible AI adoption and ethical practices will intensify, driven by regulatory scrutiny, consumer awareness, and stakeholder expectations. Organizations must prioritize fairness, transparency, and accountability in AI-driven accounting processes. Industry will have a significant impact from enforcing the AI Act: Fines of up to 6% of global turnover will apply to infringements. Compliance with the new requirements will be challenging because of the difficulty of determining what software will be treated as an 'artificial intelligence system' subject to these requirements and which entities within a financial sector group will be subject to obligations under the AI Act, especially given its extraterritorial application.

AI regulation may impose compliance costs, administrative burdens, and legal uncertainty on businesses and developers. Extensive testing, validation, and monitoring of AI systems may become necessary, which can be time-consuming and expensive. There might also be limitations on the types of applications, industries, data, or algorithms used in AI systems.

Accountants use AI to automate mundane tasks that are essential to day-to-day operations.
AI-driven automation improves data accuracy and integrity by eliminating discrepancies and inconsistencies in financial data. Machine learning algorithms can detect anomalies, reconcile differences, and validate data integrity across multiple sources. This enhanced data accuracy enables organizations to produce reliable financial reporting. Zones of efficiency include:

- Invoicing and account reconciliation
- Cash flow reporting and forecasting
- Budgeting and bookkeeping
- Document management and audit support
- Tax research and preparation
- Compliance

A survey (May 3-15, 2023, and 771 tax professionals) found that 1 in 10 1 10 accounting and tax professionals currently use ChatGPT/generative AI or plan to integrate these technologies into their operations. Tax professionals' main objection to using the current version of ChatGPT is that while it may be helpful for basic tax research, it tends to struggle with more complex tax questions.

Robotic Process Automation (RPA) emerged as a complementary technology to AI in accounting. RPA solutions utilize software robots or "bots" to automate repetitive tasks, such as data entry, reconciliation, and report generation. RPA streamlines accounting processes by mimicking human actions, interacting with multiple systems, and executing tasks quickly and accurately. The combination of AI and RPA has led to the end automation of accounting workflows, improving efficiency and reducing manual error.

Skill Gap and Training Needs: Implementing AI in accounting requires specialized skills, knowledge, and training for finance professionals. There may be a skill gap in understanding AI algorithms, data analytics, and machine learning techniques. Organizations should invest in training programs, upskilling initiatives, and knowledge sharing to

empower finance teams with AI literacy and technical expertise. Collaborating with AI experts, data scientists, and training providers can bridge the skill gap and facilitate smooth AI adoption.

Areas of focus mentioned include:

- Data Security and Privacy Concerns
- Ethical Use of AI Algorithms:
- Integration with Legacy Systems
- Regulatory Compliance and Auditing
- Cost and ROI Considerations
- Change Management and Organizational Culture

Researchers are concerned about the validity of curriculums, noting that the accounting academy has to 'take education back from the market' and provide the impetus to make accounting education more relevant to our students and the needs of contemporary society. We may now be at a cliff edge that cannot be avoided or defeated by 'looking the other way'. Doing nothing and hoping for a return to 'situation normal' is unlikely to work this time! The area of improvement: The researchers note that it is essential that accounting educators take on the difficult challenge of developing AE that moves students (further) to recognise the reality of ambiguity and the importance of judgement in the accounting field, particularly as AI will continue to automate even more of the practice of accounting.

A thorough literature review notes six main areas for potential inclusion of data analytics themes:

- New role and expectations for management accountants
- Cost management
- Capital budgeting
- Planning and control
- Variance analysis
- Managing risk and uncertainty

Similar patterns emerge for marketing. In the digital age, integrating Artificial Intelligence (AI) into marketing technologies (martech) has become pivotal for businesses aiming to remain competitive. Big data presents substantial opportunities for personalized marketing campaigns. Still, its practical implementation requires careful consideration of ethical implications, investment in technological infrastructure, and ongoing skill development. Again, we see that chatbots are dominant. In contemporary marketing strategies, AI-powered chatbots and virtual assistants are crucial in elevating the experience for target customers.

AI empowers marketers with tools that drive efficiency, enhance personalization, and facilitate data-driven decision-making, ultimately improving marketing performance and return on investment.

Themes include:

- Data Driven Decision Making
- Enhancing Customer Experience
- Improving Personalization
- Streamlining Marketing Operations

The ethical application of data is a struggle. AI relies heavily on consumer data in marketing so ensuring privacy and obtaining explicit consent is paramount.

Future trends will emphasise the importance of transparent data collection practices, clear communication regarding data use, and robust privacy measures. Ethical marketing practices will be crucial for maintaining trust and complying with evolving data protection regulations. Emerging technologies like Augmented Reality (AR), Virtual Reality (VR), voice search optimization, and blockchain integration will shape the future landscape.

The Most popular AI/Machine Learning applications already used by media professionals are:

- Image/video analysis (44% of responses)
- NLP (44% of responses)
- Audio analysis (35% of responses)
- User experience/audience analysis (31% of responses)

Given all the technologies possible and software options deployed within the industry, the successful use of cutting-edge technologies in teaching and learning processes primarily depends on the ability of all participants in educational communication to access technological equipment and the digital skills of the educators themselves.

The impact of artificial intelligence on customer engagement and advertising engagement: The marketing landscape is poised to witness a profound AI impact characterized by more sophisticated search algorithms, intelligent advertisement placements, enhanced content delivery mechanisms, extensive utilization of chatbots, robust fraud detection and data security measures, image and voice recognition technologies, predictive customer service enhancements, and precise customer segmentation strategies.

However, we should be concerned about the adoption of safety rails by enterprises. In the media professionals survey:

- Almost 39% of all survey respondents declared either that their organisation doesn't have specific ethical measures in place or that they do not know if it has.
- Only 11% of AI researchers and 4% of media professionals has ever done some kind of impact assessment like DPIA, HRIA, or ALTAI.

For a complete overview of the current trends in AI marketing, please read. AI-powered marketing: What, where, and how?

4.1.2. Regional Analysis

As part of the Future Skills and Occupations Survey, we identified key regions at the NUTS 2 level where skills focused on professional, scientific and technical skills are required. In Table 6., the percentage of people employed in that sector as part of the total workforce is shown.

Table 6: Regions identified for sectoral emphasis

Country	Region	% Employed
Austria	Oberösterreich	4.8
Austria	Wien	9.3

Croatia	Grad Zagreb	8.8
Germany	Oberbayern	8.7
Greece	Attiki	8.7
Ireland	Eastern and Midland	7.7
Slovenia	Vzhodna Slovenija	5.2
Slovenia	Zahodna Slovenija	8.0
Spain	Comunidad de Madrid	8.5

The identified regions have a relatively similar employment statistic.

4.1.3. Final Comments

AI is making significant headway. The story for this industrial sector is the loss of low-skill jobs and the enhancement of higher-valued skills. We should follow the impact of the AI Act and the skills needed to comply within an enterprise. The authors of this document expect a crunch moment when the AI Act meets current industrial practices.

Several researchers are concerned with the current training options, including the validity of formal training, especially around accountancy, access to software licences, infrastructure and trained teachers.

4.2. Wholesale and Retail Trade

Table 7:NACE2 Professions - Group G

G	WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES
46.4	Wholesale of household goods
47.1	Retail sale in non-specialised stores

4.2.1. Sector Overview

The sectoral report focuses primarily on Wholesale of household goods and Retail sale in non-specialised stores. Eurosat noted in their Business Report for 2021 that the distributive trade sector generated a net turnover of €9.9 trillion across the EU in 2021, representing 30.5 % of the EU's business economy net turnover. The distributive sector accounted for almost a fifth of the total number of persons employed in the EU in 2021.

Most distributive trade (Section G) enterprises serve a local market and consequently this sector is characterised by a large number of enterprises: in total almost 5.9 million enterprises were classified to this sector in the EU in 2021, making it the largest enterprise population among any of the NACE sections within the business economy.

More than half (57.2 %) of the enterprises within the EU's distributive trades sector in 2021 were in the retail trade subsector (Division 47); most of the remainder were in the wholesale trade subsector (Division 46) with 28.0 %, while the motor trades and repair subsector (Division 45) had the smallest share (14.8 %) of the enterprise population within the distributive trades sector.

AI services in the retail sector are predicted to increase from $5 billion to above $31 billion by 2028. AI is rapidly becoming multimodal, with audio, video, drawings, and text inputs rapidly deployed in a competitive commercial market as mainstream options. The relationship between humans and Robots is becoming more intimate and intuitive to program. The impact is that there are significant concerns due to the reduction in net employment from the deployment of such technologies. It is the combination of AI with robotics that minimises the demand for certain employment categories. The World Economic Forum notes that The retail sector has been making ground in the adoption of automation with the use of self checkouts in stores, and robots and AI in supply chains. This is largely due to rising costs and wages, tight labour markets and reduced consumer spending, industry experts say. They estimate the sector is already 40% automated, but this could jump to 60-65% over the next three to four years. The renewed focus on automation is providing opportunities for logistics groups, robotics firms, as well as retailers.

One of the central challenges in this sector is the generalisability of training opportunities outside the sphere of influence of proprietary software vendors.

4.2.3. Regional Analysis

As part of the Future Skills and Occupations Survey, we identified key regions at the NUTS 2 level where skills focused on wholesale and retail trade are required. In Table 4.2.2, the percentage of people employed in that sector as part of the total workforce is shown.

Table 8: Regions identified for sectoral emphasis

Country	Region	% Employed

Austria	Kärnten	21.0
Austria	Tirol	24.8
Germany	Niederbayern	17.5
Greece	Dytiki Elláda	24.2
Greece	Attiki	24.4
Italy	Campania	24.6
Slovenia	Zahodna Slovenija	18.5
Spain	Andalucía	27.8
Spain	Comunidad de Madrid	23.0
Turkey	Kırıkkale, Aksaray, Niğde, Nevşehir, Kırşehir	17.3

4.1.4. Final Comments

Wholesale and Retail trade as a component of overall GDP, is one of the most important sectors across all EU states. While we have highlighted key regions that should focus on supporting AI adoption into wholesale and retail trade, however, these recommendations are applicable to all regions equally.

An important component in particular for wholesale and retail trade is it's relationship with the VET sector in upskilling employees and ensuring that they are up to speed with the latest opportunities to implement AI in the workplace. As such, there is a strong demand for basic and intermediate data literacy skills within this sector.

4.3. Human Health and Social Work

Q	HUMAN HEALTH AND SOCIAL WORK ACTIVITIES
86.1	Hospital activities
86.2	Medical and dental practice activities

4.3.1. Sector Overview

The health sector in Europe is the sector most impacted by AI. It has an unusually high clustering of high-risk applications. Legislation will most affect the industry, which has a highly complex set of training requirements for consumers and those providing the services.

In 2021, the number of businesses in the EU's health and social work sector amounted to 2.3 million, representing 7.4% of all the enterprises active in the EU's business economy. The sector generated 6.2 % of the EU's value added (€579 billion). The health sector and social work are at the forefront of AI implementation. The Stanford University's Artificial Intelligence Index Report noted that In 2022, the AI focus area with the most investment was medical and healthcare ($6.1 billion), followed by data management, processing, and cloud ($5.9 billion) and Fintech ($5.5 billion).

Technology is advancing rapidly: A recent European report on healthcare identified four key expanding areas of Artificial Intelligence applications in Medicine, Healthcare and Wellbeing comprising AI tools for mental health, AI-mediated gene editing, AI tools for epidemiology and health data monitoring, and AI-mediated neurotechnologies. The WHO Global Strategy on Digital Health 2020–2025 classifies health data as sensitive personal or personally identifiable information, requiring a high standard of safety and security. Therefore, the strategy emphasises the need for a solid legal and regulatory framework to protect personal health data's privacy, confidentiality, integrity, availability and processing.

The AI Act is having a significant impact on the health sector as patient data is confidential. AI decision-making must be explainable, accurate, unbiased across demographics, and fit for purpose. We use medical devices to monitor us or incorporate them into our bodies, and the device embeds AI. The OECD provides guideposts for multinational companies working inside and outside the European Commission to promote interoperability in AI risk management. Within each Industrial sector, specific themes dominate. Both risk management and confidence in AI are particularly crucial for the health industry. The impact of Legislation reflects them.

The statistics on accidents at work suggest a future focus on AI support for stress. During 2021, 3 in 10 (31.2 %) non-fatal accidents at work in the EU took place on industrial sites. During 2021, more than one-quarter (25.7 %) of fatal accidents at work in the EU resulted from losing control of a machine, tool or transport/handling equipment. The most common types of non-fatal accidents at work in the EU resulted from physical or mental stress (23.7 %) or impact with a stationary object (22.7 %).

The following literature review links to many examples of currently deployed mental health applications. The review notes that AI presents potential solutions for improving mental health through personalised interventions, early detection of symptoms, and virtual therapy platforms. Its strength lies in its capacity to rapidly analyse extensive data, providing valuable insights and forecasting potential mental health concerns. AI-powered chatbots and virtual therapists can offer continuous support, reaching a wider demographic at reduced costs, diminishing social stigma,

and enhancing availability. AI as a technology is neither good nor bad in itself. The impact is dependent on the details of the deployment. There are enormous potential and huge risks; the processes associated with the AI Act help measure the risk and focus the necessary attention on high-risk categories. Applications in the health sector tend to be high-risk.

The areas that AI impact include:

- Medical Imaging and Diagnostic Services
- Virtual Patient Care
- Medical Research and Drug Discovery
- Patient Engagement and Compliance
- Rehabilitation of the patient
- Administrative Applications

AI used in healthcare deserves special consideration because personal and public health is at stake, and individuals are vulnerable when needing healthcare. AI especially poses risks to key populations, who may face specific vulnerabilities and multiple layering patterns of inequalities related to age, gender identity, sexual orientation, cultural identity, ethnicity, race, (digital) literacy, disability and (mental) health status, residence status, and who may already face barriers and inequalities in accessing healthcare, potentially increasing health inequities in the European Union (EU).

Researchers noted that while ChatGPT offers numerous opportunities, it also poses certain limitations. LLM responses are based on the data on which it was trained, potentially resulting in biased or inaccurate information. Ethical concerns arise when content generated by AI is mistaken for the expertise of a human.

The WHO recognises the potential of AI in enhancing health outcomes by improving clinical trials, medical diagnosis, treatment, self-management of care and person-centred care, as well as creating more evidence-based knowledge, skills and competence for professionals to support health care.

A lack of confidence among end-users (including healthcare practitioners (HCPs) and patients) in AI-based health technologies is a barrier to adoption. The barrier may be caused by aversion to perceived risk (e.g., trying a new technology), concerns about health data privacy and cyber security, and a lack of analysis of the limitations of the existing standard of care, which are often caused by shortages of skilled staff.

There is a high level of lack of trust. The general population's view on AI in medicine is leaning more toward a higher level of distrust, which is the opposite of positive publications in the mainstream media. The level of trust is dependent on what medical area is subject to scrutiny, demographic characteristics (e.g., male, higher educated, Western background), and whether there is a generally positive view on AI and its efficiency in daily life, which are significantly associated with higher levels of trust in AI in medicine.

Trust is likely associated with the perception of risk. A European Parliament Research report recognises the need for mitigation measures and policy options to minimise risks and maximise the benefits of medical AI, including multi-stakeholder engagement through the AI production lifetime, increased transparency and traceability, in-depth clinical validation of AI tools, and AI training and education for both clinicians and citizens.

A thematic analysis of the key AI principles identified six themes needed for a successful implementation of AI in medical school curricula. These themes include ethics, theory and application, communication, collaboration, quality improvement, and perception and attitude. The themes of ethics, theory and application, and communication were further divided into subthemes, including patient-centric and data-centric ethics; knowledge for practice and knowledge for communication; and communication for clinical decision-making, communication for implementation, and communication for knowledge dissemination.

Since the outing of ChatGPT in November 2022, there has been a resurgence of interest in chatbots and communication through Natural language. Researchers recognise the value of Generative AI in training: "Medical education can benefit significantly from AI-driven tools like ChatGPT. Medical students and professionals can engage with ChatGPT to access quick references, clarify doubts, and explore complex medical concepts. Its ability to explain intricate medical terminology comprehensibly aids in knowledge acquisition, fostering continuous learning and improving medical literacy".

4.3.2. NHS AI Lab

We choose the following case study due to the lab's degree of funding, openness and maturity. The authors of this document note that the quality of the output from the lab is high, and much is reusable within other national cultures.

The NHS, or National Health Service, in the UK, is a publicly funded healthcare system that provides a wide range of health services, including general practitioner (GP), hospital care, dental care, mental health services, and prescriptions. It is primarily funded through taxation and is free at the point of use for patients.

Running for three years (2024), the NHS AI lab's mission is to drive the digital transformation of the NHS and social care. It provides fertile ground to mature the application of AI in the UK's health system.

The AI lab is well funded with a roadmap that includes 86 innovation projects with grants totalling 111 million pounds. An AI diagnostic fund worth 21 million pounds. The lab is currently testing an AI deployment platform and a secure location for data. Advice and reports are also primary outputs. wo examples include a skills framework, and the second relates to the need for healthcare professionals to be confident in using AI.

Example 1: Health Education England (HEE) commissioned the University of Manchester to perform a learning needs analysis and develop a framework outlining the skills and capabilities to ensure our health and care professionals can work in a digitally enhanced environment.

The capabilities in the framework describe the skills and knowledge that the health and social care workforce should be aware of and actively develop depending on their role. The framework consists of 6 primary domains consisting of 11 sub-domains and 195 individual capability statements.

AI was one of the primary domains and includes:

- Artificial Intelligence (AI)
- Machine learning and natural language processing
- Using and implementing AI systems
- Evaluating AI systems

- Robotics

Example 2: Understanding Healthcare Workers' Confidence in Artificial Intelligence - part 1, notes

Healthcare settings adopting artificial intelligence (AI) technologies are at a critical juncture. They are moving through the early stages of AI technology development (from the proof-of-principle to proof-of-efficacy stages) and introducing AI technologies in clinical trials. For the NHS, the main challenges of these rollouts involve considerations around information technology (IT) systems, interoperability, and information governance. The researchers stressed the importance of the healthcare workforce's confidence in adopting and using AI technologies.

The report recommends developing and deploying educational pathways and materials for healthcare professionals at all career points and roles to equip the workforce to evaluate, adopt and use AI confidently. Together, both examples provide the necessary focus to expand into the details of skilling within the health sector.

4.3.3. Regional Analysis

Table 9: Regions identified for sectoral emphasis

Country	Region	% Employed
Austria	Kärnten	12.9
Austria	Oberösterreich	10.8
Austria	Steiermark	10.8
Austria	Tirol	12.1
Austria	Wien	11.9
Germany	Niederbayern	11.7
Germany	Oberbayern	12.3
Greece	Dytiki Elláda	9.7
Ireland	Eastern and Midland	12.8
Spain	Andalucía	9.8

4.3.4. Final Comments

The health sector deploys high-risk AI to support its highly valued customers, you and me. The industry uses AI to make process efficiencies and is generally the spear of impact on society. AI is a co-worker, a second opinion, a filterer of information, a focuser of our attention and a cost-effective method of bringing advice to European Citizens, Doctors, Nurses and patients. Within this context, AI literacy is crucial to society. We must equip healthcare professionals to evaluate, adopt and use AI confidently.

4.3.5. Further Reading

Consider reviewing the publications curated at the following sources:

- NHS AI lab - Understanding AI and all the resources.
- The Observatory of AI in Health aims to know and disseminate transversally on how Artificial Intelligence is generated in the health field.
- OECD Policy observatory
- AI watch, watches the European Commission's knowledge service to monitor the development, uptake, and impact of artificial intelligence (AI) in Europe.

- Psychological Practitioners Digital Competence Framework
- Digital competency framework for Allied Health Professionals (AHPs)
- Supporting Digital Literacy in the Pharmacy Workforce
- Artificial Intelligence (AI) and Digital Healthcare Technologies Capability framework

4.4. Education

P	EDUCATION
85.2	Primary education
85.3	Secondary education
85.4	Higher education

4.4.1. Sector overview

This sectorial report for the Education sector focussed on Primary, Secondary and Higher Education. The report is made more complex because not only is the industry significantly impacted by the implementation of Artificial intelligence. However, the sector trains talent for all industries and is at the forefront of European policy efforts that focus on change.

The Business Survey for Education noted that in 2021, the EU 's education sector (Section P) comprised a total of 855,700 enterprises , which represented 2.8 % of all enterprises active in the business economy (Sections B to N and P to R, as well as Divisions S95 and S96). These enterprises employed 2.4 million persons, generating C 65.2 billion in value added and accumulating a net turnover of C 106.6 billion. The EU's education sector contributed to 1.5 % of the persons employed in the business economy in 2021, and accounted for only 0.7 % of the value added.

The future of jobs report 2023 page 6 notes that Large-scale job growth is expected in education, agriculture and digital commerce and trade. Jobs in the Education industry are expected to grow by about 10%, leading to 3 million additional jobs for Vocational Education Teachers and University and Higher education Teachers world wide.

Vocational Education is the central engine for change. (ISCED 2011) defines vocational programmes as education programmes that are designed for learners to acquire the knowledge, skills and competencies specific to a particular occupation, trade, or class of occupations or trades. Such programmes may have work-based components (e.g. apprenticeships and dual-system education programmes). Successful completion of such programmes leads to vocational qualifications relevant to the labour market and acknowledged as occupationally oriented by the relevant national authorities and/or the labour market."

VET is an important and popular element of most education systems in OECD countries, with on average 44% of upper secondary students enrolled in vocational programmes. These programmes vary considerably from country to country, but there are common features that contribute to high-quality vocational education.

The Educational sector in general and vocational training in specific needs to focus on industrial demand for Artificial Intelligence.There is concern if formal education systems have the capacity to keep up with the pace of change, and which of these skills are best acquired through non-formal and informal learning.

AI research is on the rise, across the board. The total number of AI publications has more than doubled since 2010. The specific AI topics that continue dominating research include pattern recognition, machine learning, and computer vision. With 70% of EU companies reporting lack of adequate digital skills as an obstacle to investment, Europe faces a considerable skills gap. Only one in every two adults in the EU has only basic digital skills.

The future of Jobs report noted that *Page 7:* Employers estimate that 44% of workers' skills will be disrupted in the next five years. Cognitive skills are reported to be growing in importance most quickly, reflecting the increasing importance of complex problem-solving in the workplace. A study carried out by Ipsos for the European Commission, found that 42% of enterprises currently use at least one AI technology, a quarter of them use at least two types, and 18% have plans to adopt AI technologies in the next two years. Three key internal barriers to AI adoption are difficulties in hiring new staff with the right skills (57%), the cost of adoption (52%) and the cost of adapting operational processes (49%)

The European commission has a policy focus and significant concerns associated with digital skills and AI. (European Centre for the Development of Vocational Training. 2023) more than EUR 23 billion from the Recovery and Resilience Facility is available for digital skills and education. The facility aims to create a greener, more digital and resilient European Union via projects to increase the digital literacy of the population and by establishing funds to help learners finance their digital skills development.

The greening of Artificial Intelligence is an inherent contradiction with Artificial Intelligence on one side we have process optimization and discovery of new solutions has the opportunity for a greener world on the other Data shows that deploying generative AI in the same context that large tech companies have been operating until now, is more of a problem than a solution to issues such as climate change, water shortages, and high energy consumption.

However, there is still room for optimism. The future of jobs report (2023) Page 5, states that the fastest-growing roles relative to their size today are driven by technology, digitalization and sustainability. The majority of the fastest growing roles are technology related roles. AI and Machine Learning Specialists top the list of fast-growing jobs, followed by Sustainability Specialists, Business Intelligence Analysts and Information Security Analysts. Renewable Energy Engineers, and Solar Energy Installation and System Engineers are relatively fast-growing roles, as economies shift towards renewable energy.

Industry races ahead of academia. Until 2014, most significant machine learning models were released by academia. Since then, industry has taken over. In 2022, there were 32 significant industry-produced machine learning models compared to just three produced by academia.

Within this complex context the Digital Education Action Plan (2021-2027) is a renewed European Union (EU) policy initiative that sets out a common vision of high-quality, inclusive and accessible digital education in Europe, and aims to support the adaptation of the education and training systems of Member States to the digital age.

Holmes et al. 2022: Recommends that all citizens should be supported and encouraged to achieve a certain level of AI literacy. The details of training are complex as critical thinking, ethics and creativity are central themes. The future of Jobs report noted *Page 7:* Six in 10 workers will require training before 2027, but only half of workers are seen to have access to adequate training opportunities today. The highest priority for skills training from 2023-2027 is analytical thinking, which is set to account for 10% of training initiatives, on average. The second priority for workforce development is to promote creative thinking, which will be the subject of 8% of upskilling initiatives. Training workers to utilize AI and big data ranks third among company skills-training priorities in the next five years and will be prioritized by 42% of surveyed companies.

The knock-on implication of the statistical evidence is that rapidly changing technology is challenging for teachers. They will need to learn new approaches, exhibit the transversal skills necessary to apply the technologies and explain the key concepts to students with the generational advantage of early immersion in those technologies.

For a full analysis and access to datasets from Eurostat visit their statistical theme on Education and training. An observatory for Education is curated by the Higher Education Strategy Associates (HESA). Two sources of educational resources are AI on Demand and AI4K12.

Impact on Education

The Educational process is being impacted by AI, from online learning systems and mobile apps to processes around administration and course content generation.

In general, students want AI, organisations are busy with strategies around AI, and leaders are concerned about falling behind, as well as the risks. Students see opportunities to diminish stress and improve time management.

It is highly likely we have a skills gap in higher management as AI employers demand Managers to be endowed with a broad skill mix encompassing both technical and socio-emotional and foundational skills when working in prospective AI jobs. These technical skills very much mirror the skills demanded by AI talent overall and hence provide evidence that Managers in AI firms need to understand the business as well as the technical side of AI use.

Buy-in of management poses a challenge to the adoption of AI (Makarius, 2020): several experts pointed to the issue of managers understanding the added value of adopting AI technologies and applications. Managers and Leaders within the Educational sector will be even more challenged than teachers as they not only need to understand how the technology affects the process, but they will also need to be able to use the technology to make their work more efficient and, to some extent, pedological design.

Educators and school leaders need to have at least a basic knowledge of AI and data usage in order to be able to engage positively, critically, and ethically with this technology and to properly use it to exploit its full potential.

What is concerning is that logistic practices are impacted before ethical frameworks are in place for those practices within the given organisation.

University affairs notes that students expect AI support tools. Alarmingly, 60 percent of Canadian students believe their universities are not adapting quickly enough to include AI support tools. Similar sentiments are echoed globally, with 55 per cent in Australia and 64 per cent in the U.K. sharing this perception. This trend was reflected across all ages, genders, reported grades, year levels, and domestic or international status.

Students are motivated by stress, time, and money. Canadian students who felt regularly stressed in some way during their degree had the strongest expectations for AI support tools from their university. The biggest reasons for stress were “Not having enough time” and “Paying for my degree/study,”

Students believe their university could be moving faster to adapt to AI technology. The majority (54 per cent) of Canadian students expect their university to offer AI support tools. Notably, students who have been traditionally underrepresented and in some cases who report being under-supported are more likely to expect their university to offer AI support tools. For instance, of students who are also caregivers, 72 percent expect to be provided with AI support tools.

The AI effect notes that Ethical concerns mitigate successful AI adoption in higher education. While only 34 percent of respondents encountered integration difficulties and 31 percent faced budget constraints during implementation, there are distinct challenges to AI adoption within educational institutions. Notably, ethical and reputational concerns are at the forefront of educators' minds, as nearly half of respondents have ethical worries related to fairness, bias, and transparency in AI. What's more, 43% feel uncertain about the rights of students and admins regarding AI-processed data.

Institutions are concerned about falling behind. In the US most institutions are working on AI-related strategies. Only 11% of respondents of an Educause survey said that nobody at their institution is working on AI-related strategy.Institutions are primarily operationalizing these goals by providing training for faculty, staff, and students (56%, 49%, and 39%, respectively). Institutions are concerned about falling behind. Most respondents said that the rise of student use of AI in their courses and the risks of inappropriate use of AI (73% and 68%, respectively) were primary motivators for AI-related strategic planning. The goals of AI-related strategic planning are primarily related to supporting students.

The main goal of AI-related strategies is to prepare students for the future workforce. The three highest-ranking goals of AI-related strategic planning are preparing students for the future workforce, exploring new methods of teaching and learning, and improving higher education for the greater good (selected by 64%, 63%, and 41% of respondents, respectively). Further, most respondents said that their AI-related strategy is somewhat or to a great extent focused on boosting educational experiences and student services (76%).

Leaders are concerned by the risks: The Chronicle asked 404 higher-ed leaders to share their perspectives on generative AI. Their responses were a mixed bag: 78 percent agree that AI offers new ways to improve higher education. 60 percent of leaders think AI poses a threat to higher education. 84 percent of respondents say their institution is worried about AI-powered cheating.

However, in reality AI is seeping into use within the core aspects of the logistics of Education even to the point of dubious practices. College admissions notes that the Majority of schools using AI will allow it to have the final say on a college admission applicant. However, 2 in 3 admissions professionals are concerned about the ethics of AI.

University affairs describes the need for codevelopment with students. This is a good practice, Students are not a unified demographic. For example, broad trends emerge between the genders: Men tend to feel more positively about AI products and services than women. Men are also more likely than women to believe that AI will mostly help rather than harm.

Addressing the AI access divide: As AI becomes increasingly integral to academic research, addressing economic disparities and technical challenges associated with access to AI tools is essential. Providing targeted support and resources, such as free subscriptions to AI tools, can promote equal access and foster an inclusive academic environment.

Engaging students in decisions that affect them: Students are at the forefront of AI usage in academia, making their insights invaluable in shaping AI policies and practices. Encouraging their participation in decision-making processes and integrating AI ethics into the curriculum can foster a sense of responsibility and critical engagement with AI technologies' ethical implications. This process could range from students organising workshops on AI skills to contributing to the institution's policies on AI usage in academics.

Encouraging student involvement in research planning: As students become proficient in leveraging AI tools in their academic work, their active involvement in planning their research becomes critical. Open dialogues about AI's potential benefits, pitfalls, biases, and ethical considerations can foster a sense of ownership, responsibility, and critical engagement in their research journey.

Different competences are needed for teachers, school leaders, IT support personnel and other professionals in education. This can mean varying levels of knowledge, skills and attitudes related to teaching for, with and about AI

Teachers competences need to be based upon students' competences. The proposal is to start with skills students need to achieve in primary, secondary or tertiary levels of education, bearing in mind that students could be both users and developers of artificial intelligence applications. Therefore, a solid place to start defining the skills teachers need is the Digital Competence Framework for Citizens which provides more than 250 new examples of knowledge, skills and attitudes that help citizens engage confidently, critically and safely with digital technologies, and new and emerging ones such as systems driven by artificial intelligence (AI).

The main areas of AI competency for teachers are AI literacy, AI and pedagogy, ethics of AI, the use of AI for continuous professional development, and the ability to foster AI competencies for students. It is important that AI literacy and competencies incorporate both the technological and human dimensions of AI.

However, there are significant differences in competencies for those who will teach about AI (the techniques and the technologies) and those who will just use AI as support for teaching and learning processes, but all teachers need to know what impact AI has on people and have competences to teach for and with AI. All competences need to be described contextually and with existing subject-specific examples.

In summary, much is happening, and there is a gap between demand and supply. A significant degree of training for staff, teachers, and students associated with AI is required to run education and the learning process efficiently. Given the increasing requirements placed on the teacher, student and staff, it is essential that they are supported with opportunities for training, infrastructure and guidelines.

4.4.2. Regional Analysis

Table 10: Regions identified for sectoral emphasis

Country	Region	% Employed
Austria	Wien	8.8
Austria	Steiermark	7.9
Croatia	Grad Zagreb	9.7
Croatia	Sjeverna Hrvatska	7.9
Greece	Attiki	9.0
Ireland	Eastern and Midland	8.1
Italy	Campania	10.3
Slovenia	Vzhodna Slovenija	8.2
Slovenia	Zahodna Slovenija	9.1
Turkey	Gaziantep, Adıyaman, Kilis	7.9

4.4.3. Final Comments

Competency frameworks set boundaries on what we should consistently teach. One such is the European Framework for the Digital Competence of Educators (DigCompEdu). The scientifically sound framework describes what it means for educators to be digitally competent. It provides a general reference frame to support the development of educator-specific digital competencies in Europe. There is also a related framework for Educational organisations

Written by AI pioneers, there is a supplement to DigCompEdu's competencies. The supplement examines the dual challenge of AI as a tool for training and learning and as a subject for learning in VET and adult education. To achieve this, the supplement aligns AI competencies to the six critical areas of the DigCompEdu framework.

4.4.4. Further Reading

Consider reviewing the publications curated at the following sources:

- Holmes, Wayne, Jen Persson, Irene-Angelica Chounta, Barbara Wasson, and Vania Dimitrova. 2022. "Artificial Intelligence and Education. A Critical View Through the Lens of Human Rights, Democracy, and the Rule of Law. Council of Europe."

- *ISCED 2011 Operational Manual*. 2015. OECD. https://doi.org/10.1787/9789264228368-en.
- European Centre for the Development of Vocational Training. 2023. *Going digital means skilling for digital: using big data to track emerging digital skill needs.* LU: Publications Office. https://doi.org/10.2801/772175.

4.5. Accommodation and Food Services

I	ACCOMMODATION AND FOOD SERVICE ACTIVITIES
55	Accommodation
56	Food and beverage service activities

4.5.1. Sector Overview

This sector report captures the activities associated with Tourism. The three industries, viz. tourism, travel, and hospitality, essentially represent enterprises with one common goal: providing necessary and customised *services to travellers*.

A Eurostat Business Report noted that the accommodation and food services sector employed 9.9 million persons, accounting for 6.3 % of the total employment in the EU's business economy in 2021. The accommodation and food services sector accounted for 6.1 % of the total number of enterprises in the EU in 2021. The relative importance of accommodation and food services activities across various EU countries is presented in the following figure from Eurostat.

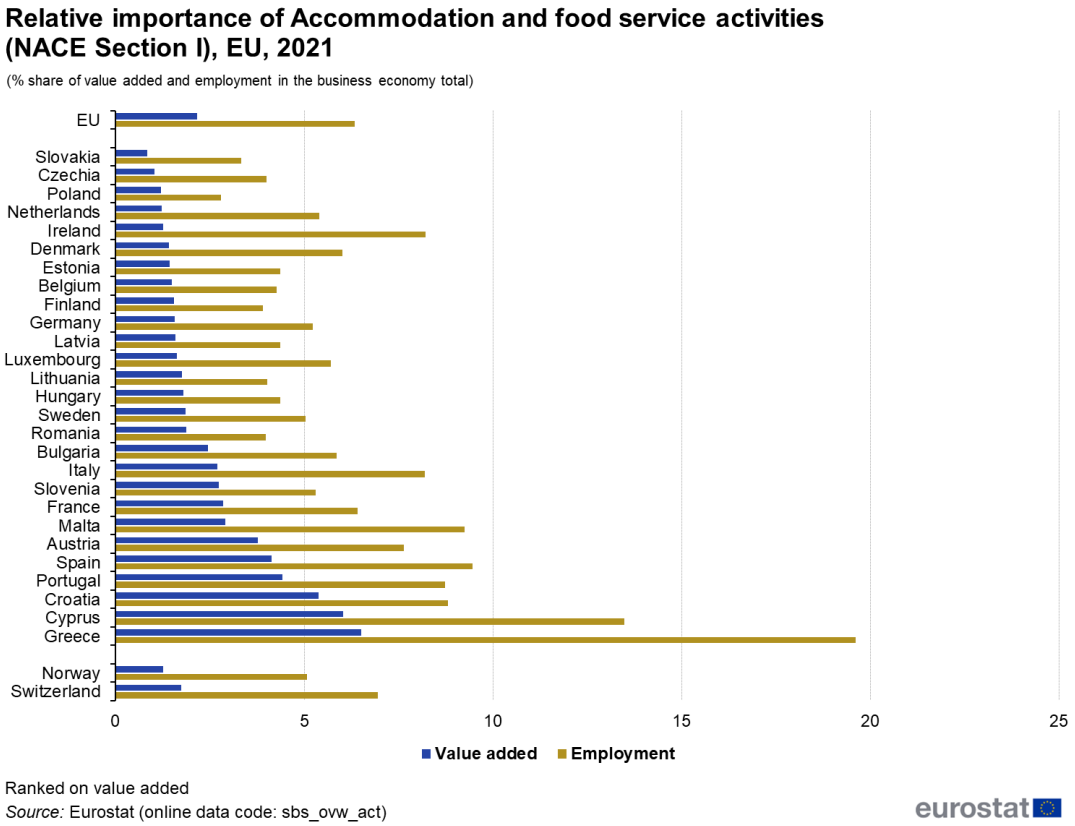

Figure 3: Relative importance of Accommodation and food service activities

In 2021, around 80 % of the enterprises and the workforce of the accommodation and food services sector were registered in the sub-sector of food and beverages, which includes traditional restaurants, fast-food or take-away restaurants, cafeterias, mobile food trucks, catering services, as well as bars, coffee shops and mobile beverage vendors. 1.5 million enterprises were active in this sector in 2021 and employed 7.7 million persons, contributing to

the EU's business economy with a value-added of €140.2 billion. The sub-sector of accommodation, including hotels, youth hostels, mountain refuges, camping grounds, recreational vehicle parks and trailer parks, student residences and railway sleeping cars, employed 2.2 million persons and generated €63.4 billion in value added.

Demographics and scale play a significant role in staffing: In 2023, the tourism industries employed more female workers than male workers, with the highest proportions being in travel agencies, tour operators and accommodation. The number of people employed in the EU tourism industry was over 11.2 million. 11 % of people employed in the tourism industry were young workers (15-24), while this share was 9 % in services and the non-financial economy.

Tourism has been one of the sectors most affected by COVID-19, and this has accelerated the AI transformation. For example, there was a rise in VR tours during the pandemic, with AI as an associated technology. Another Eurostat report notes the bounce back from the impact of the COVID lockdowns, that the nights spent in EU tourist accommodation in 2022: up by 50% compared with 2021, reaching 96% of the pre-COVID-19 levels. In 2022, German tourists accounted for nearly one in four nights spent by international guests in EU tourist accommodation. In 2022, the EU could offer 28.9 million bed places to accommodate tourists, spread over more than 621,000 establishments.

AI is already being applied in the travel sector, specifically, in the operation of scheduled assets and the optimised allocation of rooms and crews. Artificial intelligence (AI) is present in almost every area of travel and tourism, appearing in different types of applications such as personalisation and recommender systems, robots, conversational systems, intelligent travel agents, prediction and forecasting systems, language translation applications, and voice recognition and natural language processing systems. Recent improvements in big data, algorithms, and computing power have enabled significant enhancements in AI.

The AI push aligns with a thriving travel market with domestic and regional tourism experiencing substantial growth. In 2022, considerable geographical variation in the net occupancy rate of beds and bed places in hotels and similar accommodations hints at the potential for marketing and personalisation to increase demand in local markets, as shown in Figure 4.

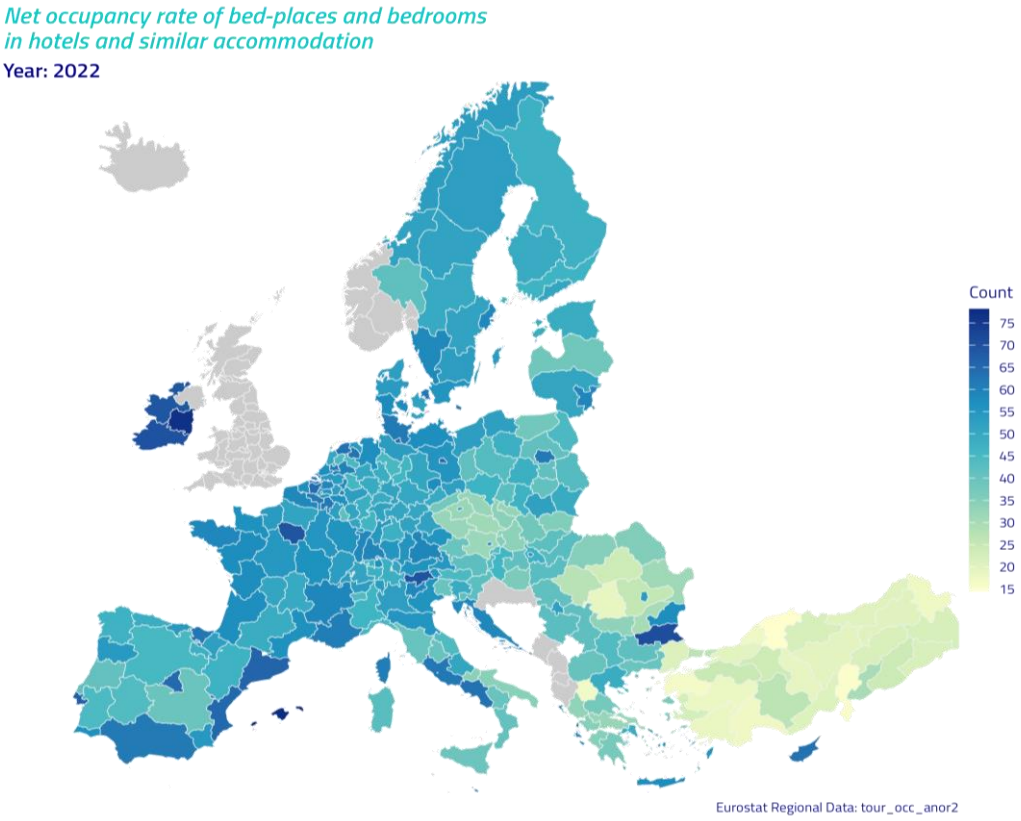

Figure 4: Net occupancy rates at the regional level (2022)

4.5.2. Final Comments

One of the challenges with this sector was the impact of COVID-19 in providing reliable estimates on total employment figures. As such, there was no regional analysis complete for the sector. However Figure 4.5.1 provides a clear overview as to which countries within the EU have the most to gain through AI adoption.

Personalisation is critical: Adopting new technologies such as AI, the Metaverse, blockchain, and robots is helping the tourism and hospitality industry deliver customers a more personalised, convenient, and immersive experience. More than 70% of travellers plan their trips online. Thus, with the introduction of new technologies such as chatbots, messengers, artificial intelligence, and robots, our tourism business is becoming more critical than ever.

The integration of ChatGPT in travel services, providing 24/7 assistance and personalised recommendations, marks a significant shift towards operational efficiency and elevated customer satisfaction. However, this shift towards AI-driven services raises critical questions about the future role of human employees in the tourism sector, pointing towards a potential redefinition of job roles and skills requirements.

AI chatbots still need to be able to replace human agents in all service interactions, as they cannot resolve complex queries and complaints. However, work is underway to improve their verbal, vocal and anthropomorphic capabilities to deliver a better consumer experience.

AI applications are embedded and a norm. For a greater range of examples, consider reading a recent literature review. Considering that the hype and evolution of chatbots is extreme due to market competition between

companies such as Microsoft, Apple, OpenAI, and Google, the authors of this report expect the lack of anthropomorphic capabilities to be fleeting.

An impact analysis of AI in tourism painted several possibilities, one of which is that most of the industry's jobs will be substituted by machines, which will cause the loss of the feeling of hospitality. The authors mentioned a range of human interactions, from robotised hotels to human-augmented hotels with robots and humans supporting distinguished hotels where front office and contact points are always with humans. Robots that interact with front-line staff or guests also increase their dominance.

The practical implications of applying AI and new technology for managerial decision-making in the tourism and hospitality industry are vast and promising. The evolution towards customer value co-creation demands a paradigm shift in management attitudes and the adoption of cutting-edge technologies like artificial intelligence (AI) and the Metaverse.

The hospitality and tourism sector cannot afford to ignore ethical issues in AI. Tourism managers and policy influencers who ignore or fail to effectively incorporate AI ethics in deploying innovative technologies risk unfavourable scrutiny from a global community now keenly interested in safe and secure AI.

5. Expert Opinion on AI related Skills applications

To gain additional converging evidence of the skills gaps at the intersection of AI and VET education, research was undertaken to gauge expert opinions on the skills required for furthering AI adoption. To undertake this research, a two-stage Delphi method was used.

The first round of feedback gathered data from experts using a series of open-ended questions (See Appendix). A total of *n* = 154 responses were received in the first round, and upon data cleaning, 106 responses were used in the first round analysis. The analysis of the first round focused on identifying skills that experts perceived as important, either currently or in the near future.

In the second round of analysis, we received 116 responses. Upon further data cleaning, we used 90 responses in total to form the expert sample. In the second round of analysis, the experts were required to rank the skills they had collectively provided from the first round. The ranking process required them to rank 10 out of 28 skills in order of importance.

Finally, a score was assigned to each skill based on their frequency and rank. For each instance that a skill was placed in rank 1 (most important), it was assigned 5 points. The score table is as follows:

Table 11: Skills Scoring Method

Rank	Score
1	5
2	4
3	3
4	2
5	1
6+	0

The result was a weighted frequency count of importance. This was completed for both questions which asked experts to rate skills. The first question focused on skills that are *currently* required for AI adoption. The results of these are presented in the following table.

Table 12: Current Skill Required for AI Adoption

Rank	Competencies as defined by experts	Score
1	Navigate AI law and regulations	124
2	Intermediate digital literacy	115
3	Understanding ethics & AI	101
4	Understanding AI	97
5	Critical Thinking	96
6	Data Literacy	66
7	Basic digital Literacy	65
8	Problem solving	64
9	Communication Skills	61

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10	Advanced digital literacy	51
11	Creativity	43
12	Fundamentals of machine learning	39
13	Mathematics	39
14	Life Long learning	38
15	Analyse data	33
16	Statistics	33
17	Critical Reflection	30
18	Prompt Engineering	28
19	Professional Expertise	23
20	Logic and Logical Reasoning	22
21	Media Literacy	21
22	Research Skills	19
23	Basic Programming Skills	15
24	Scientific Method	13
25	Data Analytics	12
26	Intermediate programming literacy	8
27	Construct Robotics	4

The second question asked experts to rate skills that are required for AI adoption into the *future*.

Table 13: Future Skills Required for AI Adoption

Rank	Competencies as defined by experts	Score
1	Navigate AI law and regulations	149
2	Intermediate digital literacy	95
3	Understanding Ethics & AI	90
4	Advanced digital literacy	86
5	Critical Thinking	81
6	Critical Reflection	66
7	Creativity	63
8	Fundamentals of machine learning	63
9	Understanding AI	62
10	Statistics	61
11	Communication Skills	59
12	Data Literacy	50
13	Prompt Engineering	42
14	Basic digital Literacy	41
15	Analyse data	40
16	Life Long learning	40
17	Problem solving	38
18	Mathematics	34
19	Media Literacy	34

20	Professional Expertise	29
21	Research Skills	25
22	Logic and Logical Reasoning	20
23	Data Analytics	16
24	Scientific Method	16
25	Basic Programming Skills	15
26	Construct Robotics	8
27	Develop Robotics	8
28	Intermediate programming literacy	4

We then formulated an overall combination of opinions; the scores from question 6 and question 7 are then combined additively to create a combined scoring of opinions with respect to AI skills required currently and into the future.

Table 14: Combined Current and Future Skills

Rank	Competencies as defined by experts	Score
1	Navigate AI law and regulations	273
2	Intermediate digital literacy	210
3	Understanding ethics & AI	191
4	Critical thinking	177
5	Understanding AI	159
6	Advanced digital literacy	137
7	Communication skills	120
8	Data literacy	116
9	Basic digital literacy	106
10	Creativity	106
11	Fundamentals of machine learning	102
12	Problem solving	102
13	Critical Reflection	96
14	Statistics	94
15	Life Long learning	78
16	Analyse data	73
17	Mathematics	73
18	Prompt Engineering	70
19	Media Literacy	55
20	Professional Expertise	52
21	Research Skills	44
22	Logic and Logical Reasoning	42
23	Basic Programming Skills	30
24	Scientific Method	29
25	Data Analytics	28
26	Construct Robotics	12
27	Intermediate programming literacy	12
28	Develop Robotics	8

($M_{Score} = 86, \underline{x}_{Score} = 92.7$)

The relevant topics to be included are those that score above the average and median scores. As such, this creates a shortlist of 14 skills for the development of curricula.

To further refine the list of skills, we can see that data literacy appears both as a general term, and as a term at varying levels (basic, intermediate, advanced). As such, by merging digital literacy as a general skill set that is mapped to different levels of competency. Importantly, intermediate data literacy consistently scored the highest of the three levels.

The final outcome is the following list of skills recommended by experts, being incorporated into the annotated list of skills, presented in the discussion section.

6. Discussion

6.1. Annotated List of Skills

This research report set out to use multiple methods of analysis to find converging evidence for key skills gaps. The result is the synthesis of multiple sources of information into an annotated table of skills, presented as Table 15.

A key part of the table's organisation is the inclusion of mappings onto the relevant sections of the ESCO 1.2 competencies framework. These codes indicate if ESCO classifies the competencies through the leading value (Skills = S, Transversal Skills = T, Knowledge Types = 0). Additionally, the table has been sorted to acknowledge the systematic literature review of Pinski and Benlian (2024) to ensure clarity as to how their work overlaps with the work from AI4VET4AI.

Table 15: Annotated List of Skills

Skills, Knowledge Domains and Competencies	ESCO 1.2 Codes	Digicomp Cluster	Description / Definition	Source					Sector/s Emphasis
				1	2	3	4	5	
Cross Area - Ethical Literacy	0223; T6.6	5. Problem solving	Understanding and addressing ethical issues and risks related to AI, such as misinformation, diversity, and employment, across AI models, data, and tool implementation in organizations.	Y	Y		Y	Y	Human Health and Social Welfare; Professional, Technical and Scientific Services
Ai Models - Computer Science Prerequisites	061	1. Information and data literacy	Essential concepts, including abstraction, programmability, algorithmic thinking, basic statistics, and IT infrastructure needed for AI comprehension.		Y	Y			Education
Data For Ai - Fundamentals	0612	1. Information and data literacy	Understanding of data structures, data sanitization, and the significance of data for various AI technologies, including the connection between input data and AI model predictions.		Y				
Ai Models - Fundamentals	0619	1. Information and data literacy	Understanding the nature of various forms of intelligence (human, animal, machine); differentiating AI from non-AI technology; grasping how AI functions, makes decisions, represents knowledge; and acknowledging AIs strengths and weaknesses.		Y				
Ai Models - Types	0619	1. Information and data literacy	Understanding the differences between machine learning, deep learning, explainable AI (XAI), and generative AI models, among others, as manifestations of AI concepts and knowledge representations.		Y				
Ai Models - Development	0619	1. Information and data literacy	While not mandatory for AI users, appreciating how AI models are constructed provides a deeper comprehension; it is deemed valuable for specific user groups and applications but not essential for all.		Y				
Ai Tools - Fundamentals	0619	1. Information and data literacy	Understanding the instantiation of AI models in specific (social) contexts in the form of AI tools and assessing which human problems can be addressed with specific AI tools.		Y				

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Ai Tools - Recognition	0619	1. Information and data literacy	Being able to identify where AI tools are used and to recognize them during interaction as they increasingly imitate humans and interact through natural communication.		Y				
Ai Tools - Handling	0619	1. Information and data literacy	Efficiently handling AI tools includes, among others, understanding the tools function range and managing privacy during interactions.		Y				
Ai Interfaces - Fundamentals	S1.11.1	2. Communication and collaboration	Comprehending how AI technologies interact with the physical world and environment, including distinguishing between the AI model (software) and its physical interfaces (hardware) to understand their connection to humans.		Y				
Ai Interfaces - Types	S1.11.1	2. Communication and collaboration	Users need to understand the range of AI interface types, including sensors and software interfaces, to recognize how AI technologies interact with the world and receive input from users.		Y				
Data For Ai - Visualization	S1.4.2	3. Digital content creation	An understanding of how to visualize complex AI-generated results to comprehend and effectively utilize the outcomes of AI technologies.		Y				
Data For Ai - Governance	S2.3.0	1. Information and data literacy	Understanding of control and authority over data management.		Y				
Data For Ai - Interpretation	S2.7.0	1. Information and data literacy	The ability to appropriately interpret output data from AI systems, recognize potential biases, and understand that output data.	Y	Y				Human Health and Social Welfare
Cross Area - Critical Literacy	T2.1	5. Problem solving	Ability to critically assess all core areas, such as AI models, tool outputs, usage needs, and the impact of AI tools.		Y				
Humans, Organizations, And Society - Human Roles In Ai Context		5. Problem solving	Understanding the various roles humans play in relation to AI tools, including programmers, data providers, evaluators, and those affected by AI tools, and their influence on AI tool development and implementation.		Y				

Humans, Organizations, And Society - Human Interactions In Ai Context		5. Problem solving	Collaborating and communicating with other human stakeholders involved in AI projects, teaching and explaining AI concepts to various stakeholders, and managing the impacts of AI interactions.		Y				
Humans, Organizations, And Society - Organizational Management Of Ai		5. Problem solving	Effectively managing AI tools within organizations, including understanding their impact on processes, developing AI strategies, anticipating economic and legal implications, identifying opportunities, and recognizing potential impacts on organization members.		Y				
Humans, Organizations, And Society - Current And Future Societal Impact Of Ai		5. Problem solving	Comprehending AIs societal implications enables citizens to be aware of AIs influence on democratic societies, anticipate future impacts, and engage in informed debates about AI technology implementations.		Y				
Cross Area - Meta Literacy		5. Problem solving	Being aware of one's own AI literacy level.		Y				
Cross Area - Future Literacy		5. Problem solving	Recognizing the dynamic evolution of AI and envisioning its future impact on AI literacy requirements as well as cultivating the learning skills to adapt to these requirements.		Y				
Communication Skills	0031; S1.4.2	2. Communication and collaboration	The ability to convey or share ideas and feelings effectively.	Y			Y	Y	Human Health and Social Welfare
Image Generation (image formation)	0211; 0619	3. Digital content creation	The creation of new images, often using artificial intelligence, that did not previously exist by understanding certain patterns, styles, or characteristics.			Y	Y		Professional, Technical and Scientific Services
Audio Analysis	0211; 0619	1. Information and data literacy	The skill of examining audio tracks to extract information, such as identifying spoken words, music genres, or the emotional tone of a voice.			Y			Professional, Technical and Scientific Services
Data Curation And Organisation	0322	1. Information and data literacy	The activity of managing and promoting the use of data from its point of creation, to ensure it is fit for contemporary purpose, and available for discovery and re-use.	Y					Education
Navigate Ai Law And Regulations	0421	5. Problem solving	The ability to understand and apply legal and regulatory frameworks pertaining to artificial intelligence.				Y	Y	

Statistics	0542	1. Information and data literacy	The science of collecting, analyzing, presenting, and interpreting data.	Y			Y	Y	Professional, Technical and Scientific Services
Learning Analytics	0542	1. Information and data literacy	The measurement, collection, analysis, and reporting of data about learners and their contexts.			Y			Education
Prompt Engineering	0611	3. Digital content creation	The art of crafting inputs that elicit the desired output from AI models.			Y	Y		Food and Accommodation Services; Education; Human Health and Social Welfare
Software-In-The-Loop	0611	1. Information and data literacy	A simulation technique used to test software components in a virtual environment.			Y			Food and Accommodation Services
Autonomous Control Systems	0611	1. Information and data literacy	Knowledge of systems that operate independently of human control.			Y			Human Health and Social Welfare
Dialog Systems	0611; 0619	2. Communication and collaboration	Knowledge of computer systems designed to converse with users using natural language.			Y			Food and Accommodation Services
Question Answering	0611; 0619	1. Information and data literacy	A field of study in AI and NLP focused on building systems that answer questions posed by users.			Y			Food and Accommodation Services
Data Analytics	0612	1. Information and data literacy	The process of inspecting, cleansing, transforming, and modeling data with the goal of discovering useful information, informing conclusions, and supporting decision-making.	Y					Education; Professional, Technical and Scientific Services
Computational Thinking	0613	1. Information and data literacy	The thought processes involved in formulating problems and their solutions in a way that a computer can effectively carry out.			Y			Education
Computer Programming	0613; S5.6.1	3. Digital content creation	The process of designing and writing computer programs.			Y	Y		Education
Principles Of Machine Learning (Neural Networks And Deep Learning)	0619	1. Information and data literacy	The foundational concepts underlying the construction and functioning of neural networks and deep learning models.	Y			Y		Human Health and Social Welfare
Rule-Based Expert Systems	0619	1. Information and data literacy	A type of artificial intelligence that uses a set of rules for making decisions or solving problems.	Y					Human Health and Social Welfare

Understand How Ai Works And Its Limitations	0619	1. Information and data literacy	Comprehension of the mechanisms behind artificial intelligence and recognition of its potential constraints and shortcomings.	Y			Y	Y	Human Health and Social Welfare
Human-In-The-Loop Process Design	0619	1. Information and data literacy	The ability to effectively integrate human feedback into the iterative processes of machine learning and AI systems			Y			Food and Accommodation Services; Human Health and Social Welfare; Professional, Technical and Scientific Services
Activity Recognition	0619	1. Information and data literacy	The ability of a system to detect and identify a particular activity being performed.			Y			Food and Accommodation Services; Human Health and Social Welfare
Image Recognition	0619	1. Information and data literacy	A subset of visual recognition, this skill focuses on identifying and classifying individual images based on their content and attributes.			Y			Professional, Technical and Scientific Services
Image Analysis	0619	1. Information and data literacy	The examination and evaluation of images to extract meaningful information. This can include identifying patterns, detecting anomalies, or understanding image content.			Y			Professional, Technical and Scientific Services
Speech Recognition	0619	1. Information and data literacy	The skill of identifying and verifying a speaker based on their voice characteristics.			Y			Professional, Technical and Scientific Services
Language Model	0619	1. Information and data literacy	A statistical model that understands language and can predict the next word in a sequence of words, often used in natural language processing.			Y	Y		Professional, Technical and Scientific Services
Data Science	0688	1. Information and data literacy	An interdisciplinary field that uses scientific methods to extract knowledge from data.			Y	Y		Education
Cognitive Computing	0688	1. Information and data literacy	These are theoretical constructs that represent the complex processes of the human mind. They help in understanding how people think, remember, learn, and solve problems.			Y			Professional, Technical and Scientific Services
Automation	0714	1. Information and data literacy	The technology by which a process or procedure is performed without human intervention.			Y			Human Health and Social Welfare

Evidence-Based Medicine	0912	1. Information and data literacy	The conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients.	Y					Human Health and Social Welfare
Technical Curiosity	A1.6.0	5. Problem solving	An eagerness to understand and learn about technology and technical subjects.			Y			Education
Manage intellectual property rights	S1.1.1; T6.3	3. Digital content creation	The use of artificial intelligence to generate written content, from marketing materials to storylines, often requiring creativity and adherence to language norms.			Y			Professional, Technical and Scientific Services
Conversational User Interface	S1.11.1	2. Communication and collaboration	A user interface that mimics chatting with a real human.			Y			Food and Accommodation Services
Training on Operational Procedures; Instruct Others; Education science	S1.3.3; T4.2, 0111	5. Problem solving	The process of learning new skills or enhancing existing skills.			Y			Food and Accommodation Services; Human Health and Social Welfare
Problem-Solving Skills	S1.9.0; T2.3	5. Problem solving	The capacity to find solutions to difficult or complex issues.	Y		Y	Y	Y	Education; Human Health and Social Welfare; Professional, Technical and Scientific Services
Information Retrieval	S2.0	1. Information and data literacy	The process of obtaining information system resources that are relevant to an information need from a collection of those resources.	Y					Human Health and Social Welfare
Intelligence Data Handling	S2.3.0	1. Information and data literacy	The process of managing and analyzing data for intelligent decision-making.			Y			Food and Accommodation Services
Medical Ai Development Workflows	S4.2.3	1. Information and data literacy	The structured sequence of processes through which medical AI systems are developed, including design, testing, and deployment.	Y					Human Health and Social Welfare
Custom Scripting	S5.1.0	3. Digital content creation	Writing custom scripts for various tasks, often for automation or data processing.			Y			Human Health and Social Welfare
Machine Learning	S5.1.0; 0619	1. Information and data literacy	A type of artificial intelligence that allows software applications to become more accurate at predicting outcomes without being explicitly programmed to do so.	Y		Y		Y	Food and Accommodation Services; Wholesale and Retail Trade; Professional, Technical and Scientific Services

Model Validation And Testing	S5.1.0; 0619	1. Information and data literacy	The process of evaluating and testing models performance on a specific task, typically by using a separate set of data not used in training the model.	Y					Professional, Technical and Scientific Services
Data Literacy.	S5.5.0	1. Information and data literacy	The ability to read, understand, create, and communicate data as information.	Y		Y		Y	Education
Sentiment Analysis	S5.5.0	1. Information and data literacy	The process of computationally determining the emotional tone behind words to gain an understanding of the attitudes, opinions, and emotions expressed within an online mention.			Y			Professional, Technical and Scientific Services
Build Data Pipelines (Use IT Tools)	S5.5.0	3. Digital content creation	Build Pipeline refers to a set of automated processes used to compile, build, and deploy code into a staging or production environment			Y			Wholesale and Retail Trade
Creativity In Digital Content Creation	S5.6.0	3. Digital content creation	The use of imagination or original ideas to create something.					Y	
Creative Inquiry	S5.6.1	5. Problem solving	A process involving the exploration of ideas, formulation of hypotheses, and experimentation to reach new conclusions or solve problems creatively.	Y					Education
Analytical Decision-Making Skills	S5.6.1	5. Problem solving	The ability to make decisions based on the systematic analysis of available information and evidence.	Y					Human Health and Social Welfare
Clinical Decision Support	S5.6.1; S4.9.0	1. Information and data literacy	Tools and systems that provide health professionals with knowledge and person-specific information.			Y			Human Health and Social Welfare
Digital Literacy	T1.3	2. Communication and collaboration	The ability to use information and communication technologies to find, evaluate, create, and communicate information.				Y	Y	
Critical Reflection On Information	T2	5. Problem solving	The process of analyzing, reconsidering, and questioning experiences within a broad context of issues.	Y				Y	Human Health and Social Welfare
Critical Thinking	T2.1	5. Problem solving	The objective analysis and evaluation of an issue in order to form a judgment.	Y			Y	Y	Education, Professional, Technical and Scientific Services
Analytical Thinking	T2.1	5. Problem solving	The ability to deconstruct complex problems into smaller, more manageable parts.			Y	Y		Human Health and Social Welfare

Context Analysis	T2.1, 0619	1. Information and data literacy	The ability to understand the context or background information surrounding a topic or situation, which is crucial for making informed decisions or understanding language.			Y			Professional, Technical and Scientific Services
Clinical Reasoning Skills	S1.9.1; T2.1	5. Problem solving	The process by which a therapist interacts with a patient, collecting information, generating and testing hypotheses, and determining optimal diagnosis and treatment based on clinical data.	Y					Human Health and Social Welfare
Teamwork	T4.3	2. Communication and collaboration	The combined action of a group, especially when effective and efficient.	Y					Human Health and Social Welfare
Deal With Technologies Responsibly		4. Safety	The practice of using technology in a way that is accountable, sustainable, and ethical.	Y					Professional, Technical and Scientific Services

Source 1 = AI4VET4AI Literature Review; Source 2 = Pinski, Benlian (2024); Source 3 = Lightcast Taxonomy Analysis; Source 4 = Future Skills and Occupations Survey; Source 5 = Expert Interviews

For the development of the final list of annotated skills lists, duplicates and overlapping competencies and skills were condensed where definitionally possible. Furthermore, proprietary skills requirements relevant to a specific type of software, for example SPSS, were removed. These skills, while relevant to AI adoption, are well established with significant educational resources available from vendors. Other skills were excluded from the list for being too specific in the context of the skills identification process. For example, stemming was identified through the lightcast skills taxonomy as an AI relevant skill. Stemming is one of several text normalization techniques that converts raw text data into a readable format for natural language processing tasks. However, in the broader context of skills gap identification, this skill is deemed so specific that it doesn't make sense to use it outside of those who are actually developing AI systems.

The annotated list of skills provides a basis for understanding what curricula should be aiming to teach. Through linking the list to the ESCO framework, we can also identify clear sections of the ESCO 1.2 taxonomy which highlight complementary skills. This is in particular for skills clusters S5.5 and S5.6, along with knowledge clusters 0611 and 0619.

Another key finding from the annotated list of skills is that there is already a large degree of convergence on what skills are required for future AI adoption. Ethics, AI regulation and data governance all form a central part of competencies that a future VET workforce must adopt. However, the level of detail and understanding is likely to be heavily influenced by organisational structures and workplace policies. This is where the role of data stewards should be emphasised.

While data protection officers focus on the regulatory compliance and use of data within an organisation, a data steward acts as an advocate for how to adopt and join data sets within the workplace. As such, data stewards need to think creatively and apply critical thinking skills to advance AI adoption within the workplace.
This is where the transversal skills, such as communication, critical thinking and reasoning, and creativity in general are important to foster in an AI enabled future. These skills cut across sectors and regions, and should form a central core of any curricula that is being offered in AI.

6.2. Limitations

Barriers to deploying AI exist, including, as mentioned in all sector reports, the need for training: Overcoming financial and technical barriers to the widespread adoption of AI in the tourism industry is an essential area for further exploration. Implementing AI technologies may require significant financial resources, including acquisition, installation, maintenance, software updates, and staff training costs.

Further experimentation and exploration of AI are needed to minimise unnecessary AI investments and maximise the potential benefits of AI incorporation. Hospitality professionals should investigate factors influencing customers' acceptance and use of AI devices.

A study of thirty years of AI-related literature found that AI research relating to the hospitality and tourism industry shows a growing trend. The first paper was published in 1991, and since 2018, the number of publications and citations rapidly increased, obtaining considerable research attention. Second, studies on AI may be grouped into four clusters: AI technology, technology acceptance, consumers' perception and future trends.

ChatGPT-like bots are impacting education for staff in the tourist industry, where researchers acknowledged that digital literacy is a crucial skill necessary to interact successfully. A review of research on literacy found that digital literacy included employability skills and disruptive digital technologies.

AI, robotics, Big Data, online planning, and personalisation are transforming the tourism industry. Management and policymakers require digital literacy, including an understanding of the impact of disruptive technologies and the technology's ethical and practical application.

7. References

References:

- Pinski, M., & Benlian, A. (2024). AI literacy for users – A comprehensive review and future research directions of learning methods, components, and effects. Computers in Human Behavior: Artificial Humans, 2(1), 100062. https://doi.org/10.1016/j.chbah.2024.100062

8. Technical Manual

8.1. Introduction

This manual describes several different interlocked methods to obtain AI literacy skills. Various techniques were necessary to capture the complexity and the dynamic natural commercial marketplace. Keeping track of what's going on without different methods shining brightly into the confusing shadows is difficult.

For the sake of reproducibility, the authors of this document describe the methods in detail.

This manual explains the standards and methods necessary to identify the regional and national AI-related skills gaps (D2.2) and to provide recommendations for VET curriculum and Syllabus development (D2.3). The authors used a variety of approaches due to the complexity of demographics, the velocity of change, and the sheer size of the European Union. Relying on one approach would weaken the validity of the conclusions and may lead to misinterpretation due to biases and methodological limitations. As always, there is a significant degree of data-driven storytelling. Here, we provide details about the methods that were leveraged to build the reader's confidence and elucidate the methodological bases for the recommendations.

As you read through the methodologies, you will realise how much of an operation it has become to keep track of AI Skills and provide recommendations for AI literacy at the regional level per industry within Europe. We have endeavoured to deliver relevant content, but due to the size and extent of the Big dataset of resources available on the Internet, we have yet to capture all the available value. However, by having a methodic set of search strategies that triangulate our intended goals, we have minimised the loss and delivered within the resources and time allotted to the task.

The approaches included:

1. Skills gap survey
2. Delphi method. A discussion with experts
3. Systematic review of the literature pertaining to AI related skills gaps identification
4. Review of skills demand in the job market via Job market intelligence based on an analysis of a large corpus of online Job advertisements
5. Systematic data review of available sources of data. Later, a number of the discovered data sources are used to support the recommendations

Through these means, we establish well grounded recommendations supported by multiple sources.

8.2. Standards & Data limitations

To be able to compare apples with apples the recommendations we provide rely heavily on standards.

To analyse and deliver recommendations for a set of Nations with great diversity and velocity of change, statistical bureaus need to agree on standard ways of comparing those data. The standardisations used in this report derive primarily from the geographical (NUTS), occupation (ESCO), and Economic levels (NACE) and are introduced in the following sections.

8.3. NUTS - Territorial Units

NUTS (Nomenclature of Units for Territorial Statistics) is a hierarchical system used by the European Union to divide its economic territory into regions for ***statistical,*** socio-economic, and regional ***policy purposes***.

Here's a breakdown of the NUTS levels:

- NUTS 0: National level, usually coinciding with the country's boundaries.
- NUTS 1: Major socio-economic regions, often more significant regions within a country.
- NUTS 2: Basic regions for applying regional policies, typically used for regional planning and funding allocations.
- NUTS 3: Small regions for specific diagnoses, often used for more detailed analyses.

The NUTS2 level is particularly significant because it's the central unit at which the EU's regional policies and funds allocation is targetted. These regions are usually composed of administrative boundaries within a country and are designed to be relatively similar in population size to allow comparability of data across the EU.

The NUTS level of an administrative unit is determined on the basis of demographic thresholds as shown in the table below.

Table 16: Geographic thresholds for NUTS levels

Level	Minimum	Maximum
NUTS 1	3 million	7 million
NUTS 2	800,000	3 million
NUTS 3	150,000	800,000

For example, within the Netherlands, the NUTS2 regions include areas such as "Noord-Holland," "Zuid-Holland," and "Noord-Brabant," each with its own socio-economic characteristics that are analysed and compared with other regions in the EU.

The NUTS classification is regularly updated to reflect changes in the administrative and territorial divisions of Member States, ensuring the relevance and accuracy of regional statistics and analyses.

Table 17: The twenty most frequently defined NUTS2 regions based on the skills survey data

Rank	Country Name	Region	NUTS_ID	Frequency
1	Greece	Dytiki Elláda	EL63	47
2	Turkey	Kırıkkale, Aksaray, Niğde, Nevşehir, Kırşehir	TR71	29
3	Ireland	Eastern and Midland	IE06	25
4	Slovenia	Vzhodna Slovenija	SI03	24
5	Slovenia	Zahodna Slovenija	SI04	24

6	Turkey	Gaziantep, Adıyaman, Kilis	TRC1	22
7	Croatia	Grad Zagreb	HR05	21
8	Italy	Campania	ITF3	21
9	Austria	Tirol	AT33	19
10	Spain	Comunidad de Madrid	ES30	19
11	Croatia	Sjeverna Hrvatska	HR06	18
12	Austria	Wien	AT13	15
13	Spain	Andalucía	ES61	14
14	Croatia	Panonska Hrvatska	HR02	13
15	Germany	Niederbayern	DE22	11
16	Austria	Oberösterreich	AT31	10
17	Germany	Oberbayern	DE21	9
18	Austria	Kärnten	AT21	8
19	Austria	Steiermark	AT22	8
20	Greece	Attiki	EL30	8

Co-funded by
the European Union

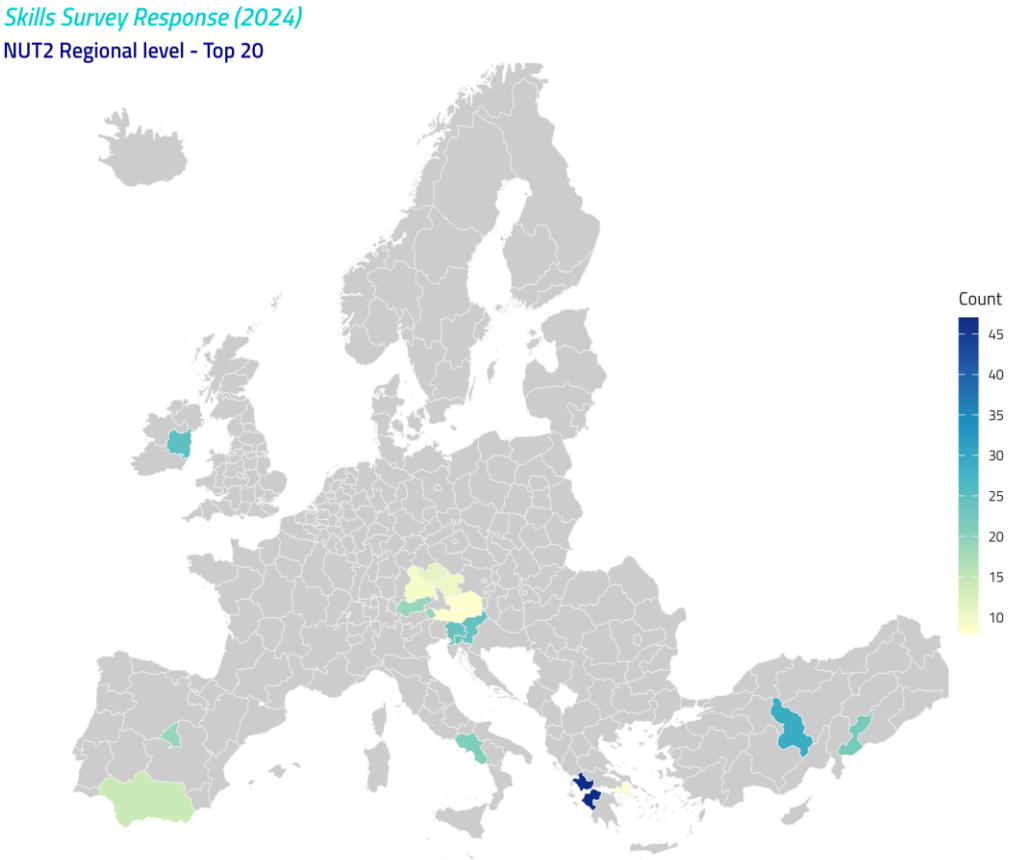


Figure 5: The geographical dispersion of Survey data

8.4. NACE version 2

The term NACE is derived from the French "Nomenclature statistique des Activités économiques dans la Communauté Européenne." or in English as the "Statistical Classification of Economic Activities in the European Community," is a system used in the European Union to classify business activities.

NACE Rev 2 classification system is structured hierarchically with four levels of detail:

- Level 1: The highest level, consisting of sections identified by alphabetical letters (e.g., A for Agriculture, Forestry, and Fishing).

Each level provides more specific details about the economic activities. For example, under "A - Agriculture, Forestry, and Fishing," you will find:

- 01 - Crop and animal production, hunting, and related service activities
- 01.1 - Growing of non-perennial crops
- 01.11 - Growing of cereals (except rice), leguminous crops, and oil seeds

This hierarchical structure allows for a detailed classification and analysis of economic activities across the European Union and is built into Eurostat statistics. It's important to note that NACE Rev. 1.2 was superseded by NACE Rev. 2, which is currently in use, and an update to NACE Rev. 2.1 is planned in the near future for 2025.

To limit the scope of the study and in agreement with the AI4VET4AI consortium, the authors of the recommendations reviewed the following NACE sectors.

Table 18: Selected NACE sections and groups

Code	Description
G	WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES
46.4	Wholesale of household goods
47.1	Retail sale in non-specialised stores
I	ACCOMMODATION AND FOOD SERVICE ACTIVITIES
55	Accommodation
56	Food and beverage service activities
M	PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES
69.2	Accounting, bookkeeping and auditing activities; tax consultancy
73.1	Advertising
73.2	Market research and public opinion polling
P	EDUCATION
85.2	Primary education
85.3	Secondary education
85.4	Higher education
Q	HUMAN HEALTH AND SOCIAL WORK ACTIVITIES
86.1	Hospital activities
86.2	Medical and dental practice activities

8.5. ESCO

This publication uses the ESCO classification of the European Commission.

ESCO (*European Skills, Competences, Qualifications, and Occupations*) is a multilingual classification system used within the European Union. ESCO describes, identifies, and classifies professional occupations and skills relevant to the EU labour market and education and training systems.

ESCO provides descriptions of roughly **3008 occupations** and **13.890 skills** linked to these occupations, translated into 28 languages (all official EU languages plus Icelandic, Norwegian, Ukrainian, and Arabic).

The ESCO classification is regularly updated to reflect the changing needs and trends of the labour market. And you can download the different versions of ESCO here

ESCO's main components:

- **Occupations:** ESCO organises occupation concepts and uses hierarchical relationships, metadata, and mappings to the International Standard Classification of Occupations (ISCO) to structure these occupations.
- **Skills/Competences:** The skills pillar of ESCO distinguishes between skill/competence concepts and knowledge concepts, providing descriptions and a set of related terms for each concept.
- **Qualifications:** ESCO also includes information on qualifications, the formal outcomes of an assessment, and the validation process obtained when an individual has achieved learning outcomes according to given standards.

The current version of ESCO (May 2024) is version 1.12 and is the one used for analysis within this report.

To establish a baseline for skills recommendations, we look at the current (May 2024) version of ESCO version 1.1.2 and compare what it has in terms of skills with any new skill recommendations. Next is a surface review, which the authors expand on in greater detail with skill recommendations using data-driven approaches later in the technical section.

The scoping method was to download v1.1.2 of the ESCO data set in CSV format. Next, the words " **data** " and "**artificial intelligence**" were searched for in the description of tables *`occupations_en.csv`* and *`skills_en.csv`*, and summary statistics were generated via R code. The Digital skills collection was formatted by reading a file named "*digCompSkillsCollection_en.csv*".

Table 19: ESCO Summary statistics

Description	Fact
Total Occupations	3007
Total skills	13896
AI occupations	3
AI skills	9
Data Occupations	82
Data Skills	313
AI Occupation coverage	**0.1 %**
AI Skill coverage	**0.06 %**
Data Occupation coverage	**2.7 %**
Data Skill coverage	**2.25 %**

Given the limited volume of occupations and related AI literacy skills we conclude that there is opportunity to expand the list of ESCO skills considerably.

8.6. Educational Attainment Level

For tracking the flow of students and other vital statistics Eurostat has implemented ISCED 2011, which includes both a classification of levels of education programs (ISCED-P) and a classification of educational attainment (ISCED-A) in terms of qualifications resulting from formal education programs. This framework has been used in all EU data collections since 2014. The official coding manual can be found here.

8.7. Data Limitations

8.7.1. Measurement units change over time

Geographic units such as NUTS have thresholds in terms of demographic populations. If the population grows or shrinks substantially, they will move between NUTS levels and might wander between different surveys and thus, datasets. This evolution also happens for occupations, their associated skill sets, and the economic sector. For example, during this study, the ESCO and NACE minor versions were about to change.

- For more information on the current ESCO version visit the official website.
- You can at the time of writing find correspondence tables between the various versions of NACE here.

8.7.2. Geographic coverage

A subset of Eurostat data was reported at the NUT2 level and sometimes contained only a subset of all the possible regions in Europe. Many of the longitudinal datasets changed regions over the years. As an example we show the geographic dispersion of a specific dataset in the following figure.

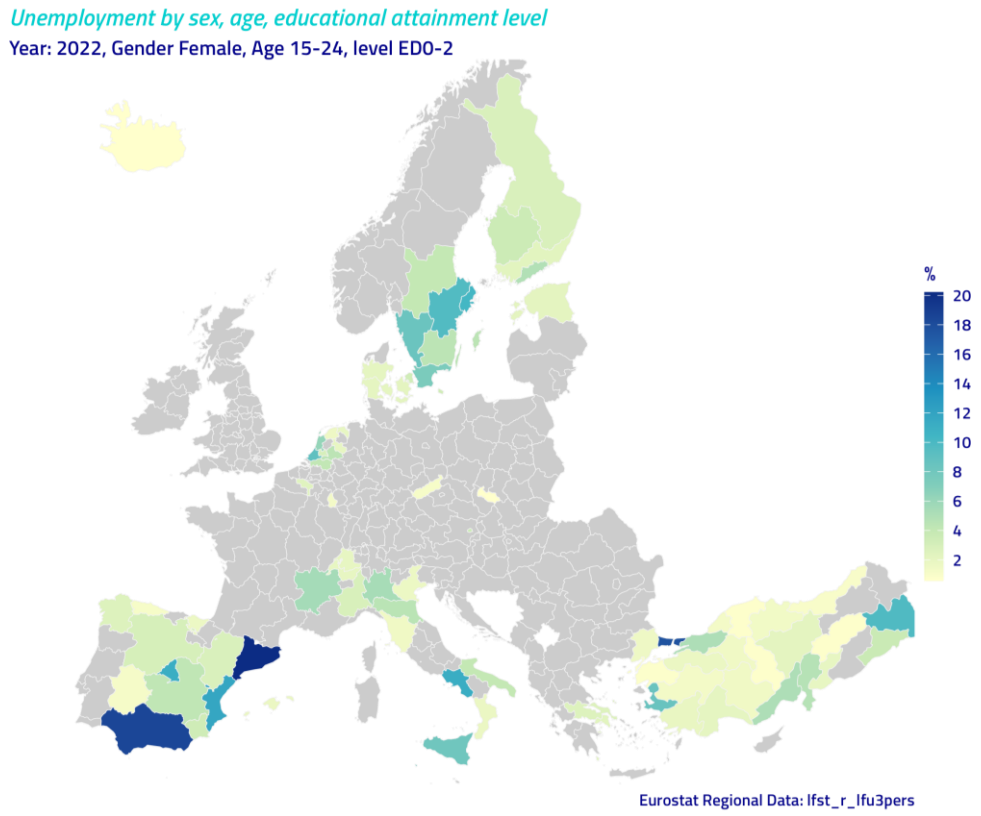


Figure 6: Pictorial example of the quality of geospatial coverage

8.7.3. Freshness

Depending on the Survey method, priority or scale, some datasets are old or ripe for revaluation. We show an example in the table below. The table describes the freshness of datasets available from Eurostat, the table generated in May 2024. You can see that Eurostat refreshed the average dataset approximately a year or slightly later.

Table 20: The number of available Eurostat datasets vs the year last updated.

Year	Datasets
2025	5
2024	484
2023	2.644
2022	1.850
2021	718
2020	654
2019	428
2018	271

8.8. Systematic Literature Review[2]

The main aim of the systematic literature review was to scour the extant research literature for methods and outcomes pertaining to AI related skills gaps identification. We closely mapped the literature review to the Prisma method. The core theme of the research is to track emerging skills related to AI that could complement the skills listed in ESCO version 1.12. Specifically, the authors performed a systematic literature review of articles published between 2021 and November 7th, 2023 (the query search date), initially based on seven research questions developed in a previously formulated research plan.The original research questions were:

RQ1: What are the current skill gaps at the intersection of AI related skills and VET?
RQ2: What AI skills are in increasing demand from 2020 onwards, for VET students or graduates in the labour marketplace?
RQ3: Which occupations are going to need an AI skilled, VET qualified workforce, the most in the next 10 years?
RQ4: What skills belong to the AI literacy skill set?
RQ5: Are there any country or regional differences in the AI skills gap by occupation?
RQ6: What methods can be implemented to provide ongoing and adaptive recommendations for the

[2] Next to the TiB and UvA project teams, we acknowledge Alenka Pandiloska, Serdjan Verbic, Stephan Schloegl, Janez Kolar, Monika Rohlik Tunjić, Maja Brkljačić,Leao Mrsic, and Silvia Cosimato for their contributions to conceptualization, screening, and coding.

development of state of the art AI skills curricula?
RQ7: What are the most effective methods for disseminating AI teaching materials?

To provide a focus for coding the full text of papers, we refined these Research Questions into three themes:

1. **AI literacy**: Defining the skills that belong to the AI literacy skill set, which are the essential skills for understanding, using, and interacting with AI systems and applications. AI literacy is occupation a-specific and may form prerequisite for more advanced AI education and training.
2. **AI skills gap analysis:** Identifying current or future unmet skill demand associated with the proliferation of AI, In particular at the occupational level. The misfit can be between: Educational curricula and specific occupation or job candidates and specific occupations.
3. **AI teaching methods:** Innovative (e.g., gamification) and interactive online teaching methods (including means of content development) that are leveraged to upskill or reskill individual VET students.

The catalogues involved were also broad in the variety of topics they covered. The search engines were:

- Scopus
- Web of science
- OVID
    - All Ovid journals
    - BIOSIS Previews 1993 to 2015
    - Embase Classic+Embase 1947 to 2023 November 14
    - Ovid MEDLINE(R) ALL 1946 to November 14, 2023
    - ERIC 1965 to September 2023
    - APA PsycInfo 1806 to November Week 1 2023
- EBSCO
    - Academic Search Premier
    - Business Source Premier
    - Library Information Science & Technology Abstracts
    - OpenDissertations

We set a wide net to capture papers relevant to all the research questions. Designed in the following structure:

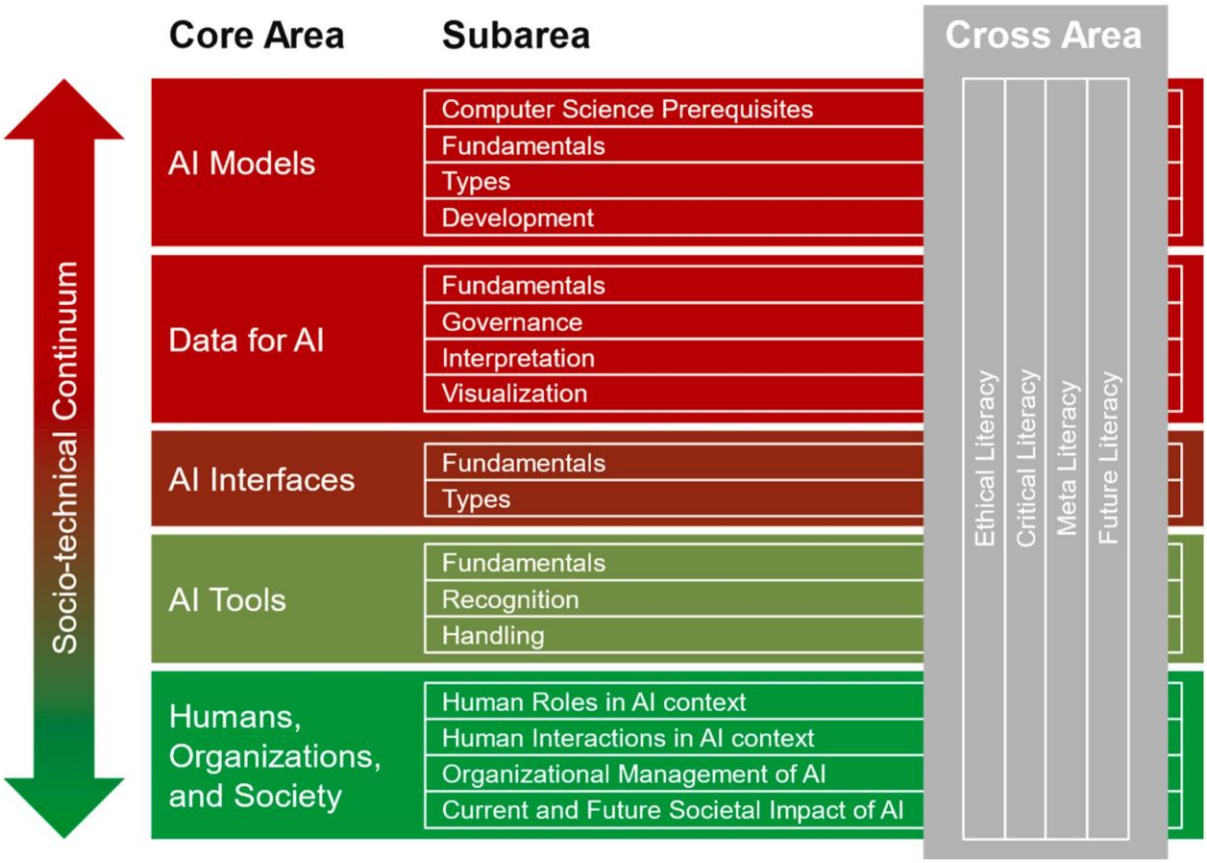
(AI) AND (Skills) AND (Labour Market) AND (Education)

We wrote the queries using syntax specific to the different library catalogues involved. Please refer to Appendix 10 for the specific queries that we ran.

After downloading the results of the queries in CSV format, we imported the results into an online service for systematic reviews (https://www.rayyan.ai). The service allowed us to automatically deduplicate the imported papers and filter and label the papers. Domain experts added 290 papers to the list for further filtering.

The initial set of papers discovered was 11,335. After deduplication, we screened the titles and abstracts of the 7420 papers that remained, yielding 1050 papers that went through a more rigorous review involving labelling on methodological quality (0-4), contribution (0-4), and the research question(s) RQ1, RQ2, and/or RQ3 the paper addressed.

To contribute to achieving D2.2 and D2.3 it was decided to focus our initial effort on retrieving those skills identified in articles that had been classified as addressing RQ2. The reason for this is that RQ1 had already been comprehensively addressed in a recently published literature review (see Pinski and Benlian, 2024). Although worthy in its own right, RQ3 was deemed irrelevant to D2.2 and D2.3, because it involves teaching methods as opposed to identifying AI related Skills Gaps and using those to generate targeted recommendations as to VET curriculum and syllabus development.



Note. This figure that summarizes the 5 core AI Literacy Areas, was produced by:Pinski, M., & Benlian, A. (2023). AI literacy-towards measuring human competency in artificial intelligence. Reprinted with permission from the authors under a Creative Commons CC-BY licence.

Hence, we selected papers for full-text coding only if they met the following criteria. The experts labelled documents for RQ2 (AI Skills Gaps Analysis), Contribution level 3 and Methodology was greater than 0. At the end of the filtering, a domain expert who was not involved in the initial screening task provided an extra 12 based on a more targetted search for methodologically rigorous means of identifying AI related skills gaps. This approach ensured that the domain experts enriched the library catalogue queries and thus increased the quality of the final output. The final count was 108 papers for full text analysis.

Finally, coding took place, and the domain experts and authors divided coded content across the NACE sections of this report. For the curious, you can find the coding book in Appendix 11 for the complete text analysis.

8.9. Systematic Data Review

How do we update advice promptly?

As mentioned previously, there is a limitation with the freshness and quality of research and the provision of recommendations. This is driven by competition in improving AI architecture and an arms race for improving models through training of virtually the whole text on the Internet. The ease of use of AI accelerates impact across all industries with the future being felt by the workers faster than other industries. Change leads to increasing capabilities and a wide range of ever-improving techniques and de facto design patterns for service delivery.

The authors launched a systematic data review to help answer the question of freshness of advice. **How do we update advice promptly?** Research papers take time to be published; at the National level, data from traditional survey methods takes time to collect, analyse and publish.

The velocity of change limits the quality of datasets and information related to AI literacy. Sources get old very quickly. The method used to define the minimal level of quality was **Chain of Trust**. Our initial selection of papers was those that have passed peer review. We then trusted the quality of the sources mentioned and those cited by the selected sources. After this filtering, we reviewed the prime candidates by downloading and manipulating a subset via R.

The authors performed a data review to address the timeliness issue of recommendations based on slowly evolving sources. We gathered data from fresh and focused information sources. The papers are then filtered for relevancy to generate recommendations. The recommendations based on the research questions defined within the research methods documentation produced earlier in the AI4VET4AI project timeline. After an initial ***review of 669 papers***, the authors determined the results based on awareness of the content of the discovered papers and the data and information sources. The author then applied a taxonomy to divide the filtered paper list into categories.

The review involved the following steps:

1. Querying the Scopus catalogue.
2. Initial filtering: Reviewing each paper for relevance, removing the less relevant from the list
3. The creation of a taxonomy
4. Review the citations within the read papers for relevance.
5. Via Google Scholar, performing a forward search, e.g., reviewing papers that cited the paper
6. Placement of the papers into the taxonomy
7. Reviewing specific data sources, organisations and repositories for relevance to research questions
8. Automate and apply a minority of the data sources via R code as graphics, tables and citations within this recommendation document.

We defined a six-part taxonomy after a studious selection of research papers and a discussion within the authoring team (TIB and UvA).

The highest valued resource was **observatories,** which were set up mainly by governance or standards bodies to observe specific trends around the impact of AI: experts and the analysis of a gold standard curate the content. Of course, not all observatories have the word observatory in their title, but many groups are effectively an observatory.

The observatories are an excellent place to start when updating recommendations. Automating web crawling and NLP to deliver notifications on specific themes is feasible based on feeds from the 30 observations discovered.

The second level of value is relevant reports that international organisations generate **periodically**. The insights and data sources are valuable for policymakers and the adjustment of recommendations.

The authors detail both Observatories and periodic reports in the appendices.

The next level in the value chain is **datahubs**, which provide primarily the raw data. Eurostat is an example of a most valued data hub. However, it is worth noting that the researchers sometimes found the datahubs needed clarification as there are interrelationships and various versions of datasets that datahubs share in different versions within the organisational networks that the hubs represent.

Next are specific, actionable **datasets**—their availability, complexity, and evolution on the Internet of an extensive data set. The datasets can be considered representative.

Repositories are less curated than observatories but are libraries of, at times, actionable documents. Observatories occasionally link specific documents from the repositories.

Two OER materials were mentioned in the literature.

The following table provides counts of the materials found by label. The total from the review was 150, of which there were thirty observatories.

Table 21: Taxonomy Count

Domain	Description	Count
DATA	A specific, actionable dataset	63
OBSERVATORY	A curated set of AI evidence that is regularly updated. The Observatories are normally setup to keep track of evolving themes of concern for a region or governance body	30
DATAHUB	A central repository of many datasets.	23
REPOSITORY	An uncurated set of publications with a subset of relevant publications	21
PERIODIC	Reports or other sources of information that are published periodically, such as every year	11
OER	OER resources. Just a few sources that example the potential	2

8.10. Future Skills and Occupations Survey

The EU-funded project AI4VET4AI is conducting a study to understand how artifical intelligence can be used to enhance the modern workplace. Specifically, we are interested in how to leverage the Vocational and Education Training (VET) systems in 11 EU countries to better prepare workplaces for the future of work.

Vocational education and training (VET) is a type of education that prepares people for a specific trade, craft, or career at various levels of education. It is designed to provide practical skills and knowledge that can be applied directly to the workplace. VET can take place at the secondary, post-secondary, or tertiary level, and can include apprenticeships, internships, and other forms of work-based learning.

This anonymous survey is intended to capture organisation data, that is, information about a whole school, training organisation, or company, and should be completed by either people working in Vocational Education and Training (VET) or Future Education and Training (FET), or by Human Resource Managers or Product Line Managers who employ people with VET qualifications. You need to have organisational knowledge on the training undertaken within your organisation.

This research survey is being conducted by the Technische Informationsbibliothek Hannover (TIB) as part of the AI4VET4AI consortium. We strive to adhere to the highest standards of transparency and openness while protecting the sensitive information collected in this study.

A comprehensive outline of the projects aims and goals including details on data collection, data protection and ethics, can be found here: Survey Data Protection and Ethics

This survey has been approved under ethics approval code: Class: 004-01/24-01/01; File no: 251-785-03-01-24-01

We strictly adhere to the regulations for GDPR. If you have any concerns or questions at any point before, during or after participating in this study, do not hesitate to contact us at: Survey.AI4VET4AI@tib.eu

For your convenience we also provide translations of this consent form in Croatian, Dutch, French, German, Greek, Italian, Serbian, Slovenian, Spanish, and Turkish

By clicking on the "next" button indicates that:

- You have read the above information
- You voluntarily agree to participate
- You are at least 18 years of age

If you do not wish to participate in the research study, please close this window.

RESPONDENT INFORMATION

ARE YOU EITHER:

- AN EDUCATOR WORKING IN THE VOCATIONAL EDUCATION AND TRAINING SYSTEM OR FUTURE EDUCATION AND TRAINING OR
- AN EMPLOYER / ENTERPRISE?

Choose one of the following answers
Please choose **only one** of the following:

Educator
Employer / Enterprise
Neither

EDUCATORS

QUESTION 1: WHAT IS YOUR CURRENT JOB TITLE?
Please write your answer here:

QUESTION 2: WHERE IS YOUR ORGANISATION APPROXIMATELY LOCATED?
Please write your answer here:

This doesn't need to be exact, just sufficient to identify country and statistical regions

QUESTION 3: WHAT ARE THE MAIN SECTORS YOUR STUDENTS ATTAIN QUALIFICATIONS IN?
Check all that apply

Please choose **all** that apply:

Agriculture, forestry and fishing
Accommodation and Food Service Activities
Administrative and Support Service Activities
Arts, Sports, and Recreation
Construction
Education
Electricity, Gas, Steam and Air Conditioning Supply
Financial and Insurance Activities
Human Health and Social Work Activities
Mining and Quarrying
Manufacturing
Professional, Scientific and Technical Activities
Public Administration and Defence
Publishing, Broadcasting, and Content Production and Distribution Activities
Real Estate Activities
Telecommunications, Computer Programming, Consultancy, Computing Infrastructure, and other Information Service Activities
Transportation and Storage
Water Supply
Wholesale and Retail Trade
Other:

Select all boxes that apply

QUESTION 4: APPROXIMATELY, HOW MANY PEOPLE WERE ENROLLED OVERALL TO STUDY WITH YOUR ORGANISATION LAST YEAR?
Only numbers may be entered in this field.
Please write your answer here:

QUESTION 5: WHICH SKILLS DO YOU THINK WILL SUPPORT THE UPTAKE OF ARTIFICIAI INTELLIGENCE (AI) AND AI RELATED TOOLS IN THE WORKPLACE?
Please write your answer here:
These skills can be any skills, not only those related directly to AI.
We define AI as "A method of information processing that allows computers ot autonomously solve problems"

EMPLOYERS

QUESTION 1: WHAT IS YOUR CURRENT JOB TITLE?
Please write your answer here:

QUESTION 2: WHERE IS YOUR DEPARTMENT OR ORGANISATION LOCATED?
Please write your answer here:

This only needs to be an approximate location to preserve you anonymity.

QUESTION 3: WHAT SECTOR IS YOUR BUSINESS IN?
If you choose 'Other:' please also specify your choice in the accompanying text field.

Please choose **only one** of the following:

- Agriculture, forestry and fishing
- Accommodation and Food Service Activities
- Administrative and Support Service Activities
- Arts, Sports, and Recreation
- Construction
- Education
- Electricity, Gas, Steam and Air Conditioning Supply
- Financial and Insurance Activities
- Human Health and Social Work Activities
- Mining and Quarrying
- Manufacturing
- Professional, Scientific and Technical Activities
- Public Administration and Defence; Compulsory Social Security
- Publishing, Broadcasting, and Content Production and Distribution Activities
- Real Estate Activities
- Telecommunications, Computer Programming, Consultancy, Computing Infrastructure, and other Information Service Activities
- Transportation and Storage

Water Supply
Wholesale and Retail Trade
Other

QUESTION 4: HOW LARGE IS YOUR ORGANIZATION?
Choose one of the following answers

Please choose **only one** of the following:

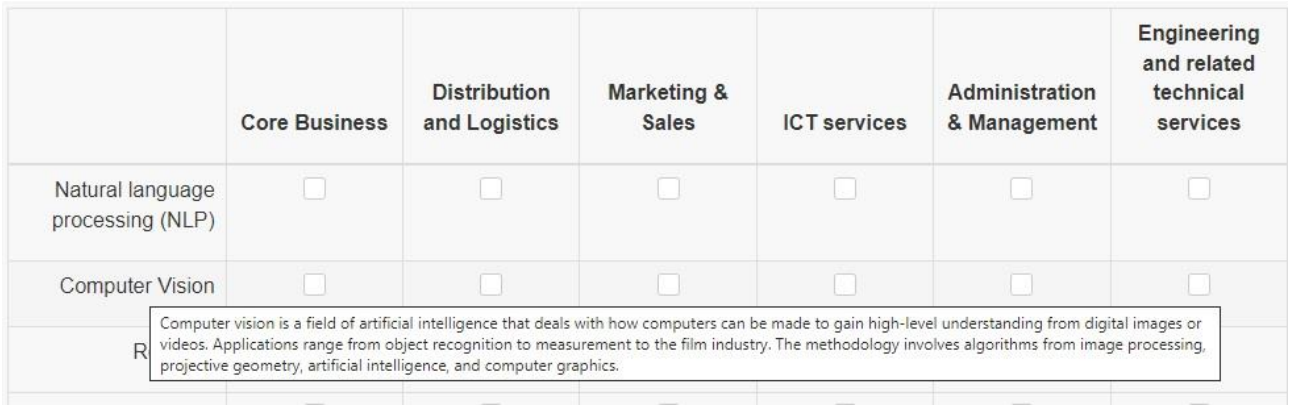
1 - 9
10 - 49
50 - 249
250+

QUESTION 5: WHICH SKILLS DO YOU THINK WILL SUPPORT THE UPTATE OF ARTIFICAL INTELLIGENCE (AI) AND AI RELATED TOOLS WITHIN YOUR ORGANISATION?
Please write your answer here:
These skills can be any skills, not only those related directly to AI.
We define AI as "A method of information processing that allows computers ot autonomously solve problems"

OCCUPATIONS

WE ARE INTERESTED IN UNDERSTANDING THE MAIN OCCUPATIONS THAT COULD BE ENHANCED THROUGH AI AND AI RELATED TOOLS. THE FOLLOWING BLOCK OF QUESTIONS REQUIRE YOU TO THINK OF A SPECIFIC OCCUPATION AND PROVIDE A DETAILED DESCRIPTION OF HOW AI COULD BE IMPLIMENTED IN THAT ROLE. WE REQUIRE AT LEAST ONE OCCUPATION TO BE ENTERED, BUT YOU CAN ADD UP TO FIVE DIFFERENT OCCUPATIONS IN TOTAL. YOU CAN EXIT THE SURVEY BY INDICATING THAT YOU DO NOT WISH TO ADD ANY MORE OCCUPATIONS.

Key terms and definitions can be found as tool tips when hovering the mouse over the term as shown in the image below:



QUESTION 6: WHAT IS AN OCCUPATION IN YOUR ORGANISATION WHICH COULD BE ENHANCED BY AI AND AI RELATED TOOLS?
Please write your answer here:
Think about ALL roles within your organisation, not just IT related roles. Include the number of people employed with this occupation and the amount of training undertaken.

QUESTION 7: WHAT BUSINESS FUNCTION DOES THIS OCCUPATION TYPICALLY PERFORM?
Check all that apply

Please choose **all** that apply:

- Core Business
- Distribution and Logistics
- Marketing & Sales
- ICT services
- Administration & Management
- Engineering and related technical services
- Research & Development (R & D)

Hover the mouse over the text for definitions and examples

QUESTION 8: HOW MANY PEOPLE WITH THIS OCCUPATION DO YOU CURRENTLY EMPLOY OR TRAIN IN A YEAR?
Only numbers may be entered in this field.

Please write your answer here:

QUESTION 9: IS THE TYPICAL EDUCATIONAL REQUIREMENTS FOR THIS OCCUPATION ATTAINED FROM UNIVERSITY OR THROUGH VOCATIONAL / FURTHER EDUCATION AND TRAINING (VET/FET)?

Choose one of the following answers

Please choose **only one** of the following:

- University
- VET / FET
- Both
- Other

QUESTION 10: WHAT AMOUNT OF TRAINING WOULD ONE PERSON IN THIS OCCUPATION RECIEVE EACH YEAR?
Please write your answer here:

Include Units of Measurement (Hours / ECTS points / ECVET points)

QUESTION 11: WHAT TYPE OF AI IS CURRENTLY USED OR TRAINED IN YOUR ORGANIZATION FOR THIS OCCUPATION? YOU CAN ADD COMMENTS AS REQUIRED AND TICK ALL BOXES THAT APPLY.
Comment only when you choose an answer.

Please choose all that apply and provide a comment:

- Natural language processing (NLP)
- Computer Vision
- Robotics
- Expert Systems
- Intelligent Agents

Speech Recognition
Emotion Recognition
Recommendation Systems
Generative Models
Other:

Hover over the terms with your mouse to get definitions and examples.

QUESTION 12: WHAT TYPE OF AI DO YOU PREDICT WILL BE USED OR TRAINED IN YOUR ORGANIZATION FOR THIS OCCUPATION IN 5 YEARS TIME? YOU CAN ADD COMMENTS AND TICK ALL BOXES THAT APPLY.
Comment only when you choose an answer.

Please choose all that apply and provide a comment:
Natural language processing (NLP)
Computer Vision
Robotics
Expert Systems
Intelligent Agents
Speech Recognition
Emotion Recognition
Recommendation Systems
Generative Models
Other:
Hover over the terms with your mouse to get definitions and examples.

DO YOU WANT TO ADD ANOTHER OCCUPATION? *
Choose one of the following answers

Please choose **only one** of the following:
Yes
No

8.11. Expert Interview Protocol

FUTURE OF AI SKILLS IN VET - DELPHI METHOD EXPERT FEEDBACK

This is the portal for entering in Expert Opinions on the future of AI Skills in Vocational Education and Training (sometimes referered to as Further Education and Training).

Please submit all responses in English.

This questionnaire is the 1st round of input. You will be contacted for a 2nd round of input in the coming months where the combined responses of experts will be evaluated by the experts themselves.

Ethics approval has been granted for this research from the project coordinating parner, Algebra University, under ethics approval class: 004-01/24-01/01 and File no: 251-785-03-01-24-01

Should you require any additional help, please contact survey.AI4VET4AI@tib.eu

There are 12 questions in this survey.

EXPERT INFORMATION

QUESTION 1: WHAT STAKEHOLDER CATEGORY DOES THE EXPERT REPRESENT?
Please choose **all** that apply:

- VET Organisations
- HEI Organisation
- VET Teachers and Trainers
- VET Students
- VET Life-long learners
- HEI Students
- HEI Teachers
- Research Organisation
- Sector Representative / Industry Body
- Enterprise / Company
- Entrepreneur
- Technology Provider

QUESTION 2: WHAT IS THE EXPERTS CURRENT JOB TITLE?
Please write your answer here:

QUESTION 3: WHERE IS THE EXPERT OR THEIR ORGANISATION APPROXIMATELY LOCATED?
Please write your answer here:

This doesn't need to be exact, just sufficient to identify country and statistical regions

QUESTION 4: WHAT ARE THE MAIN SECTORS THE EXPERT WORKS WITH?

Please choose **all** that apply:

- Agriculture, forestry and fishing
- Accommodation and Food Service Activities
- Administrative and Support Service Activities
- Arts, Sports, and Recreation
- Construction
- Education
- Electricity, Gas, Steam and Air Conditioning Supply
- Financial and Insurance Activities
- Human Health and Social Work Activities
- Mining and Quarrying
- Manufacturing
- Professional, Scientific and Technical Activities
- Public Administration and Defence
- Publishing, Broadcasting, and Content Production and Distribution Activities
- Real Estate Activities
- Telecommunications, Computer Programming, Consultancy, Computing Infrastructure, and other Information Service Activities
- Transportation and Storage
- Water Supply
- Wholesale and Retail Trade
- Other:

Select all boxes that apply

QUESTION 5: HOW MANY YEARS EXPERIENCE DO THEY HAVE WITH THEIR CURRENT PROFESSION?
Please write your answer here:

DELPHI QUESTIONS

QUESTION 6: IN YOUR OPINION, WHAT ARE GOING TO BE THE MOST VALUABLE SKILLS CURRENTLY REQUIRED TO USE AI?
Please write your answer here:

QUESTION 7: WHAT SKILLS ARE GOING TO BE THE MOST VALUBLE FOR USING AI IN THE FUTURE?
Please write your answer here:

QUESTION 8: ARE THERE SKILLS YOU WOULD CONSIDER PREREQUISITE SKILLS BEFORE SOMEONE CAN USE OR IMPLIMENT AI?
Please write your answer here:

QUESTION 9: WHAT ARE THE BIGGEST CHALLENGES IN TRAINING PEOPLE IN AI RELATED SKILLS?
Please write your answer here:

QUESTION 10: WHAT ARE THE BEST RESOURCES AND METHODS FOR TRAINING AI RELATED SKILLS?

Please write your answer here:

QUESTION 11: HOW WOULD YOU GO ABOUT TEACHING THESE SKILLS IN LOW-TECH LEARNING SPACE WHERE DIGITAL RESOURCES ARE SCARCE?
Please write your answer here:

QUESTION 12: IF YOU COULD AUTOMATE ANY TASK YOU CURRENTLY PERFORM, WHAT WOULD THAT TASK BE?
Please write your answer here:

Submit your survey.

Thank you for completing this survey.

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8.12. Glossary of terms

Due to the mixed methods approach and the complexity of the recommendations we are trying to elucidate, the glossary section contains analytic terminology and organisational abbreviations, standards skills and Economic labels.

Terms	Description
AI watch	AI Watch is the artificial intelligence website of the European Commission's Joint Research Centre (JRC), which presents the outputs of our activities in Trustworthy AI.
Artificial Intelligence	Artificial intelligence (AI) refers to computer systems capable of performing complex tasks that historically only a human could do, such as reasoning, making decisions, or solving problems. Today, the term "AI" describes a wide range of technologies that power many of the services and goods we use every day
Bibliometrics	Bibliometrics is the application of statistical methods to the study of bibliographic data, especially in scientific and library and information science contexts, and is closely associated with scientometrics (the analysis of scientific metrics and indicators) to the point that both fields largely overlap.
Competencies	The proven ability to use knowledge, skills, and personal, social, and/or methodological abilities, in work or study situations and in professional and personal development. Competencies are described in terms of responsibility and autonomy, and they typically refer to the ability of a person to apply knowledge and skills in an independent and self-directed way, especially when facing new situations and unforeseen challenges.
CSV	(Comma-Separated Values): A file format used to store tabular data, such as a spreadsheet or database, in plain text. Each line of the file is a data record, with individual records separated by line breaks and each field within the record separated by commas. Fields that contain a comma, line break, or double-quote are typically enclosed in double-quotes. CSV files are widely supported by many applications, particularly for data exchange and import/export operations

Datahubs	A location where a range of data are accessible on a specific theme
Deep Learning	Deep learning is the subset of machine learning methods based on neural networks with representation learning. The adjective "deep" refers to the use of multiple layers in the network. Deep Learning is a subset of The field Machine Learnng which itself is within the field of Artificial Intelligence
Delphi method	The Delphi method is like a group project where instead of meeting in person, experts in a particular field answer questionnaires in several rounds. After each round, everyone's answers are collected and summarized, and then shared with the group. This lets the experts see what the others think and adjust their next set of answers accordingly. It's a bit like a game of 'guess what everyone is thinking' until the group reaches a common understanding or decision. It's a way to make sure that everyone's expert opinion is considered and that the final decision is something they all agree on
ESCO	The ESCO classification identifies and categorises skills, competences, and occupations relevant for the EU labour market and education and training. It systematically shows the relationships between the different concepts.
EUROSTAT	Our mandate: Eurostat is the statistical office of the European Union. Our mission: Our mission is to provide high-quality statistics and data on Europe.
JSON	(JavaScript Object Notation) is a lightweight data-interchange format. It is easy for humans to read and write. It is easy for machines to parse and generate.
LLM	Large language models (LLM) are very large deep learning models that are pre-trained on vast amounts of data. The underlying transformer is a set of neural networks that consist of an encoder and a decoder with self-attention capabilities. The encoder and decoder extract meanings from a sequence of text and understand the relationships between words and phrases in it.
NACE	he Statistical classification of economic activities in the European Community, abbreviated as NACE, is the classification of economic activities in the European Union (EU); the term NACE is derived from the French

	Nomenclature statistique des activités économiques dans la Communauté européenne. Various NACE versions have been developed since 1970. NACE is a four-digit classification providing the framework for collecting and presenting statistical data according to economic activity in a wide variety of European statistics in the economic, social, environmental, and agricultural domains.
NUTS	The NUTS classification (Nomenclature of territorial units for statistics) is a hierarchical system for dividing up the economic territory of the EU for the purpose of: the collection, development and harmonisation of European regional statistics socio-economic analyses of the regions NUTS 1: major socio-economic regions NUTS 2: basic regions for the application of regional policies NUTS 3: small regions for specific diagnoses
Observatory	An online location where experts currate content for a wide audience on a specific subject such as AI. AI Watch is one expample of an observatory
OER	Open Educational Resources (OER) OER are freely and publicly available teaching, learning, and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use and re-purposing by others.
Prisma method	The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) is a 27-item checklist used to improve transparency in systematic reviews.
R package	You can call libraries of functions that are helpful on specific themes in R. Much hard work has gone into these packages. Therefore, we should acknowledge the package writers contributions
Skills	The term skill refers typically to the use of methods or instruments in a particular setting and in relation to defined tasks. The terms skill and competence can be distinguished according to their scope. The term competence is broader and refers typically to the ability of a person - facing new situations and unforeseen challenges - to use and apply knowledge and skills in an independent and self-directed way.

9. Appendices

Appendix 1: Eurostat structure

The hierarchy in the Eurostat datasets is organised as a navigation tree with multiple levels:

- Themes: The broadest categories under which data is grouped, such as 'Economy and finance' or 'Population and social conditions'.
- Categories: Within each theme, there are specific categories like 'National accounts' or 'Population structure and ageing'.
- Subcategories: These are more detailed classifications within each category.
- Datasets: Under the subcategories, you will find the individual datasets that contain the actual data.

Table 22: The first two levels of the Eurostat theme hierarchy

Theme
General and regional statistics
European and national indicators for short-term analysis
Regional statistics by NUTS classification
Regional statistics by typology
Degree of urbanisation
City statistics
Other sub-national statistics
Land cover and land use, landscape (LUCAS)
Non EU countries
Economy and finance
National accounts (ESA 2010)
Government statistics
Exchange rates
Interest rates
Prices
Balance of payments - International transactions
Balance of payments - International transactions (BPM6)

Population and social conditions
Population and housing censuses
Demography, population stock and balance
Population projections
Migration
Health
Disability
Education and training
Labour market
Living conditions and welfare
Income, consumption and wealth - experimental statistics
Social protection
Culture
Sport
Crime and criminal justice
Industry, trade and services
Short-term business statistics
Business structure and dynamics
Globalisation in business statistics
Tourism
Agriculture, forestry and fisheries
Agriculture
Forestry
Fisheries
International trade
International trade in goods
International trade in services
Transport

Multimodal data
Railway transport
Road transport
Inland waterways transport
Oil pipeline transport
Maritime transport
Air transport
Environment and energy
Environment
Energy
Science, technology, digital society
Science and technology
Digital economy and society
Tables on EU policy
Macroeconomic imbalance procedure indicators
Euro indicators / PEEIs
Circular economy indicators
Sustainable development indicators
Employment and social policy indicators
European pillar of social rights (EPSR)
Cross cutting topics
Quality of life
Migrant integration and children in migration
Economic globalisation indicators
Equality and non-discrimination
Quality of employment
Agri-environmental indicators
Climate change

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Skills-related statistics
Youth

Table 23: The count of datasets across theme level

Note: The majority of themes are between theme level 5-6 suggesting a relative detailed focus.

Hierarchy Level	Count
0	2
1	11
2	64
3	395
4	1.877
5	3.664
6	3.802
7	1.271
8	147
9	21

Table 24: The number of available datasets vs the year last updated.

Note: The average freshness of data lags approximately two years behind the current date.

Year	Datasets
2025	5
2024	484
2023	2,644
2022	1,850
2021	718
2020	654
2019	428
2018	271

Appendix 2: R packages

The following R packages mentioned next were extensively used during the processing and reporting of specific sets of data mostly from Eurostat.

A2.1. Table of Purposes

Table 25: Package descriptions and citation

Package	Description	Citation
countrycode	The countrycode package is designed to standardise country names and convert them into over 40 different coding schemes.	Arel-Bundock, Enevoldsen, and Yetman (2018)
dplyr	Eases the burden to manipulate data	Wickham et al. (2023)
eurostat	Allows us to search and retrieve data systematically from Eurostat	Lahti et al. (2017)
flextable	Creates tables in a variety of formats and themes	Gohel and Skintzos (2024)
ggplot2	Creates great looking charts	Wickham (2016)
ggthemes	Adds extra themes and graphics options for ggplot2	Arnold (2024)
jsonlite	Allow us to convert JSON from web API's into a format readable by R	Ooms (2014)
knitr	Used for dynamic document generation	Xie (2024)
R	The R programming Language	R Core Team (2024)
readr	Allows us to read CSV files	Wickham, Hester, and Bryan (2024)
sf	Handles spatial data by providing classes and methods to work with spatial vector data, such as points, lines, and polygons	Pebesma and Bivand (2023)
tm	Good at cleaning and mining text	Feinerer and Hornik (2024)
wordcloud	To create word clouds	Fellows (2018)

A2.2. Package Citations

Package citations:

- Arel-Bundock, Vincent, Nils Enevoldsen, and CJ Yetman. 2018. "Countrycode: An r Package to Convert Country Names and Country Codes" 3: 848. https://doi.org/10.21105/joss.00848.
- Arnold, Jeffrey B. 2024. "Ggthemes: Extra Themes, Scales and Geoms for 'Ggplot2'." https://CRAN.R-project.org/package=ggthemes.
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- Fellows, Ian. 2018. "Wordcloud: Word Clouds." https://CRAN.R-project.org/package=wordcloud.
- Gohel, David, and Panagiotis Skintzos. 2024. "Flextable: Functions for Tabular Reporting." https://CRAN.R-project.org/package=flextable.
- Lahti, Leo, Janne Huovari, Markus Kainu, and Przemyslaw Biecek. 2017. "Retrieval and Analysis of Eurostat Open Data with the Eurostat Package" 9. https://doi.org/10.32614/RJ-2017-019.
- Ooms, Jeroen. 2014. "The Jsonlite Package: A Practical and Consistent Mapping Between JSON Data and r Objects." https://arxiv.org/abs/1403.2805.
- Pebesma, Edzer, and Roger Bivand. 2023. "Spatial Data Science: With Applications in r." https://doi.org/10.1201/9780429459016.

- R Core Team. 2024. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. https://www.R-project.org/.
- Wickham, Hadley. 2016. "Ggplot2: Elegant Graphics for Data Analysis." https://ggplot2.tidyverse.org.
- Wickham, Hadley, Romain François, Lionel Henry, Kirill Müller, and Davis Vaughan. 2023. "Dplyr: A Grammar of Data Manipulation." https://CRAN.R-project.org/package=dplyr.
- Wickham, Hadley, Jim Hester, and Jennifer Bryan. 2024. "Readr: Read Rectangular Text Data." https://CRAN.R-project.org/package=readr.
- Xie, Yihui. 2024. "Knitr: A General-Purpose Package for Dynamic Report Generation in r." https://yihui.org/knitr/

Appendix 3: ESCO AI Occupations

At the time of writing the three occupations that specifically mention artificial intelligence are in the following table:

Table 26: ESCO occupations where AI is explicitly mentioned in the description

Title	Description
computer vision engineer	Computer vision engineers research, design, develop, and train artificial intelligence algorithms and machine learning primitives that understand the content of digital images based on a large amount of data. They apply this understanding to solve different real-world problems such as security, autonomous driving, robotic manufacturing, digital image classification, medical image processing and diagnosis, etc.
ICT intelligent systems designer	ICT intelligent systems designers apply methods of artificial intelligence in engineering, robotics and computer science to design programs which simulate intelligence including thinking models, cognitive and knowledge-based systems, problem solving, and decision making. They also integrate structured knowledge into computer systems (ontologies, knowledge bases) in order to solve complex problems normally requiring a high level of human expertise or artificial intelligence methods.
knowledge engineer	Knowledge engineers integrate structured knowledge into computer systems (knowledge bases) in order to solve complex problems normally requiring a high level of human expertise or artificial intelligence methods. They are also responsible for eliciting or extracting knowledge from information sources, maintaining this knowledge, and making it available to the organisation or users. To achieve this, they are aware of knowledge representation and maintenance techniques (rules, frames, semantic nets, ontologies) and use knowledge extraction techniques and tools. They can design and build expert or artificial intelligence systems that use this knowledge.

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Appendix 4: ESCO AI Skills

The skills that specifically mention artificial intelligence are in the following table:

Table 27: ESCO skills where AI is explicitly mentioned in the description

Title	Description
human-robot collaboration	Human-Robot Collaboration is the study of collaborative processes in which human and robot agents work together to achieve shared goals. Human-Robot Collaboration (HRC) is an interdisciplinary research area comprising classical robotics, human-computer interaction, artificial intelligence, design, cognitive sciences and psychology. It is related to the definition of the plans and the rules for communication to perform a task and achieve a goal in a joint action with a robot.
data mining	The methods of artificial intelligence, machine learning, statistics and databases used to extract content from a dataset.
machine learning	The principles, methods and algorithms of machine learning, a subfield of artificial intelligence. Common machine learning models such as supervised or unsupervised models, semi- supervised models and reinforcement learning models.
perform data mining	Explore large datasets to reveal patterns using statistics, database systems or artificial intelligence and present the information in a comprehensible way.
emergent technologies	The recent trends, developments and innovations in modern technologies such as biotechnology, artificial intelligence and robotics.
artificial neural networks	A network of artificial neurons composed for solving artificial intelligence problems. These computing systems are inspired by the biological neural networks that constitute brains. Understanding of its general model and its elements. Knowledge of its use possibilities for automation.
teach computer science	Instruct students in the theory and practice of computer science, more specifically in the development of software systems, programming languages, artificial intelligence, and software security.
principles of artificial intelligence	The artificial intelligence theories, applied principles, architectures and systems, such as intelligent agents, multi-agent systems, expert systems, rule-based systems, neural networks, ontologies and cognition theories.
deep learning	The principles, methods and algorithms of deep learning, a subfield of artificial intelligence and machine learning. Common neural networks like perceptrons, feed-forward, backpropagation, and convolutional and recurrent neural networks.

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Appendix 5: ESCO Digital Skills collection

1.201 ESCO skills and knowledge concepts are now labelled as *digital*. The following are the digital skills collection:

Table 28: ESCO digital skills collection

Title	Description
solve technical problems	Identify technical problems when operating devices and using digital environments, and solve them (from trouble-shooting to solving more complex problems).
engage in citizenship through digital technologies	Participate in society through the use of public and private digital services. Seek opportunities for self-empowerment and for participatory citizenship through appropriate digital technologies.
creatively use digital technologies	Use digital tools and technologies to create knowledge and to innovate processes and products. Engage individually and collectively in cognitive processing to understand and resolve conceptual problems and problem situations in digital environments.
evaluate data, information and digital content	Analyse, compare and critically evaluate the credibility and reliability of sources of data, information and digital content. Analyse, interpret and critically evaluate the data, information and digital content.
computer programming	The techniques and principles of software development, such as analysis, algorithms, coding, testing and compiling of programming paradigms (e.g. object oriented programming, functional programming) and of programming languages.
identify digital competence gaps	Understand where one's own digital competence needs to be improved or updated. Be able to support others with their digital competence development. Seek opportunities for self-development and keep up-to-date with the digital evolution.
collaborate through digital technologies	Use digital tools and technologies for collaborative processes, and for co-construction and co-creation of resources and knowledge.
protect personal data and privacy	Protect personal data and privacy in digital environments. Understand how to use and share personally identifiable information while being able to protect oneself and others from damages. Understand that digital services use a "Privacy policy" to inform how personal data is used.
share through digital technologies	Share data, information and digital content with others through appropriate digital technologies. Act as an intermediary, know about referencing and attribution practices.
ICT safety	Personal protection, data protection, digital identity protection, security measures, safe and sustainable use.

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identify technological needs	Assess needs and identify digital tools and possible technological responses to address them. Adjust and customise digital environments to personal needs (e.g. accessibility).
manage data, information and digital content	Organise, store and retrieve data, information and content in digital environments. Organise and process them in a structured environment.
digital communication and collaboration	Communicate in digital environments, share resources through online tools, link with others and collaborate through digital tools, interact with and participate in communities and networks, cross-cultural awareness.
integrate and re-elaborate digital content	Modify, refine, improve and integrate information and content into an existing body of knowledge to create new, original and relevant content and knowledge.
develop digital content	Create and edit digital content in different formats, express oneself through digital means.
digital data processing	Identify, locate, retrieve, store, organise and analyse digital information, judging its relevance and purpose.
problem-solving with digital tools	Identify digital needs and resources, make informed decisions on most appropriate digital tools according to the purpose or need, solve conceptual problems through digital means, creatively use technologies, solve technical problems, update own and other's competence.
use online conventions of etiquette	Apply behavioural norms and know-how while using digital technologies and interacting in digital environments. Adapt communication strategies to the specific audience and be aware of cultural and generational diversity in digital environments.
interact through digital technologies	Interact through a variety of digital technologies and understand appropriate digital communication means for a given context.
copyright and licenses related to digital content	Understand how copyright and licences apply to data, information and digital content.
manage digital identity	Create and manage one or multiple digital identities, be able to protect one's own reputation, deal with the data that one produces through several digital tools, environments and services.
protect the environment from the impact of the digital technologies	Be aware of the environmental impact of digital technologies and their use.
protect health and well-being while using digital technologies	Be able to avoid health-risks and threats to physical and psychological well-being while using digital technologies. Be able to protect oneself and others from possible dangers in digital environments (e.g. cyber bullying). Be aware of digital technologies for social well-being and social inclusion.
protect ICT devices	Protect devices and digital content, and understand risks and threats in digital environments. Know about safety and security measures and have due regard to reliability and privacy. Make use of tools and methods which maximise security of ICT devices and information by controlling access, such as

	passwords, digital signatures, biometry, and protecting systems such as firewall, antivirus, spam filters.
browse, search and filter data, information and digital content	Articulate information needs, search for data, information and content in digital environments, access them and navigate between them. Create and update personal search strategies.
digital content creation	Create and edit new content (from word processing to images and video); integrate and re-elaborate previous knowledge and content; produce creative expressions, media outputs and programming; deal with and apply intellectual property rights and licences.

Appendix 6: Observatories

Here are links to AI observatories or direct links to relevant aspects of the observatory.

Table 29: List of observatories associated to AI themes

Title	Details	URL
CEDEFOP - Vocational education and training in Europe. Detailed description of VET systems in Europe	This database is the main source of information about vocational education and training (VET) systems in the European Union, Iceland and Norway	https://www.cedefop.europa.eu/en/tools/vet-in-europe/systems/
DESI - Visualization	From 2014 to 2022, the Digital Economy and Society Index (DESI) summarised indicators on Europe's digital performance and tracked the progress of EU countries.	https://digital-decade-desi.digital-strategy.ec.europa.eu/
European Composite Indicators	European Scorecards (149 - Dec 2023)	https://composite-indicators.jrc.ec.europa.eu/explorer/explorer/indices-and-scoreboards
OECD AI policy Observatory	A global hub for AI policy OECD.AI's tools, data and other AI policy resources are freely accessible to all actors and stakeholder groups in developed and developing countries.	https://oecd.ai/en/
OECD AI policy Observatory - Education	A global hub for AI policy OECD.AI's tools, data and other AI policy resources are freely accessible to all actors and stakeholder groups in developed and developing countries.	https://oecd.ai/en/dashboards/policy-areas/PA7
OECD AI policy Observatory - AI & the digital economy	A global hub for AI policy OECD.AI's tools, data and other AI policy resources are freely accessible to all actors and stakeholder groups in developed and developing countries.	https://oecd.ai/en/dashboards/policy-areas/PA5
OECD AI policy Observatory - AI & Economy	A global hub for AI policy OECD.AI's tools, data and other AI	https://oecd.ai/en/dashboards/policy-areas/PA6

	policy resources are freely accessible to all actors and stakeholder groups in developed and developing countries.	
AI Observatory Africa	Snapshot of incident database	https://www.africanobservatory.ai/about
AI Standards Hub-Research & Analysis	Find information on AI-related research & analysis using the search and filtering capabilities below. This database currently covers nearly 300 relevant standards that are being developed or have been published by a range of prominent Standards Development Organisations.	https://aistandardshub.org/research-and-analysis-search/
OECD programme on AI in Work, Innovation, Productivity and Skills - AI Diffusion	OECD programme on AI in Work, Innovation, Productivity and Skills	https://oecd.ai/en/work-innovation-productivity-skills/key-themes/ai-diffusion
AI incident database	The AI Incident Database is an incident collection initiated by an industrial/non-profit cooperative to enable AI incident avoidance and mitigation. The database supports a variety of research and development use cases with faceted and full text search on more than 2,000 incident reports archived to date.	https://incidentdatabase.ai
AI Watch - Observatory	Searchable set of curated publications	https://ai-watch.ec.europa.eu/publications_en
AI on Demand - Educational Resources	Welcome to the Education Catalog! Here you can browse, search and access all the AI education resources currently indexed in the AI4EU AI-on-demand platform, including distance courses, onsite courses, and more.	https://www.ai4europe.eu/education/education-catalog
AI4K12 - Learning Materials	The Artificial Intelligence (AI) for K-12 initiative (AI4K12) is jointly sponsored by AAAI and CSTA. The initiative is developing (1)	https://ai4k12.org/resources/list-of-resources/

	national guidelines for AI education for K-12, (2) an online, curated resource Directory to facilitate AI instruction, and (3) a community of practitioners, researchers, resource and tool developers focused on the AI for K-12 audience. Check out the following information to learn about this initiative.	
AI4Media - Resources	The European AI Media Observatory is a knowledge platform that monitors and curates relevant research on AI in media, provides expert perspectives on the potentials and challenges that AI poses for the media sector and allows stakeholders to easily get in touch with relevant experts in the field via our directory.	https://www.ai4media.eu/resources-library/
AI4Media - Feed	The European AI Media Observatory is a knowledge platform that monitors and curates relevant research on AI in media, provides expert perspectives on the potentials and challenges that AI poses for the media sector and allows stakeholders to easily get in touch with relevant experts in the field via our directory.	https://www.ai4media.eu/your-ai-media-feed/
CEDEFOP - Online Tools	Cedefop is one of the EU's decentralised agencies. Founded (1) in 1975 and based in Greece since 1995, Cedefop supports development of European vocational education and training (VET) policies and contributes to their implementation. The agency is helping the European Commission, EU Member States and the social partners to develop the right European VET policies. Cedefop: helping develop the right policies to provide the right skills	https://www.cedefop.europa.eu/en/online-tools

Global Observatory of Urban Artificial Intelligence (GOUAI)	The Global Observatory of Urban Artificial Intelligence (GOUAI) is a joint project of CIDOB (Barcelona Centre for International Affairs), and the cities of Barcelona, Amsterdam, and London with the support of UNHabitat. It falls within the frame of the Cities Coalition for Digital Rights, an international city network association that puts together more than 45 cities in the world committed to technological sovereignty and to the promotion of digital rights. GOUAI fills the gap of the lack of consensus and actionable research taking into consideration the local context and aims to contribute to the development of standards through the monitoring of AI initiatives and the research and reflection on key technological issues around AI. The goal is to promote ethical artificial intelligence systems in cities and ensure that algorithmic tools are sustainable, fair, aligned to democratic values, accountable, transparent, cyber secure, and that they safeguard people's digital rights.	https://gouai.cidob.org/resources/
OCEANIS	The Open Community for Ethics in Autonomous and Intelligent Systems (OCEANIS) will provide a high level global forum for discussion, debate and collaboration for organisations interested in the development and use of standards to further the development of autonomous and intelligent systems.	https://ethicsstandards.org/repository/
Map of Science - AI	TO's Map of Science collects and organises the world's research literature, revealing key trends, hotspots, and concepts in global science and technology.	https://sciencemap.eto.tech/?all_subjects=artificial+intelligence&mode=summary

	The Map of Science includes hundreds of millions of scholarly publications from around the world, algorithmically organised into over 85,000 research clusters. These clusters are groups of papers that cite each other a lot - typically because they share other things in common, such as subject matter, language of publication, or other important characteristics. By filtering clusters according to growth, key topics, countries, and other characteristics, you can quickly pinpoint scientific trends and communities.	
DS4Skills - Inventory of Skills and data	The Data Space for Skills (DS4Skills) is a 1-year project aiming to prepare the ground for the development of an open and trusted European Data Space for Skills that supports sharing and accessing skills data.It is funded by the European Commission under the Digital Europe Programme and involves 14 ambitious partners from the industry, education and data ecosystem sectors.	https://inventory.skillsdataspace.eu
ARTIFICIAL INTELLIGENCE AND DEMOCRATIC VALUES - Library	The < AI & Equality > Toolbox is a collaboration between Women at the Table and EPFL, in consultation with OHCHR.	https://aiequalitytoolbox.com/library/
India AI	Envisioned as an umbrella programme by the Ministry of Electronics and Information Technology (MeitY) for leveraging transformative technologies to foster inclusion, innovation, and adoption for social impact. Consequently, INDIAai (The National AI Portal of India) is poised to assume the pivotal role of a content repository for the INDIAai programme.	https://indiaai.gov.in/

AI in Health Observatory - Tools	The AI in Health Observatory has already identified more than 100 Artificial Intelligence tools in Health from the Catalan Health System (SISCAT), research centres, universities and companies.	https://iasalut.cat/en/observatori-ia-en-salut/registre-dalgorismes/
AI Observatory - Policy	Observatory on AI Policies in Canadian Post-Secondary Education	https://higheredstrategy.com/ai-observatory-home/ai-observatory-policies-and-guidelines/
AI Observatory - Research	Observatory on AI Policies in Canadian Post-Secondary Education	https://higheredstrategy.com/ai-observatory-home/ai-observatory-news-and-research/
AI Standards Hub - Policy	UK - Find AI-related documents published by governmental and other official sources within your area of interest.	https://aistandardshub.org/policy-and-strategy-search/
AI Standards Hub- Standards	Find information on AI-related standards using the search and filtering capabilities below. This database currently covers nearly 300 relevant standards that are being developed or have been published by a range of prominent Standards Development Organisations.	https://aistandardshub.org/ai-standards-search/
AI Landscape Startups	It is essential to shine a light on the top AI startups in Europe in order to drive AI adoption and create more partnership opportunities between startups and corporations. By creating a centralized database of quality AI startups, corporations and SMEs will have easier access to AI partners they can trust. With the objective to foster and accelerate AI in Europe, the appliedAI Institute for Europe (Germany), Hub France IA, Ignite Sweden, AI Sweden, RISE Research Institutes of Sweden (Sweden) and the Netherlands AI Coalition (NL AIC) came together in early 2020 to start the initial steps in mapping	https://www.ai-startups-europe.eu/

	the AI startup ecosystem in Europe.	
Global Index AI	The Global Index is designed to equip governments, civil society, and stakeholders with the evidence needed to advance rights-based principles for the responsible use of AI	https://global-index.ai/

Appendix 7: Periodic Reports

Table 30: List of periodic reports associated to AI themes

Title	Details	URL
Standford AI Index	The AI Index is an independent initiative at the Stanford Institute for Human-Centered Artificial Intelligence (HAI), led by the AI Index Steering Committee, an interdisciplinary group of experts from across academia and industry. The annual report tracks, collates, distills, and visualizes data relating to artificial intelligence, enabling decision-makers to take meaningful action to advance AI responsibly and ethically with humans in mind.	https://aiindex.stanford.edu/report/
WIPO The Future of Jobs Report	The Future of Jobs Report 2023 explores how jobs and skills will evolve over the next five years. This fourth edition of the series continues the analysis of employer expectations to provide new insights on how socio-economic and technology trends will shape the workplace of the future.	https://www.weforum.org/publications/the-future-of-jobs-report-2023/
OECD Employment Outlook	OECD's annual report on jobs and employment in OECD countries. Each edition reviews recent trends, policy developments, and prospects. A statistical annex provides data on unemployment rates, incidence of part-time employment, employment/population ratios, and activity rates. Also included are data on expenditure on labour market programmes, average annual wages, and earnings dispersion. Special Chapters examine issues of topical interest.	https://www.oecd-ilibrary.org/employment/oecd-employment-outlook-2023_08785bba-en
Global Innovation Index	The Global Innovation Index (GII) takes the pulse of innovation against a background of an economic and geopolitical environment fraught with uncertainty. It reveals the most innovative economies in the world, ranking the innovation performance of around 132 economies while highlighting innovation strengths and weaknesses.	https://www.wipo.int/global_innovation_index/en/
Global Innovation Index - Dashboard	The Global Innovation Index (GII) takes the pulse of innovation against a background of an economic and geopolitical environment fraught with uncertainty. It reveals the most innovative economies in the world, ranking the innovation performance of around 132 economies while highlighting innovation strengths and weaknesses.	https://www.wipo.int/gii-ranking/en/

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UN E-Government Survey 2022	The United Nations E-Government Survey 2022 is the 12th edition of the United Nations' assessment of the digital government landscape across all 193 Member States. The E-Government Survey is informed by over two decades of longitudinal research, with a ranking of countries based on the United Nations E-Government Development Index (EGDI), a combination of primary data (collected and owned by the United Nations Department of Economic and Social Affairs) and secondary data from other UN agencies. This edition of the Survey includes data analysis in global and regional contexts, a study of local e-government development based on the United Nations Local Online Service Index (LOSI), consideration of inclusion in the hybrid digital society, and a concluding chapter that outlines the trends and developments related to the future of digital government. As wish all editions, it features extensive annexes on its data, methodology and related pilot study initiatives.	https://publicadministration.un.org/egovkb/en-us/Reports/UN-E-Government-Survey-2022
GovTech Maturity Index	The GovTech Maturity Index (GTMI) was developed as part of the GovTech Initiative to introduce a measure of GovTech maturity in four focus areas — supporting core government systems, enhancing service delivery, mainstreaming citizen engagement, and fostering GovTech enablers— and to assist practitioners in the design of new digital transformation projects. Constructed for 198 economies, the GTMI is the most comprehensive measure of digital transformation in the public sector. The GTMI is not intended to create a ranking or assess a country's readiness for or performance of GovTech; rather, it is intended to complement existing tools and diagnostics by providing a baseline and benchmark for GovTech maturity and identifying areas for improvement.	https://www.worldbank.org/en/programs/govtech/gtmi
ARTIFICIAL INTELLIGENCE AND DEMOCRATIC VALUES - Report	n 2020, the Center for AI and Digital Policy published the first worldwide assessment of AI policies and practices. Artificial Intelligence and Democratic Values rated and ranked 30 countries, based on a rigorous methodology and 12 metrics established to assess alignment with democratic values. The 2021 AI Index expands the global coverage from 30 countries to 50 countries, acknowledges the significance of the UNESCO Recommendation on AI ethics, and reviews earlier country ratings. The 2021	https://www.caidp.org/reports/aidv-2022/

	report is the result of the work of more than 100 AI policy experts in almost 40 countries.The 2022 AI Index covers 75 countries. The metrics have been updated to take into consideration the implementation of the 2021 UNESCO Recommendation on AI Ethics as well as the 2022 Global Privacy Assembly Resolution on Facial Recognition. Country reports headings have been harmonized to ease reference and comparative analysis. Relevant regional frameworks have been systematically taken into account in the country reports.The 2022 report is the result of the work of more than 200 AI policy experts in almost 60 countries.	
GLOBAL EDUCATION MONITORING REPORT	@globale2023 Global education monitoring report, 2023: technology in education: a tool on whose terms?	https://unesdoc.unesco.org/ark:/48223/pf0000385723
AI Readiness Index	Oxford Insights remains committed to providing valuable insights at the intersection of government and AI. This year we assess the AI readiness of 193 governments across the world. We are also introducing an interactive map to make our data more accessible!	https://oxfordinsights.com/ai-readiness/ai-readiness-index/
Digital Intelligence Index (DII)	Digital Intelligence Index Digital Intelligence Index (DII) is an interactive research platform of scorecards built to provide evidence-driven, actionable insights on how to enhance digital competitiveness, nurture trust in the digital economy, and foster responsible use of data, AI, and other advanced technologies for enhanced productivity and the greater good. The scorecards and the insights of the DII are meant to inform decision making by technologists, innovators, investors, policymakers, and business leaders on our collective journey from a digital present towards a data-enriched, inclusive, artificial intelligence-augmented future. The current index encompasses the third edition of the Digital Evolution scorecard, following up on our earlier editions (in 2017 and 2014) and the second edition of our Digital Trust scorecard. It paints a picture of global digital development, sheds insight on key factors driving change and momentum, and unpacks the impact digital trust and digital evolution have on a country's digital competitiveness. This edition of the DII offers data, insights, and international comparisons to guide decision-makers to chart a path out of the pandemic-induced economic challenges of 2020 and	https://digitalplanet.tufts.edu/digitalintelligence/

	toward a data-enabled, artificial intelligence-augmented, and inclusive digital future.	

Appendix 8: NUT2 regions in the survey

Table 31: Survey results, full list of respondent location vs frequency aggregated at the NUT2 level.

Rank	Country Name	Region	NUTS_ID	Frequency
1	Greece	Dytiki Elláda	EL63	47
2	Turkey	Kırıkkale, Aksaray, Niğde, Nevşehir, Kırşehir	TR71	29
3	Ireland	Eastern and Midland	IE06	25
4	Slovenia	Vzhodna Slovenija	SI03	24
5	Slovenia	Zahodna Slovenija	SI04	24
6	Turkey	Gaziantep, Adıyaman, Kilis	TRC1	22
7	Croatia	Grad Zagreb	HR05	21
8	Italy	Campania	ITF3	21
9	Austria	Tirol	AT33	19
10	Spain	Comunidad de Madrid	ES30	19
11	Croatia	Sjeverna Hrvatska	HR06	18
12	Austria	Wien	AT13	15
13	Spain	Andalucía	ES61	14
14	Croatia	Panonska Hrvatska	HR02	13
15	Germany	Niederbayern	DE22	11
16	Austria	Oberösterreich	AT31	10
17	Germany	Oberbayern	DE21	9
18	Austria	Kärnten	AT21	8
19	Austria	Steiermark	AT22	8
20	Greece	Attiki	EL30	8
21	Austria	Salzburg	AT32	7
22	Germany	Oberpfalz	DE23	7
23	Italy	Lazio	ITI4	7
24	Austria	Vorarlberg	AT34	6

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25	Serbia	City of Belgrade	RS11	6
26	Austria	Niederösterreich	AT12	5
27	Croatia	Jadranska Hrvatska	HR03	5
28	Ireland	Southern	IE05	5
29	Netherlands	Noord-Holland	NL32	5
30	Spain	País Vasco	ES21	4
31	Italy	Lombardia	ITC4	4
32	Germany	Schwaben	DE27	3
33	Lithuania	Sostinės regionas	LT01	3
34	Germany	Freiburg	DE13	2
35	Germany	Mittelfranken	DE25	2
36	Greece	Peloponnisos	EL65	2
37	Spain	Castilla y León	ES41	2
38	Spain	Castilla-La Mancha	ES42	2
39	Spain	Comunitat Valenciana	ES52	2
40	Spain	Región de Murcia	ES62	2
41	Italy	Veneto	ITH3	2
42	Italy	Emilia-Romagna	ITH5	2
43	Netherlands	Noord-Brabant	NL41	2
44	Netherlands	Limburg (NL)	NL42	2
45	Serbia	Autonomous Province of Vojvodina	RS12	2
46	Serbia	Region Južne i Istočne Srbije	RS22	2
47	Turkey	İzmir	TR31	2
48	Turkey	Antalya, Isparta, Burdur	TR61	2
49	Turkey	Kayseri, Sivas, Yozgat	TR72	2
50	Germany	Tübingen	DE14	1
51	Germany	Unterfranken	DE26	1
52	Germany	Düsseldorf	DEA1	1

53	Germany	Köln	DEA2	1
54	Greece	Kentriki Makedonia	EL52	1
55	Greece	Dytiki Makedonia	EL53	1
56	Greece	Thessalia	EL61	1
57	Spain	Galicia	ES11	1
58	Spain	Cataluña	ES51	1
59	Finland	Pohjois- ja Itä-Suomi	FI1D	1
60	Ireland	Northern and Western	IE04	1
61	Italy	Friuli-Venezia Giulia	ITH4	1
62	Netherlands	Flevoland	NL23	1
63	Netherlands	Zuid-Holland	NL33	1
64	Romania	Nord-Vest	RO11	1
65	Romania	Sud-Vest Oltenia	RO41	1
66	Turkey	İstanbul	TR10	1
67	Turkey	Aydın, Denizli, Muğla	TR32	1
68	Turkey	Ankara	TR51	1
69	Turkey	Adana, Mersin	TR62	1
70	Turkey	Şanlıurfa, Diyarbakır	TRC2	1

Appendix 9: Notification – AI usage within this report

During the recommendations development process, we worked with generative AI.

In our pursuit of excellence and efficiency in research, we have embraced the capabilities of generative AI, not as a data processor, but as a support for descriptive text. This AI specialises in crafting notes around the standards, guidelines, and protocols essential to assembling recommendations from disparate sources.

Our primary motivation was to work in the current paradigm while generating AI literacy recommendations that will motivate a large number of students to work in the same paradigm.

The generated content undergoes a rigorous validation process, meticulously reviewed by at least two doctoral researchers. This strategic integration enabled us to maintain the integrity of our research while operating in a realistic coworking environment. Many will be working in such an environment sooner rather than later.

In the process we rediscovered the obvious that consistency, creativity and critical thinking are the core skill sets needed in a working relationship with AI.

The models used were ChatGPT 3.5 and Lama 3. By the time you have read this, the models will be outdated, and more nuance and capabilities will be available.

We chose ChatGPT because of its freely available access and Lama 3 because of its ability to run locally without passing data through the Internet. Both models were performant and fit the researcher's needs. We look forward to further refinements and model improvement and welcome near-future improvements especially around data processing and the generation of accurate diagrams and prognose.

Appendix 10: Literature Review - Search Queries

A10.1. Scopus

ABS (((("openai" OR "explainable ai" OR llm OR "xai" OR "generative ai" OR "ai" OR "nlp" OR "artificial intelligence" OR "machine learning" OR "data science" OR "neural networks" OR "natural language processing" OR "intelligent agents" OR "business intelligence" OR chatgpt OR dalle OR "synthetic data" OR bing OR "google bard" OR "copilot" OR "deep learning" OR "neural networks") AND ("skill" OR "skills" OR "competen*" OR "21st" OR "capabilit*" OR "capacit*" OR "critical thinking" OR creativity OR teamwork OR leadership OR "emotional intelligence" OR adaptability OR innovation OR entrepreneur* OR transversal OR literacy) AND ("labor market" OR eu OR nber OR ec OR cedefop OR eurostat OR employment OR "occupat*" OR workforce OR industry OR sector OR career OR profession OR wage OR salary OR income OR productivity OR esco OR national OR onet OR isco OR soc OR "disruption" OR "forecast" OR future OR policy OR impact OR "digital transformation" OR transformative OR "case study") AND (qualification OR "end terms" OR certificate OR diploma OR school OR college OR academy OR education OR "technical training" OR "vocat*" OR "curricul*" OR "cvet" OR "cvt" OR "graduat*" OR "student" OR "students" OR "life long learner" OR workplace))))

A10.2. Web of science

AB =(((("openai" OR "explainable ai" OR llm OR "xai" OR "generative ai" OR "ai" OR "nlp" OR "artificial intelligence" OR "machine learning" OR "data science" OR "neural networks" OR "natural language processing" OR "intelligent agents" OR "business intelligence" OR chatgpt OR dalle OR "synthetic data" OR bing OR "google bard" OR "copilot" OR "deep learning" OR "neural networks") AND ("skill" OR "skills" OR "competen*" OR "21st" OR "capabilit*" OR "capacit*" OR "critical thinking" OR creativity OR teamwork OR leadership OR "emotional intelligence" OR adaptability OR innovation OR entrepreneur* OR transversal OR literacy) AND ("labor market" OR eu OR nber OR ec OR cedefop OR eurostat OR employment OR "occupat*" OR workforce OR industry OR sector OR career OR profession OR wage OR salary OR income OR productivity OR esco OR national OR onet OR isco OR soc OR "disruption" OR "forecast" OR future OR policy OR impact OR "digital transformation" OR transformative OR "case study") AND (qualification OR "end terms" OR certificate OR diploma OR school OR college OR academy OR education OR "technical training" OR "vocat*" OR "curricul*" OR "cvet" OR "cvt" OR "graduat*" OR "student" OR "students" OR "life long learner" OR workplace))))

A10.3. OVID

(("openai" or "explainable ai" or llm or "xai" or "generative ai" or "ai" or "nlp" or "artificial intelligence" or "machine learning" or "data science" or "neural networks" or "natural language processing" or "intelligent agents" or "business intelligence" or chatgpt or dalle or "synthetic data" or bing or "google bard" or "copilot" or "deep learning" or "neural networks") and ("skill" or "skills" or "competen*" or "21st" or "capabilit*" or "capacit*" or "critical thinking" or creativity or teamwork or leadership or "emotional intelligence" or adaptability or innovation or entrepreneur* or transversal or literacy) and ("labor market" or eu or nber or ec or cedefop or eurostat or employment or "occupat*" or workforce or industry or sector or career or profession or wage or salary or income or productivity or esco or national or onet or isco or soc or "disruption" or "forecast" or future or policy or impact or "digital transformation" or transformative or "case study") and (qualification or "end terms" or certificate or

diploma or school or college or academy or education or "technical training" or "vocat*" or "curricul*"or "cvet" or "cvt" or "graduat*" or "student" or "students" or "life long learner" or workplace)).ab.

A10.4. EBSCO

AB (("openai" or "explainable ai" or llm or "xai" or "generative ai" or "ai" or "nlp" or "artificial intelligence" or "machine learning" or "data science" or "neural networks" or "natural language processing" or "intelligent agents" or "business intelligence" or chatgpt or dalle or "synthetic data" or bing or "google bard" or "copilot" or "deep learning" or "neural networks") and ("skill" or "skills" or "competen*" or "21st" or "capabilit*" or "capacit*" or "critical thinking" or creativity or teamwork or leadership or "emotional intelligence" or adaptability or innovation or entrepreneur* or transversal or literacy) and ("labor market" or eu or nber or ec or cedefop or eurostat or employment or "occupat*" or workforce or industry or sector or career or profession or wage or salary or income or productivity or esco or national or onet or isco or soc or "disruption" or "forecast" or future or policy or impact or "digital transformation" or transformative or "case study") and (qualification or "end terms" or certificate or diploma or school or college or academy or education or "technical training" or "vocat*" or "curricul*" or "cvet" or "cvt" or "graduat*" or "student" or "students" or "life long learner" or workplace))

Appendix 11: Literature Review - Coding Book

Table 32: Literature Review - Coding Book

Instruction	Description
Explicitly includes discussion of skills gap	Does the paper explicitly discuss the concept of a skills gap or differences in skills. Possibly also usage of labour supply and demand
Includes methods for identifying Skills Gaps	Does the paper specifically mention a method for identifying the skills gap
Gap Identified between:	Who are the stakeholders identified on either side of the gap?
References or Develops Skills Framework	Does the paper reference or develop a skills framework that indicates some level of organisation of skills into clusters, hierarchy, and/or prerequisites?
Skill x	The name of skills (Eg. Critical thinking, Ability to use AI for rapid prototyping) - Include only explicit skills mentioned. There is room for 10 skills per paper
Sector	indicate which NACE2 Sector/s the paper covers specifically
Occupation	Does the paper make reference to a specific occupation?
Region	Does the paper focus on a specific region?
Key Quotes / Citations	Include here any relevant Sentences or Paragraphs of text, so that these can be incorporated into the final report. These should be profound and/or important statements
Page Reference	Include a page reference for any such in-text quotes - Room for up to 3 per paper!

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