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ADVANCED DIGITAL SKILLS

D2.2 LEADS GAP ANALYSIS

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Authors	Leonardo Bulgarelli Freitas (IDC), Brendan Rowan (BLU), Nuria de Lama Sanchez (IDC), Christopher Karachristos (MAG), Nikos Achilleopoulos (MAG), Fanis Orphanoudakis (MAG), Evagelia Peristeri (MAG), Spiros Borotis (MAG), Ernestina Menasalvas (UPM), Martín Robles (BLU), Sam Jones (BLU), Nina Blessing (BLU), Shirley Kavanagh (TCD), Flora Josette Thibaudeau (TCD)
Reviewers	Brendan Rowan (BLU), Eugenia Kypriotis (MAR), Na Fu (TCD)

Abstract	This document provides the GAP analysis between the demand assessment for ADS skills and forecasts building on previous reports (D1.1, D1.2, D1.3), primary data from the survey and a series of workshops with experts and the supply assessment of ADS skills in education developed on D2.1. The goal of this research is to establish a comparison between the industry appetite for ADS skills vs what is currently being offered in the European educational landscape to assess gaps of knowledge and areas to be improved within ICT education.
Keywords	Skills, demand, forecast, roles, jobs, framework, Artificial Intelligence, Business Intelligence, Data Science, Cybersecurity, IoT, Quantum, Cloud, Edge, High-level Education, Gap

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EXECUTIVE SUMMARY

D2.2 LEADS gap analysis provides an analytical comparison between the offering of ADS in the EU and the expected demand. As such, it builds upon previous works released by the project and in particular, the demand analysis reflected in “ADS Demand and Forecast Reports” produced by LEADS (D1.2, D1.3) as well as the analysis of the supply, showcased by D2.1 “Programme and course analysis and mapping”.

On the demand side, LEADS has established a framework of definitions and estimated current and future demand for over 30+ skills pockets, 80+ skills details in six different technology areas (AI, IoT, Cloud, Cybersecurity, Quantum Computing and Business Intelligence/Data Science). To reach current estimates, the demand model was based on publicly available information and IDC proprietary data from over 20 different data trackers, linking technology spending in 150+ industry use cases to the needs for specific skills to drive development, implementation and maintenance of these.

On the supply side, LEADS has designed a data collection framework based on the definition of skills and technology areas (the LEADS Framework), analysing over 1100 STEM related ADS courses in Europe from Higher Education institutes (Bachelors and Master programmes), Vocational Education Training (VET) and Third-Party Training providers. The goal of data collection was to understand the presence (or lack thereof) of ADS skills (same skills defined by the demand side) in the European learning landscape, identify which subjects have more presence and where, and those in need of revaluation.

The results exposed in this document have then been confronted with a series of external experts in the domains tackled by the project through three workshops that have helped us to enrich the context, assumptions, and trends, as well as to validate the work carried out by the LEADS team in the last months. Direct input from the validation workshops is included in this report for convenience. The content has been combined with our findings for the elaboration of conclusions and recommendations on how ADS should be tackled by the EU to address the current and increasing gap between supply and demand and thus, ensure sovereignty and competitiveness of our economy and society.

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ABBREVIATIONS

ADS	Advanced Digital Skills
AI	Artificial Intelligence
API	Application Programming Interface
BI	Business Intelligence
CAWI	Computer-Assisted Web Interview
EC	European Commission
ENISA	European Union Agency for Cybersecurity
EU	European Union
GRC	Governance, Risk, and Compliance
HE	Higher Education
HEI	Higher Education Institutions
HR	Human Resources
ICT	Information and Communication Technologies
IDC	International Data Corporation
IoT	Internet of Things
IT	Information Technologies
NPVP	National Public Vet Provider
STEM	Science, Technology, Engineering and Mathematics
VET	Vocational Education Training
WP	Work Package

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1 INTRODUCTION

D2.2 “LEADS gap analysis” is the final report of the most research-oriented part of the LEADS project, composed by WP1 and WP2, where both demand and supply of ADS in Europe have been analysed. As such, it builds on previous work and notably the four additional reports published by LEADS. On the demand side, it builds on D1.1 “Demand Assessment Framework” (where all the technology areas, skills and skills pockets are defined and relationships with other frameworks are depicted, especially with respect to job roles), D1.2 “First draft of ADS Demand and Forecast Report” and D1.3 “Final ADS Demand and Forecast Report”, both of them providing insights on the demand assessment and forecasts for the upcoming years in the EU, including forecast for different scenarios in the case of D1.3. On the supply side, this deliverable builds upon the analysis of the supply provided by D2.1 “Programme and course analysis and mapping”. The added value of this document is that it connects both supply and demand to offer a comprehensive perspective of what the gap is for the different skills under analysis. As such, it is intended to be of interest for policy makers taking decisions on educational programs, as well as training/upskilling/reskilling strategies and more globally, to those policy makers involved in labour market policies and digital transformation strategies. Data and recommendations also concern providers of ADS -including public and private entities- as well as industries that represent the demand and that could find here a good basis for the design of their strategies. All these actors will surely be surprised by the figures, which describe a quite complex and pessimistic scenario for Europe regarding the availability of talent and professionals that are and will be needed to guarantee sovereignty and competitiveness. The other side of the coin is that the data and analysis presented by LEADS should drive and motivate a series of changes to address the skills gap and this, an initial set of recommendations concludes this deliverable.

1.1 Context: Overview of ADS Skills in Europe

Over the past decade, the European landscape of technological skills has seen a rapid evolution, with the demand for specific Advanced Digital Skills (from now on referred to as ADS) increasing in various industries across Europe. Significant and impactful trends have also taken the continent by storm, resulting in technology adoption across several sectors. Digital transformation has been the centre of that change as organisations strive to embrace it to retain their competitive edge as well as improve their operational efficiency. Across society ,too, we see Europe wide efforts to digitalise public services with the aims of efficiency and inclusion. These steady trends, which include cloud computing adoption, data analytics and AI solutions implementation, digitalisation of processes, and online customer and citizen experience enhancement, have underpinned and shifted the focus of our economy and society.

However, the rapid development of new technologies has created challenges such as skill shortages for organisations and a lack of digital competence for employees and leaders that must be overcome. The shortage of skills has become a top priority to address in Europe in recent years. Based on a study in 2019[1], nearly 77% of businesses surveyed were faced with difficulties in locating individuals possessing the necessary skill sets for their workforce.

[1] Eurofound, European Company Survey 2019

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Furthermore, a report conducted by the European Labour Authority[2] indicated that as many as 28 job categories were encountering skill shortages, specifically for occupations in the fields of IT and security, with a heightened focus on cybersecurity, and individuals with backgrounds in science, technology, engineering, and mathematics (STEM). This highlights an alarmingly increased need for highly skilled workers.

The speed of technological advancement has resulted in a disparity between the skills held by individuals and emergent labour market needs presenting challenges for both individuals and organisations. Education and training systems are struggling to keep pace with the advancements, producing fewer graduates with the necessary technological competencies. A mismatch of skills taught in educational institutions and those demanded by the labour market can be observed as one of the key reasons for this emerging talent gap. Organisations in fields, such as information technology and data science, are experiencing increased difficulties in acquiring candidates with the right skills. Therefore, it is imperative to create better collaboration between industry leaders and educational institutions to align market needs with curriculum in order to reduce the gap between the demand and the supply of ADS.

Large corporations are proposing certifications to individuals in order to upskill or reskill themselves to better meet the demands of the current market. Additionally, initiatives and programmes are underway to support education policies at a European level. The Digital Education Action Plan[3] for instance is a relevant strategy that will help address the increasing need for ADS workers. Nevertheless, the acquisition of digital skills is also reliant on the functioning of the educational system from primary through to third level. This creates challenges for universities and their ability to produce the volume of graduates needed at scale with the required digital knowledge and skills. Therefore, universities will need to consider their curriculum offerings and their capacity to deliver new curricula focused on digital skills development. Additional capacity can be obtained through vocational education and training, which would require increased investment but could be an important element for employees and European citizens to obtain the necessary skills. Skills development offered through vocational channels could offer the opportunity to provide solutions more quickly, at scale and with a closer link to industry needs. It is clear that the current provision of education and the policies implemented at a national level will be insufficient to meet demands and more innovative approaches will be needed to meet the challenges ahead.

1.2 Importance of matching educational curricula with Digital Transformation

The goal consequently is no longer just to provide a basic education for all, but to provide an education that can adapt to the rapidly evolving technology situation centred not only on

[2] European Labour Authority, Report on labour shortages and surpluses 2021 and ENISA, Cybersecurity skills development in the EU, March 2020. The ENISA studies identify there is a gap of 291,000 professionals in cybersecurity

[3] Digital Education Action Plan (2021-2027), https://education.ec.europa.eu/focus-topics/digital-education/action-plan

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producing new professionals but to be able to re-skill and up-skill workers. To achieve this goal, educational curricula must be adapted to embody these educational aims[4].

The development of curriculum is a dynamic, cyclical process that involves processes to assess and adapt it over time. These processes can be long in time and typically involve quality accreditation agencies. However, as it has been seen in the demand analysis performed by LEADS (D1.2, D1.3), The rapid evolution is asking for processes that are shorter in time.

Matching education curricula with the current needs is central to provide Europe with the labour force that is required. Otherwise, the gap between supply and demand will only increase.

Despite the question on how to contextualise the curricula to the particular needs of each country, in today's context the education needs have become universal; as it has been seen the need of certain skills for companies is not any longer occurring at a national level, but it is a global problem[5]. The analysis of demand has made clear which ADS skills are required all over Europe. On the other hand, the supply analysis shows that the curricula of all EU countries will have to rapidly adapt to provide the proper skills not only in content but also in the way in which contents are delivered.

When designing the curriculum, it is now paramount that the choices concerning content reflect the needs that have been analysed as crucial to be able to fill the gap and provide the market with the required professionals. The Higher Education sector has a key role to play in the acquisition and further enhancement of ADS, as it has been highlighted in the supply analysis albeit in strong interaction with industry and other stakeholders. However, HE on its own will not be able to respond to the high growing demand. The supply analysis has also stressed the insufficient number of Vocational Education Training (VET) in ADS. Adapting the VET curriculum will also be a lever to fill the gap of required professionals. In particular, HE and VET alliances could provide a skill path.

One important aspect is that not only the learning outcomes that are required should be stated but also the guidance on how to structure learning activities and how to assess learning achievements[6]. To this respect, the curriculum must consider the different needs and profiles. Another important aspect will be how to train the trainers. In order for changes in curriculum and expected learning outcomes to be carried into practice, ongoing teacher development must be central to curriculum policy[7].

[4] OECD: Education at a Glance 2022: OECD Indicators, OECD Publishing, Paris, 2022

[5] DeBoer, G. 2011. 'The globalization of science education.' Journal of Research in Science Teaching. 48(8).

[6] Shavelson, R.J. et al. 2008. 'On the impact of curriculum-embedded formative assessment on learning: A collaboration between curriculum and assessment developers.' Applied Measurement in Education. 21.

[7] Curriculum and expected learning outcomes. UNESCO report 2023

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2 METHODOLOGY

2.1 Research Design & objectives of the GAP Analysis

The design of the LEADS GAP Analysis of ADS is based on the analysis and comparison of the findings obtained in the WP dealing with the demand assessment (WP1) and data collected in the WP focusing on education data collection, i.e., supply assessment (WP2).

On the demand side, LEADS has established a framework of definitions and estimated current and future demand for over 30+ skills pockets, 80+ skills details in six different technology areas (AI, IoT, Cloud, Cybersecurity, Quantum Computing and Business Intelligence/Data Science). To reach current estimates, the demand model was based on publicly available information and IDC proprietary data from over 20 different data trackers, linking technology spending in 150+ industry use cases to the needs for specific skills to drive development, implementation and maintenance of these.

On the supply side, LEADS has designed a data collection framework based on the definition of skills and technology areas (see LEADS Framework), analysing over 1100 STEM related ADS courses in Europe from Higher Education institutes (Bachelors and Master programmes), Vocational Education Training (VET) and Third-Party Training providers. The goal of data collection was to understand the presence (or lack thereof) of ADS skills (same skills defined by the demand side) in the European learning landscape, identify which subjects have more presence and where, and those in need of revaluation.

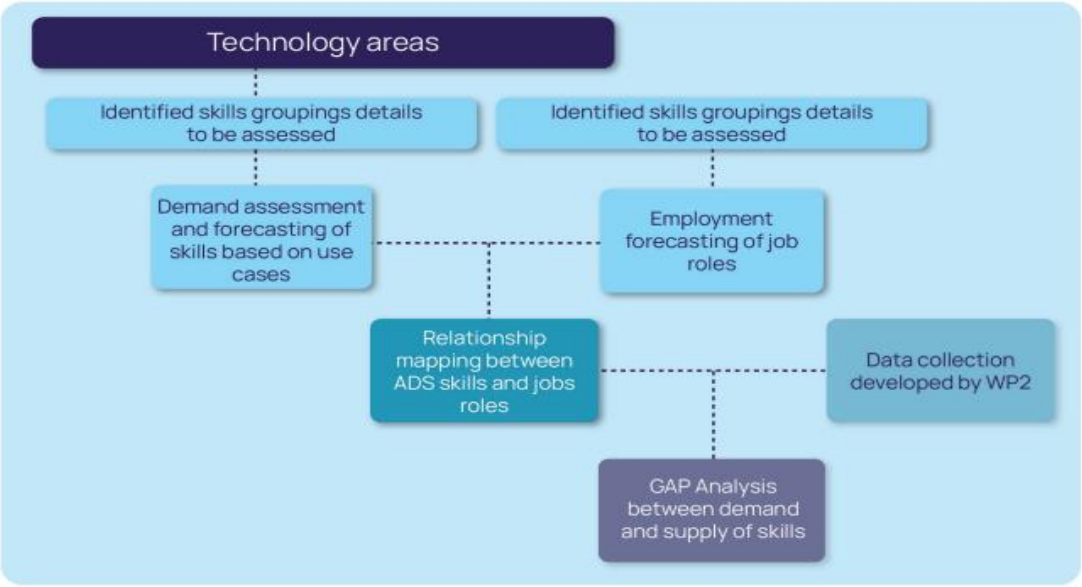

Figure 1. Methodological framework of the LEADS Gap Analysis

With the demand side mapped and reported through D1.1 Demand Assessment Framework, D1.2 First draft of ADS Demand and Forecast Report and D1.3 Final ADS Demand and Forecast Report, and completion of the data collection on the supply side, the GAP analysis will now merge results from both fronts to:

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- Understand the presence (or lack) of training in advanced skills in high demand mapped in the LEADS competence framework to assess their reach within the European educational system.
- Provide an overview, by technology area, to different stakeholders on which actions should be taken to address skills gaps in different technology areas.
- Understand whether current educational efforts are well positioned in terms of the expected growth in demand for different skills pockets.
- Build assumptions on the different upskilling approaches by technology area and where to optimise ICT training and development both within and outside the educational sector.

As both datasets (demand and supply) are by nature different and rely on distinct methodologies, merging the data has its own challenges. For instance, one of the previous goals of the GAP Analysis was to provide an overview of educational coverage vs. demand growth by the skill detail level. However, as data collection on the supply side only allowed us to go up to the skills pocket level as detailed topics are not explicitly stated in course summaries, syllabus and curricula, a decision was made to match data to the 30+ skills pockets' level of advanced competencies identified by WP1 so that clearer insights could be generated.

Despite the barriers, the chosen approach for the Gap Analysis enabled LEADS to establish key correlations between skills demand and educational presence across pockets within the technology areas proposed, serving as a stepping stone for the analysis of advanced skills training in Europe, which we hope will help shape the direction of travel for upcoming training courses, educational efforts and enhanced communication channels between industry and educational sector.

2.2 Sampling and data collection

The demand for ADS had two key components:

- A demand model was based on publicly available information and IDC proprietary data from over 20 different data trackers, linking technology spending in 150+ industry use cases to the need for specific skills to drive development, implementation and maintenance of these.
- A professional survey on 885 European organisations using Computer Assisted Web Interviewing (CAWI) techniques. The sample questioned was as representative as possible; first and foremost, it aimed to organisation located in 12 EU countries[8], aiming to equally represent all EU regions and market volumes.

Moreover, the survey questioned managers and professionals primarily from the IT sector, and to a lesser degree from the HR sector, so as to gain rich insights from different viewpoints. The survey tried to achieve a balanced sample across industries reflecting the business demographics of European organisations, and aimed at respondents that were currently involved in sourcing or

[8] Austria, Belgium, Denmark, France, Germany, Greece, Italy, Netherlands, Poland, Romania, Spain, Sweden.

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managing the demand for ADS, with the vast majority of them also involved in evaluating the future demand for these skills in the organisation.

Concerning the supply for ADS, a pan European survey was conducted (in all 27 EU countries), on HEI and VET training programnes and courses. The HEIs in every country were selected[9] according to their position in the International University Rankings 2022 (subject option: Engineering and Technology), the popularity of its ICT programmes, the number of students studying them, and other factors (e.g. related to their reputation).

In each case, all computer science degree programmes (undergraduate and postgraduate) were identified, selecting at least one programme from each category. Based on that, as well as the volume of the country, a number of 1 to 5 ADS courses were analysed further. The analysis focused, among other, on the mapping of the ADS courses to the LEADS technologies skills pockets, so as to identify the degree of their coverage (not at all, average, fully). Overall, the sample included 44 HEIs, 125 programmes, 3445 courses recorded, with the 971 of them categorised as ADS courses.

Concerning VET, we focused on identifying National Public Vet Providers (NPVPs) in each country and the "Computer Science" and "Engineering" programmes they offered (EQF5). We also searched among global VET providers' programmes offered in Europe, and those offered by popular global distance learning platforms. Again in this case, a series of ADS courses were identified and analysed further. Overall, the sample included 50 VETs, 109 programmes, 650 courses recorded, with 271 of them categorised as ADS courses.

2.3 In-depth Overview of LEADS Supply Analysis

The European education and training landscape provides many programmes and courses in various levels (EQF 4-8) that are in a (albeit relative) proximity to the idea of ADS. The close proximity can be found to education or training programmes which focus directly on the ICT sector, or in programmes that exploit contemporary technology (e.g. cybersecurity in health).

LEADS decided to design a methodology so as to analyse at least 600 ADS courses, that would (a) be consistent and replicable, (b) have a clear objective and scope, (c) use standardised evaluation criteria, (d) involve all stakeholders to its design, (e) be transparent and accountable, (f) allow for continuous improvement. In this regard, the methodology established included mainly the following steps (see figure 2):

- Definition of selection criteria for educational / training programmes on various levels (HEI - VET);
- Identify programmes and courses following the defined criteria;
- Categorise courses identified as non-ADS and ADS;
- Analyse ADS courses.

[9] The EU27 countries were separated into 5 clusters. Cluster 1 included the bigger countries, i.e. Germany, France, Italy, Spain, Poland and Romania; Cluster 2 included the Netherlands, Belgium, Greece, Czechia, Sweden and Portugal; Cluster 3 included Hungary, Austria, Bulgaria, Denmark, Finland and Slovakia; Cluster 4 included Ireland, Croatia, Lithuania, Slovenia, Latvia and Estonia; Last, Cluster 5 included Cyprus, Luxembourg and Malta.

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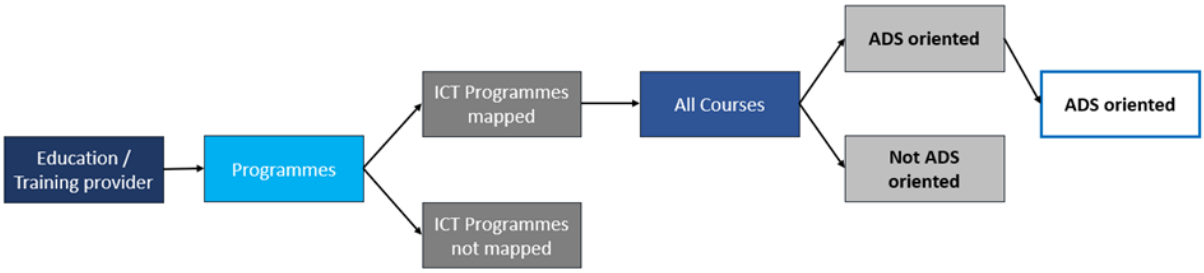

Figure 2. Overview of the methodological approach for the LEADS Supply Analysis

2.3.1 Definition of selection criteria for educational / training programmes on various levels (HEI - VET)

A range of prerequisites was considered in order to define the programmes selection criteria. First and foremost, we had to define the areas of ADS. For this purpose, we used the ADS Framework proposed by LEADS under WP1 (Skills Profiling and Demand Mapping) that includes six technology areas and 29 skills pockets (see figure 3). These technology areas and skills pockets should be used to categorise and analyse further the ADS courses (their degree of coverage) identified into the selected education and training programmes. For obvious reasons, the non-ADS courses identified should not be categorised into the technology areas and skills pockets.

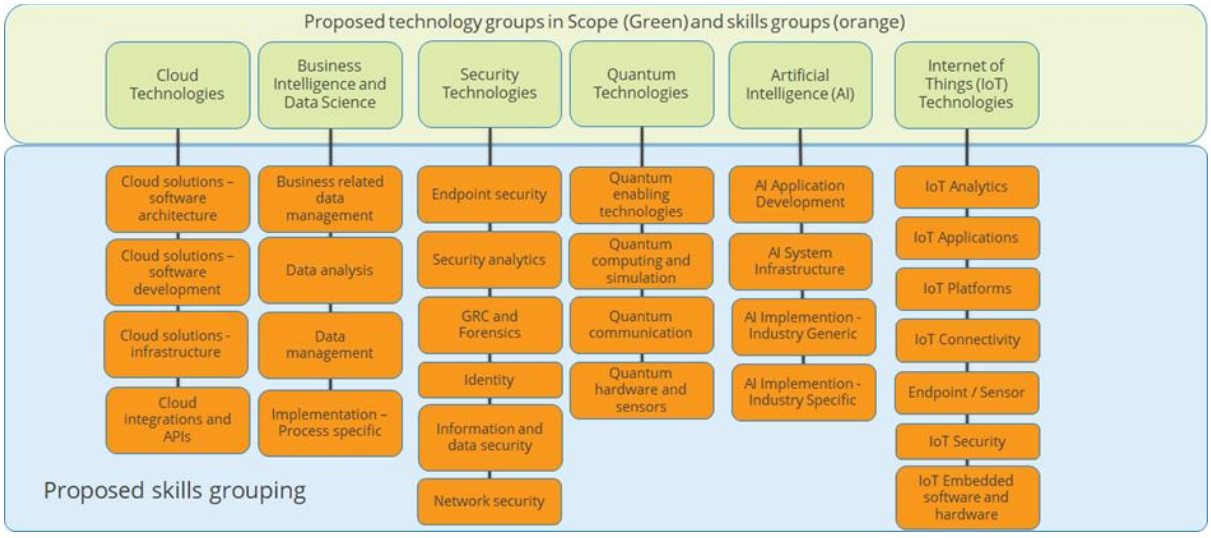

Figure 3. Technology areas and Skills Pockets as defined by the LEADS Framework in WP1

Second, we had to define the types of suppliers. In general, and given the nature of ADS, the LEADS consortium decided to focus on EQF 5-7. Programmes and courses below EQF 5 are typically not supporting the development of ADS, whereas for EQF 8 (PhD) it is very difficult to assess learning outcomes and associate them with the development of particular skills (usually this information is not even available). Moreover, the vast majority of professionals employed in the market should possess ADS within the levels between 5 and 7.

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In this regard, we selected programmes in the different technology areas from (a) Officially recognised (national level) Higher Education Institutions that award academic degrees (undergraduate and postgraduate) in different academic disciplines; (b) Public and private vocational training (VET) providers at national level, as well as global and online VET providers well recognised by the industry. The desk research that was conducted has been based on reliable and accurate sources, taking into account the latest developments and the different perspectives, etc., so as to ensure that the information gathered was trustworthy.

Third, the country dimension was addressed. LEADShad to collect supply side information from all the EU-27 countries; in order to ensure enhanced coverage, and in parallel the representation of different magnitudes of the supply market (institutions) from the different countries, we decided to separate the EU-27 countries in five clusters.

- **Cluster 1:** Germany, France, Italy, Spain, Poland, Romania
- **Cluster 2:** Netherlands, Belgium, Greece, Czechia, Sweden, Portugal
- **Cluster 3:** Hungary, Austria, Bulgaria, Denmark, Finland, Slovakia
- **Cluster 4:** Ireland, Croatia, Lithuania, Slovenia, Latvia, Estonia
- **Cluster 5:** Cyprus, Luxembourg, Malta

Fourth, LEADS had to select representative HEI and VET institutions from each country, so as to identify the most trustworthy, valuable and up-to-date results (courses) for further analysis. Thus, partners searched among the most "popular" HEIs in every country focused on "Computer Science" and "Engineering" schools.

2.3.2 Identifying programmes and courses that matched our selection criteria

In the second step, and concerning higher education, partners had to search the HEIs selected in the previous step for all computer science degree programmes (undergraduate and postgraduate). At least one undergraduate programme per country and at least one per technology area should be investigated. The maximum number of programmes depends on the cluster the country belongs to. If the necessary number of ADS-oriented courses to a technology area could not be found in one programme, we should move on to the next programme within the university or we should move on to the next university/programme etc. If we were not able to find the courses needed within the first cluster, the searching process stopped. Table 1 below presents the detailed numbers per cluster.

Table 1. Minimum and Maximum programmes and ADS courses per country

COUNTRY CLUSTERS	MIN UNDERGRADUATE PROGRAMMES INVESTIGATEDEUR (BN)	MIN ADS COURSES ANALYSED
Cluster 1: Germany, France, Italy, Spain, Poland, Romania	1	5
Cluster 2: Netherlands, Belgium, Greece, Czechia, Sweden, Portugal	1	4

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Cluster 3: Hungary, Austria, Bulgaria, Denmark, Finland, Slovakia	1	3

Concerning VET, we focused on identifying National Public Vet Providers (NPVPs) in each country and the "Computer Science" and "Engineering" programmes they offered (EQF5). We also searched among global VET providers' programmes offered in Europe, and those offered by popular global distance learning platforms. The ADS are mostly delivered in a higher education level (EQF6+), while VET (EQF5) is also participating in this data collection, but mostly in a lower degree. Therefore, we decided to account VET for 20% of the total sample. This limit did not allow us to support any total "coverage" numbers but instead, provide a snapshot of the technology area relevance by course type.

2.3.3 Categorise courses identified to non-ADS and ADS

In order to identify more accurate and trustworthy information, we decided to accept programmes and courses with descriptions in languages other than English. Moreover, we recorded all the courses of a programme regardless of whether it was an ADS-oriented course or not and characterised them accordingly. Last, if the indicator of e.g., 5 ADS courses was achieved in one programme, but the programme had more ADS courses, we decided to analyse all ADS courses of this programme and not a part of them (for coherence reasons).

2.3.4 Analysing ADS courses

Next, we analysed the ADS courses identified (mapping all the ADS-courses identified within the sample). The analysis mapping process in the different technology areas and the skills pockets of the ADS Framework was done in a three-point Likert scale (not at all/average/fully). For each technology, the analyst should choose the skill areas that the course is categorised into.

Concerning HEI, the sample included 44 HEIs, 125 programmes, 3445 courses recorded, with the 971 of them categorised as ADS courses. Concerning VET, the sample included 50 VETs, 109 programmes, 650 courses recorded, with the 271 of them categorised as ADS courses. For more information, the reader is encouraged to study LEADS "D2.1 Programme and course analysis and mapping".

2.3.5 Data Analysis

The data analysis provided in this research has laid the foundations for the LEADS D2.2 GAP Analysis report and consists on the cross-comparison and extraction of insights from both key data gathering exercises:

- WP1 ADS Skills Demand Assessment.
- WP2 Educational supply data collection.
- LEADS survey results.

As explained above in chapters 2.1, 2.2 and 2.3, although the definitions that were used to perform the data collection on the supply side were aligned to the demand assessment framework (same technology areas, skills groupings and skills details), the nature and depth of the data points collected from both the demand and supply sides were substantially distinct.

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To quantify the demand side of LEADS, hard data built over the years (and proprietary to IDC) has been used to give a solid north of the development of advanced capabilities and corroborate the estimations on the industry appetite for advanced skill sets in Europe through a set of 150+ use cases already in use by the industry.

On the supply side, however, despite the robust sample of courses analysed (over 4000 in total; 1169 of these courses with focus on advanced skills), the limited amount of information contained on course syllabus and programme overviews has not allowed us to delve into the detail of what each programme was covering. We succeeded, however, in mapping the coverage of the aforementioned courses at skill pocket level with a certain level of success to give us an idea of the popularity of different advanced skill sets across the educational sector in Europe. With the limited amount of information available, covering the output of professionals of said courses or level of proficiency expected by graduates when finishing such programmes was unfortunately not an option.

However, results generated from the LEADS survey have helped to shape the data analysis by filling the gaps with the perception of industry players on the lack of certain ICT skills and level of preparedness of graduates when leaving university. The survey has also enabled us to understand the impact of certification, university diploma and professional work experience for ICT workers when conducting their day-to-day tasks.

In summary, the focus of this analysis is to assess the presence (or lack thereof) of different skill sets across the educational sector versus the expected growth in demand (generated by WP1) to provide a snapshot of course coverage by subject, which course types best address the learning of certain skills in ICT, what is missing from graduates/skills that are difficult to hire from an industry perspective and where should the educational sector focus their efforts to enhance current course programmes with the most in-demand skill areas.

2.3.6 Points to consider when interpreting the Gap Analysis data

Based on the summary given in sections 2.2 and 2.3 of this report, as social research converges into quantification, it is important to clarify some key points and take the readers through some of the barriers faced when extracting insights from the data collection done in WP1 and WP2:

- To best represent the diversity of EU countries covered in this research, the WP2 education supply sample aimed to include a certain number of top tier ranked universities and courses reliant on country size (population) as explained in section 2.3.2. The approach, however, may overlook certain specialised courses from smaller universities, and this should be taken into account when analysing the results of this gap analysis.
- Data collection on the educational supply side was performed in over 12 different languages with the support of translation tools (such as Google Translate) to match the definitions of the skills pockets defined within the D1.1 LEADS ADS skills framework and information about each of the courses (syllabus and course descriptions). Although the chosen approach was the most suitable based on the research timeframe and resources available, matching LEADS English-based ADS skills definitions with other languages across Europe was a considerable challenge and should also be taken into consideration when interpreting the results of the Gap analysis.

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- As HEI represents the biggest proportion of the sample collected in WP2, different course types (HEI, VET and Online) are not equally represented in the educational data gathering of LEADS. That said, there were difficulties faced by the project in building a proportional sample between different course types as it became clear that the reach of VET and Online courses, as well as the balance between practical skills and theoretical learning varies greatly between academia and professional learning. Therefore, readers should interpret the total coverage sum by skill pocket as a rough indication of the topic's presence across education and should be cautious when drawing statistical conclusions from such data points.
- Although the LEADS consortium has delivered a greater educational data collection sample than previously agreed when the project was set up (from 600 ADS courses to over 1100) even more inputs would have been necessary to have an in-depth, clear picture of the educational landscape of ADS skills in Europe. While we are confident that the gap analysis has delivered important insights and mapping of ADS skills supply and demand trends across Europe, a higher level of detail would require an even greater sample of courses. This is important information for any upcoming research projects aiming to build upon the results of LEADS.

2.3.7 Validation Workshops

After key points of the gap analysis were established, LEADS was also tasked with the validation of findings and conclusions. The validation model established by the consortium occurred through a series of different validation workshops (three in total) covering key aspects of the research directly with industry and ICT education experts. Notice that a high number of workshops and other community activities have been already running for each of the particular research segments of the project.

The goal of the three sessions was to present the results of the gap analysis undertaken by LEADS and validate its main results with a series of experts to help the consortium achieve a deeper understanding in several aspects of the analysis. The event was open to a wider audience (over 60 participants were present) so more opinions could be captured. Below is a summary of the key topics covered by each of the sessions.

Roundtable one: Skill gaps across technology areas

- **LEADS** has quantified the demand for a wide umbrella of skills and has analysed the current skills offering. But how will supply react to the future demand? This workshop focused on the validation of the gap across technology areas discussing challenges, technology convergence and the impact of digital transformation in many sectors that will put more pressure on the demand for ADS.

Roundtable two: How can HE/VET align supply with demand for ADS?

- Which skills match better with Higher Education and which ones adapt better to VET? A good balance and understanding on how to structure the generation of ADS as well as how to face upskilling and reskilling.

Roundtable three: Can we scale current activities to the needs of Europe?

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- How can we invest in a smart way? Which activities can scale? Are there barriers and rules that prevent Europe from designing the right skills paths?

Each of the sessions lasted over 75 minutes, with the participation of 12 selected experts, members of the LEADS consortium and general public. Key insights extracted from each of the round tables can be found in this report in section 3.3.

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3 GAP ANALYSIS FINDINGS

3.1 Overview of Results

The chart below aims to portray the current and expected workforce possessing skills within the different technology areas covered by the LEADS framework (AI, BI/Data Science, IoT, Cybersecurity and Cloud). The "current" line represents the amount of professionals already working in each of the areas, while the "baseline" variable shows our expected demand forecasting of workers needed in these areas by 2027.

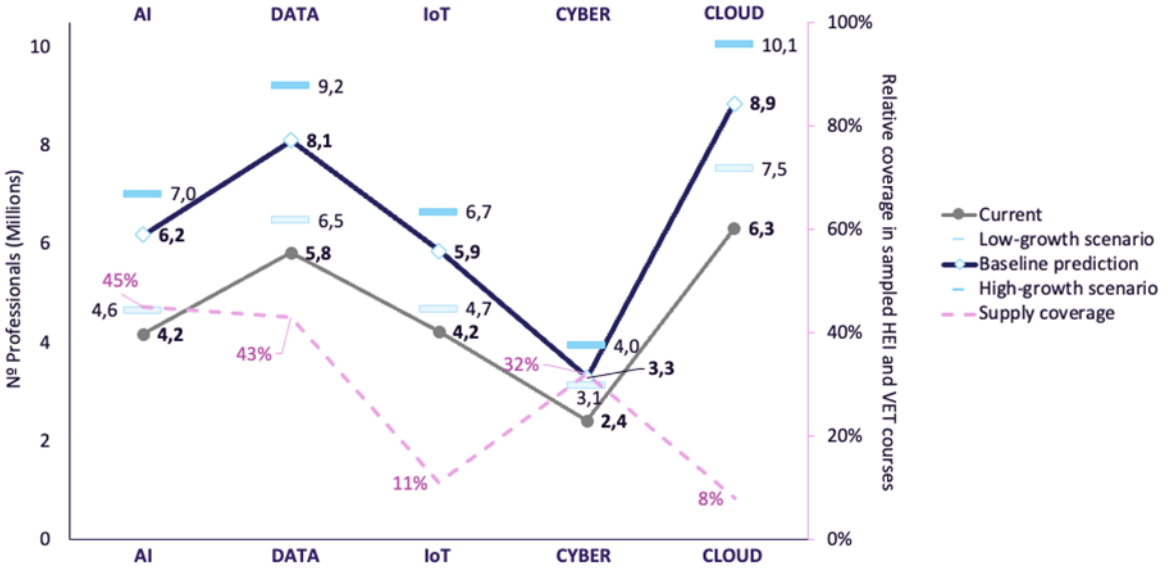

Figure 4. Workforce with ADS including demand predictions for different scenarios

In addition to a baseline estimation of future workforce, two additional scenarios were considered: A "low growth" scenario, where technology adoption and industry appetite for investments are lower, and a "high growth" scenario, where technology adoption and investment pace surpasses current projections (see LEADS D1.3 for detailed information on the forecasts for the three scenarios). In addition to workforce numbers prediction, the red dotted line in the chart above represents the estimated coverage in education within HEI, VET and Online combined for each of the technology areas. It is also important to remind readers that our methodology on supply collection relied more heavily on HEI courses, so this has to be borne in mind when interpreting results for total coverage in this chart.

As analysed previously, while technology areas may present a different coverage depending on training modality and course type (with some areas such as cybersecurity and cloud more prominent in VET and online training while others such as AI more present at HEI), the teaching of advanced skills in its totality, even at specialised STEM courses is still not widespread enough to cater for the substantially high increase in ICT professionals needed by the industry over the next years.

According to EC's and LEADS estimates, the European industry will need over 11 million new workers in ICT to have a chance to close the technology skills gap over the next years while

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less than half of EU specialised ICT courses are currently covering the most emerging advanced skills in their curricula.

To give a concrete idea of the effort needed in bringing new workers into ICT, the estimated future workforce numbers represent an increase of over 85% versus the current number of professionals working in the sector (circa 12.5 million). In reality, to reach such numbers with only HEI graduates, around 50% of university leavers across Europe in all subjects (including and excluding STEM) would need to make a move into ICT which is an impossible consideration.

The hypothesis above helps to illustrate that upskilling/reskilling outside the University, both inside and outside of the workplace, must be considered and invested on to transform the ICT skills landscape in Europe.

The LEADS educational supply data below presents the estimated coverage of advanced skill sets within five different technology areas split by training course type, including Global VET Courses, Public VET Courses, and Higher Education (HEI) programmes (PhD and Master programmes). To interpret the coverage results concerning Third Party Online courses and Global VET, it is important to bear in mind the reduced size of the sample (as explained in section 2.3 of this report). That said, readers should interpret these results as a rough indication of topic presence but not a fully statistical representation of all available courses in Europe.

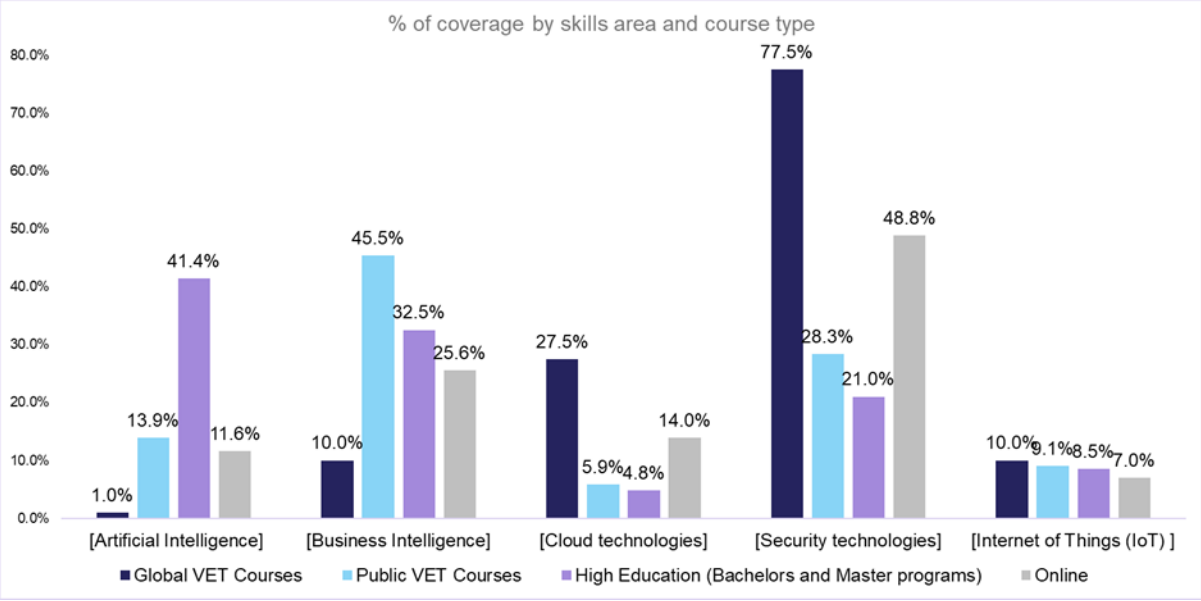

Figure 5. Coverage of existing offering of major technology areas (per course type)

Results reveal that security technologies receive the highest coverage percentage in Global VET Courses, with a significant 77.5%. In contrast, Public VET Courses and HEI programmes allocate relatively lower percentages of coverage, with 28.3% and 21% respectively. This suggests that, although security technologies are a priority in vocational training, there is a certain presence of the topic in HEI due to its importance but also further room for increased emphasis on security within universities.

Cloud technology ADS skills have moderate coverage across certain training courses. Global VET Courses allocate 27.5% coverage while online 14%, indicating a significant emphasis on

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cloud technologies in vocational education. However, Public VET Courses and HEI programmes provide comparatively lower coverage percentages of 5.9% and 4.8% respectively. The data suggests that there is potential for increased coverage of cloud technologies especially within publicly funded VET and higher education programmes.

Artificial Intelligence (AI) ADS skills exhibit varying levels of coverage across the training courses. HEI programmes lead in providing coverage with a significant 41.4%, indicating a strong focus on AI in higher education. Public VET Courses offer a coverage percentage of 13.9%, while Global VET Courses have a substantially lower coverage of the topic at 1.0%. These figures suggest that AI is gaining recognition and importance in educational programmes, particularly within higher education institutions. However, this may also mean that a more hands-on learning and on-the-job upskilling of AI is still to be further developed as HEI modalities have a smaller reach within professional learners.

Business Intelligence (BI) and Data Science skills exhibit an interesting distribution of coverage across the training courses. Public VET Courses lead with a significant coverage percentage of 45.5%, suggesting a strong focus on BI within vocational education. HEI programmes allocate 32.5% coverage, indicating a considerable emphasis on BI in higher education. Global VET Courses offer a comparatively lower percentage of 10.0%. These findings indicate that BI is highly regarded within vocational and higher education, but there is potential for increased coverage of advanced skill sets in global training programmes.

In summary, results highlight important nuances of upskilling/reskilling efforts across different technology areas, showcasing varying levels of coverage on each skill within Global VET Courses, Public VET Courses, and HEI programmes. The data provides insights into the priorities and trends of skill coverage within different educational settings, enabling stakeholders to identify areas of focus and potential gaps in training programmes.

With the demand assessment forecast developed during LEADS WP1, the consortium established the direction of travel and industry appetite for different advanced skills in technology, which are now being compared to the presence of these topics within master and PhD courses, public and global Vocational Education Training (VET) and online training platforms.

Although the analysis does not focus on the proficiency or level of depth of said courses, the presence (or not) of certain ICT competencies in European educational programmes may provide us with an idea of whether such topics should be looked after more closely and if fast demand increases in such competences are currently being factored in when course programmes are established.

The data from the LEADS demand and supply assessment of ADS skills can be seen on the chart below:

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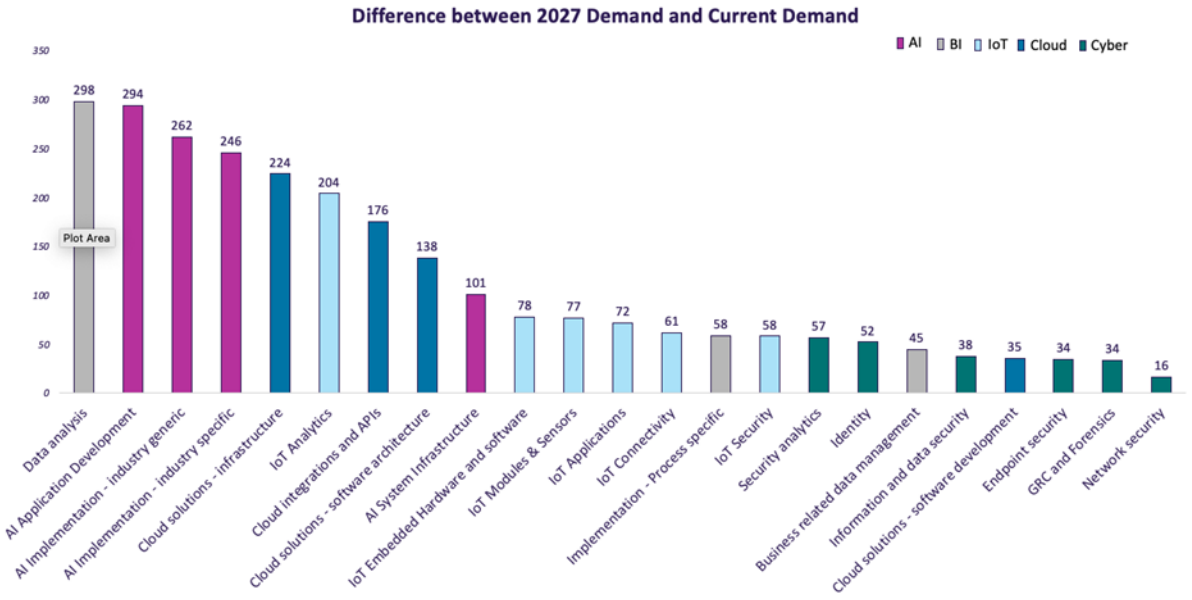

Figure 6. Difference between current demand and the forecasts in 2027 showing relative growth of the demand for ADS

Overall, although the teaching of some highly demanded skill sets such as AI Application Development and Data Analysis exists across different specialised educational programmes, coverage of advanced skills across the board are lower than expected. Taking into consideration that only specialised ICT courses were analysed during WP2 skills supply data collection, around 78% of the 1100 courses analysed are currently not addressing the teaching of advanced ICT skills, focusing solely on more basic skills and theoretical learning of concepts that, later on, will need to be complemented with practical training at work.

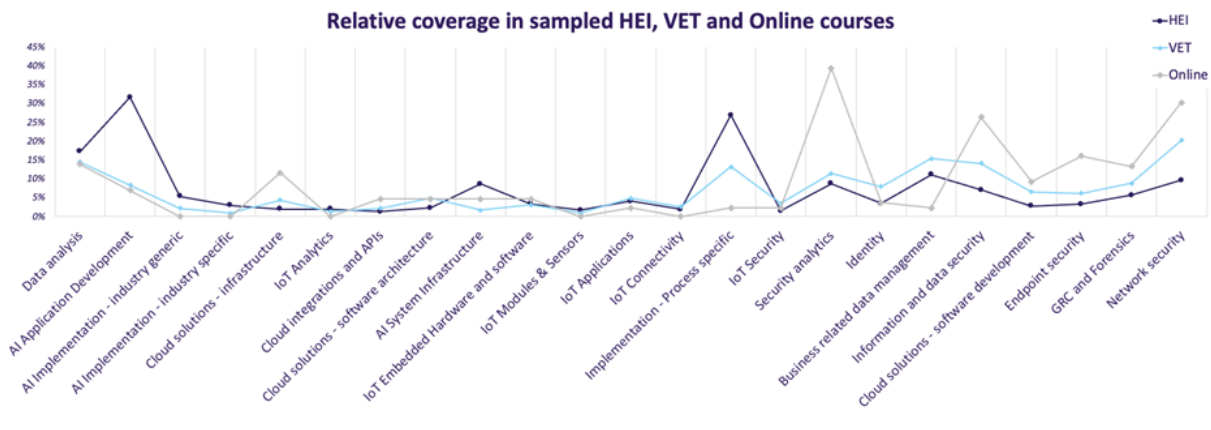

Figure 7. Relative coverage of ADS by different typologies of courses

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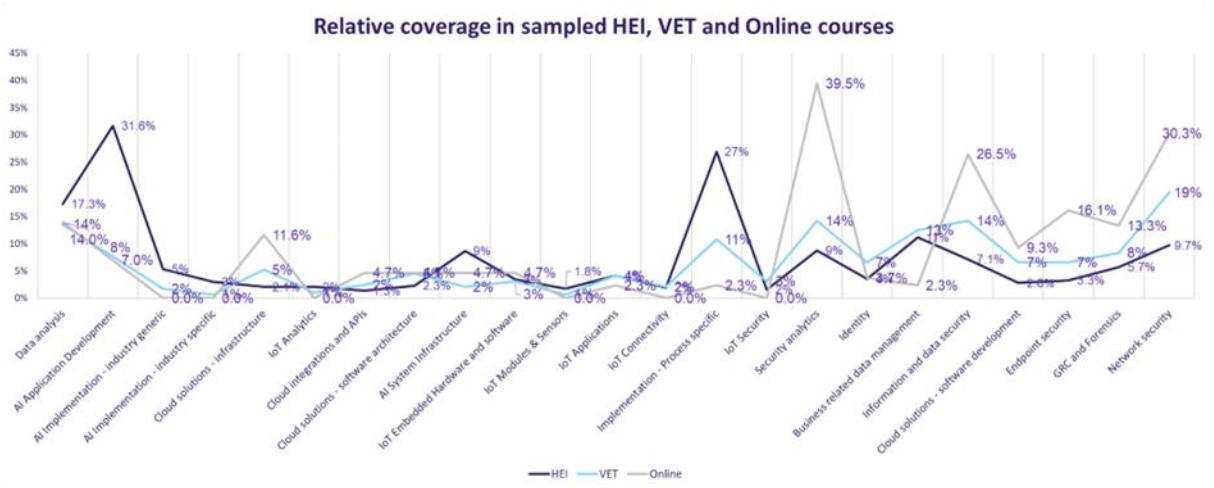

Figure 8. Relative coverage of ADS by different typologies of courses (including percentages)

Regarding training for specific skills, as it can be observed above in figure 8, some competencies that are also expected to grow quickly over the next five years such as Cloud Infrastructure skills and IoT Analytics are rarely present in training courses across Europe. Without a proper learning framework for such skills and given the current appetite of the industry, we can expect an increase in the skills gap in such areas considering the current market demand for AI, cloud, cybersecurity, IoT and Data Science skills.

For AI related skills, for example, there is a noticeable difference between *pockets* involving a more theoretical base (such as AI Application Development) where HEI courses currently have reasonable coverage, and more industry-oriented, practical skills such as AI Implementation (both industry generic and specific), where coverage is still considerably low, while such skills are expected to grow exponentially over the next five years.

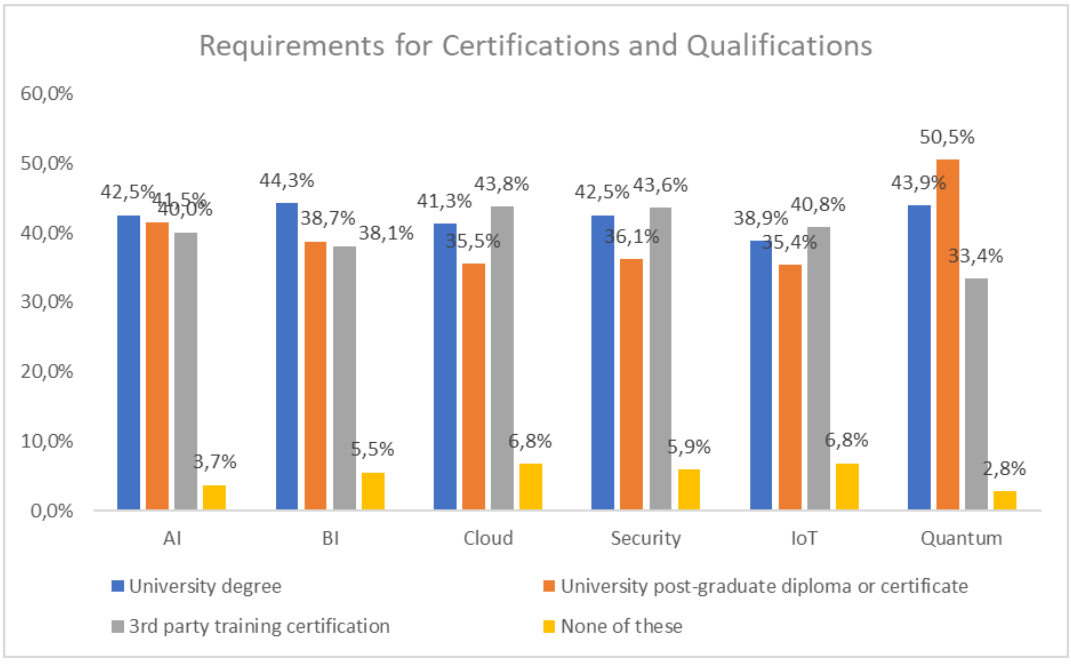

Figure 9. Requirements for Certifications and qualifications for skills in different technology areas

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In the context of the LEADS survey on advanced competencies run in April 2023 -whose results were reported in LEADS D1.3-, respondents from different industry sectors were asked about their perceptions on requirements for certifications and qualifications on different skill sets. Although some of the results seem quite similar, there are few important insights that can be extracted from the chart above:

- Quantum computing and AI skills, for example, have received a higher weight by respondents when it comes to university degrees and post-graduate diploma, possibly indicating that such topics have a bigger theoretical aspect that needs to be picked up by users before more practical, on-job skills are learned.
- Advanced security and cloud skills have received a higher weight on 3rd party training certification. One of the reasons behind such responses may be that these topics are less likely to need a HEI diploma to be absorbed and can be taught to learners outside the Higher Education environment through VET programmes and third-party courses.
- Less than 7% of respondents believe there are other paths to upskilling/reskilling outside of the options provided in the survey (University degree, University post-graduate diploma and third-party training certification)

In addition to the results presented in figure 9, we also asked LEADS survey respondents about those advanced skill sets they think University graduates are lacking the most:

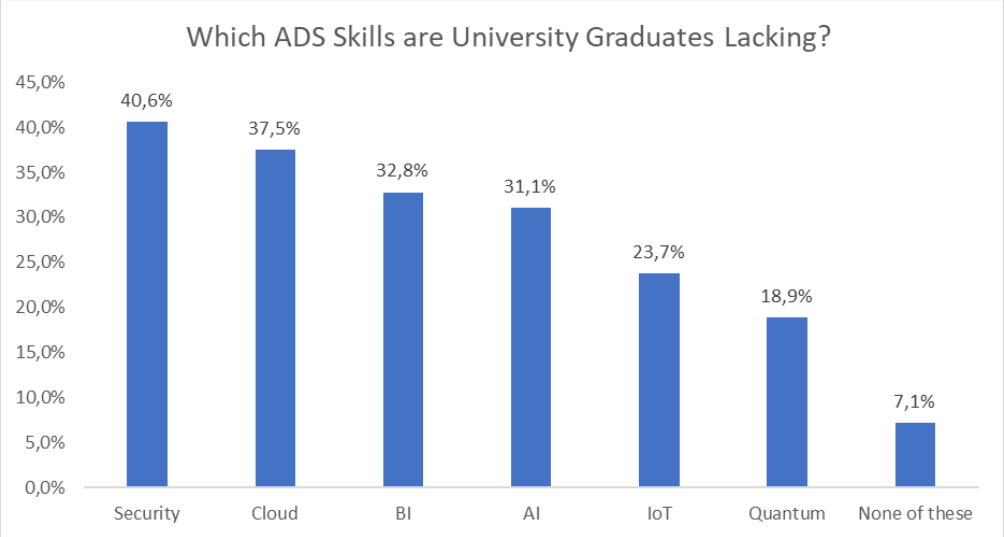

Figure 10. ADS Skills that are mostly lacking from University Graduates

Unsurprisingly, security and cloud ADS skills were the most affected ones with 40.6% and 37.5% of respondents respectively. The perception of the industry on the lack of ADS skills from University graduates in security and cloud may indicate that these two subjects are not well covered within Higher Education as seen in the previous analysis, with the upskilling focus happening outside University through VET and online third party training courses due to the more hands-on nature of the topics.

Taking into account the existing skills gap across ICT and difficulties from the industry to source the right talent to fuel their digital transformation projects, more needs to be done to complement the upskilling of critical ADS skills across Europe. With the current analysis, a few questions arise, such as:

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- Are Universities offering the right hands-on tools within ICT courses to prepare their students on real job tasks and focusing on the right technology areas?
- Are there subjects within ICT that can be primarily taught outside the University so the focus on expanding courses in such technology areas would not fall necessarily on the bachelor/master/PhD remit?
- Is the industry planning ahead on the skills it will need in the future to foresee and mitigate such skills bottlenecks before they happen with enough on-the-job upskilling?

While the lack of coverage in education/training and high demand for certain ADS skills are generating bottlenecks in recruiting, we have also aimed to map where difficulties in hiring were the biggest. To reach such results, the LEADS Survey has assessed the perception from industry respondents on their struggles with hiring talent with certain ADS skills:

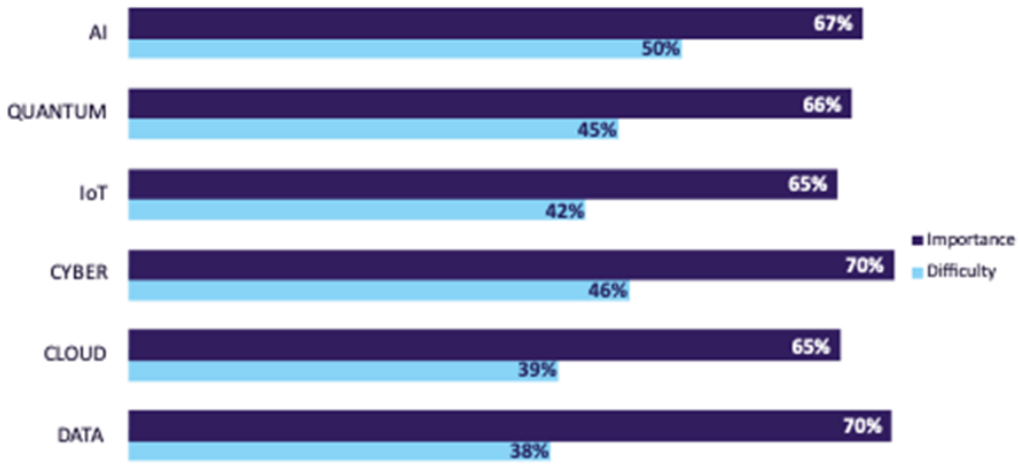

Figure 11. Areas in which industry has difficulties to find the right talent

According to the survey results, over half of respondents (50.4%) stated that recruiting talent with ADS AI skills is the most difficult, followed by Cybersecurity (45.8%) and Quantum technologies (44.6%). Although some of the results may seem similar across tech areas, the reasons behind such barriers may vary. Below are some of the potential assumptions:

- For AI related skills, barriers to finding technically able talent may be linked to the gap between theoretical learning of AI and practical skills within the field. As universities tend to put more emphasis in theoretical learning and coverage in VET/Online courses to address hands-on skills is still low, University graduates may not be fully prepared to enter the workforce after their graduation and need additional upskilling.
- The market for Quantum Computing is still incipient when compared to more mature technology areas. As the topic requires a very strong theoretical base (and hands-on skills/tasks within quantum are not yet fully established), it will take time until more upskilling programmes are developed in the area (reliant on upcoming disruptive use-cases of the technology and wider industry adoption). In summary, the demand for quantum skills is yet to be shaped.
- For cybersecurity, cloud, IoT and Business Intelligence, although such topics have a certain coverage in VET, third party training courses and HEI to a lesser degree (albeit potentially not enough to address current staffing needs), these areas have seen

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substantial market growth fuelled by the need of digital transformation over the past five years, in such a pace that it did not allow for the adaptation of the supply side. Additionally, organisations in Europe are “fishing from the same pond” when it comes to finding talent and the attractiveness of the ICT sector in the continent needs to be addressed.

In summary, there is no one-size fits all approach when it comes to mitigating different gaps in knowledge and upskilling students/workers in ICT. For a more effective skills and talent supply strategy, different technology areas need to be analysed case by case so upskilling/reskilling needs can be addressed, common skills across different areas can be identified to optimise learning and have learners focusing on what really matters when it comes to using such skills at work.

3.2 ADS Skills Gap Analysis by Technology Areas

3.2.1 Artificial Intelligence (AI)

The LEADS consortium defines Artificial intelligence (AI) as the study and research of providing software and hardware that attempts to emulate the processing capacity of humans. Skills within the technology relate to systems that learn, reason, and self-correct. These systems hypothesise and formulate possible answers based on available evidence andcan be trained through the ingestion of vast amounts of content, and automatically adapt and learn from their mistakes and failures.

Within the LEADS framework, AI related advanced skills are grouped into four key skills groupings/pockets (AI Application Development, AI System Infrastructure, AI Implementation - Generic and Industry Specific).

Results from the LEADS education data collection shows that only 34% of analysed specialised HEI, VET and Online courses currently cover the AI in an advanced manner (402 out of the 1169 courses analysed). Out of the totality of courses covering AI, there is a larger proportion allocated to AI Application Development ADS skills, which is expected to register the highest growth in demand across AI.

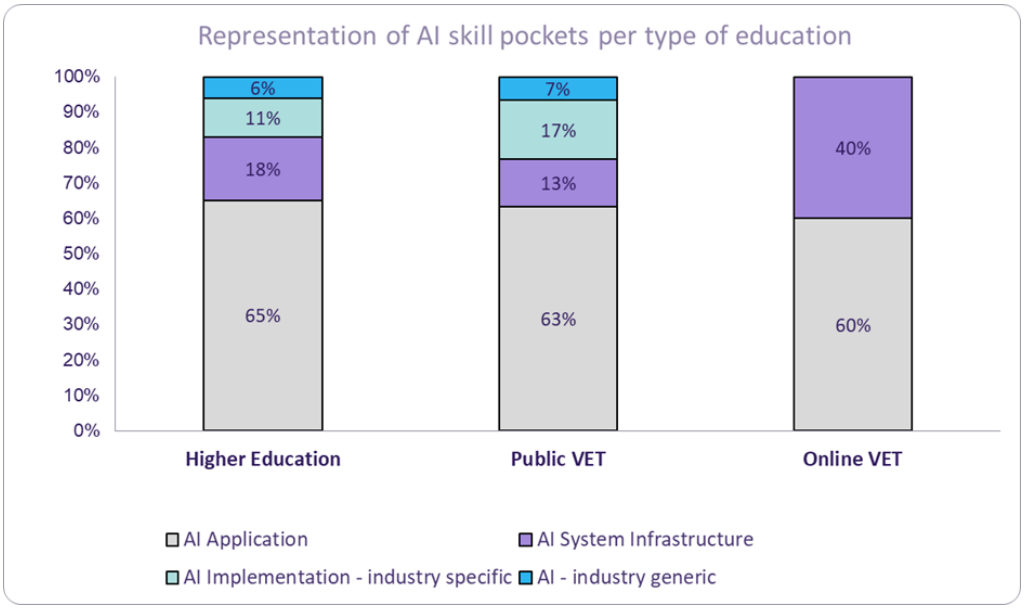

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Figure 12. Coverage of AI Skills pockets per type of education

It is important to notice that, compared to HEI, results concerning global and public VETS were much smaller or even negligible for certain skills pockets within AI when compared to the total sample (such as AI Implementation). Therefore, the first results from the educational data collection beyond HEI indicate an underrepresentation of AI in specialised courses outside of universities to date.

When crossing results from LEADS ADS skills demand analysis and skills supply data collection, there are indications that some high demand growth areas for the next five years (such as AI system Infrastructure and AI implementation skills, both generic and industry specific) are currently not being covered in existing courses.

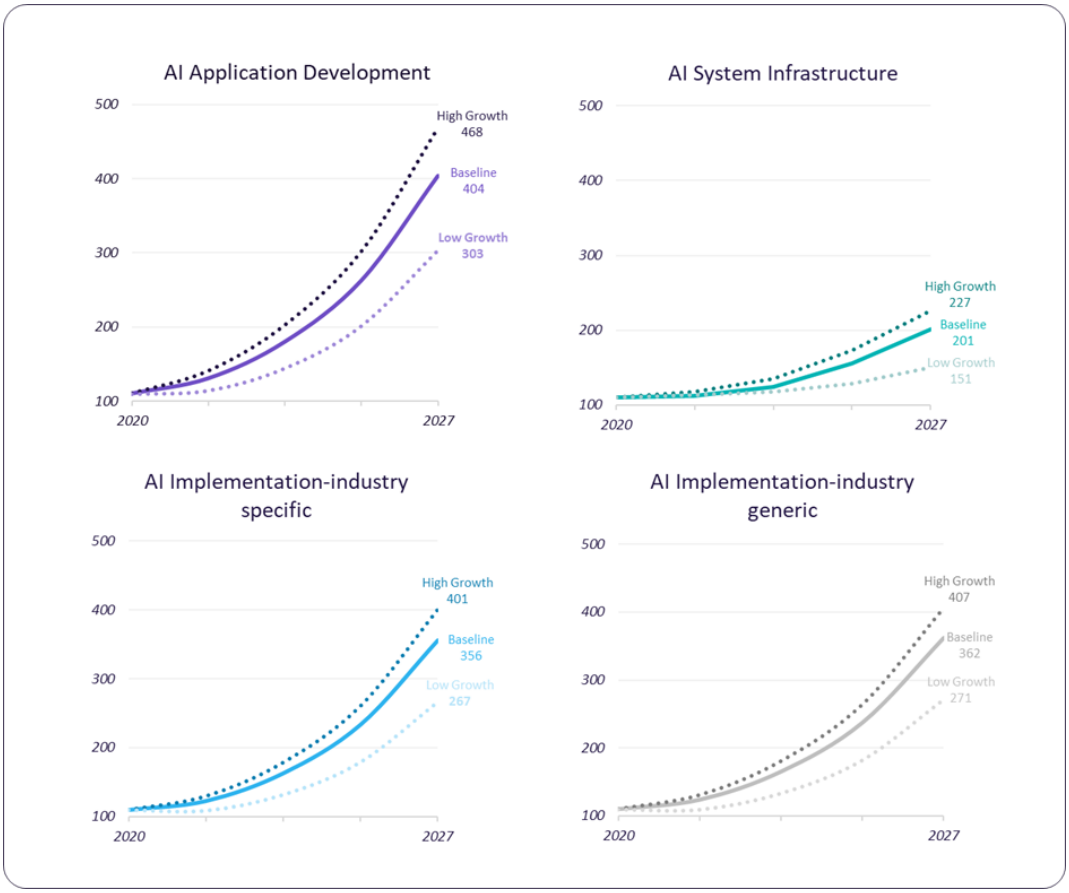

Figure 13. Scenario-based demand forecast of AI Skills

While, by definition, AI implementation and infrastructure skills tend to have a bigger practical component in terms of upskilling, HEI courses seem to be focusing more on the theoretical side of learning and therefore present a lower coverage of such topics. According to the LEADS survey, the two key barriers to recruiting talent with advanced AI skills are the lack of professional qualifications and work experience, of which are harder to overcome with only university qualifications.

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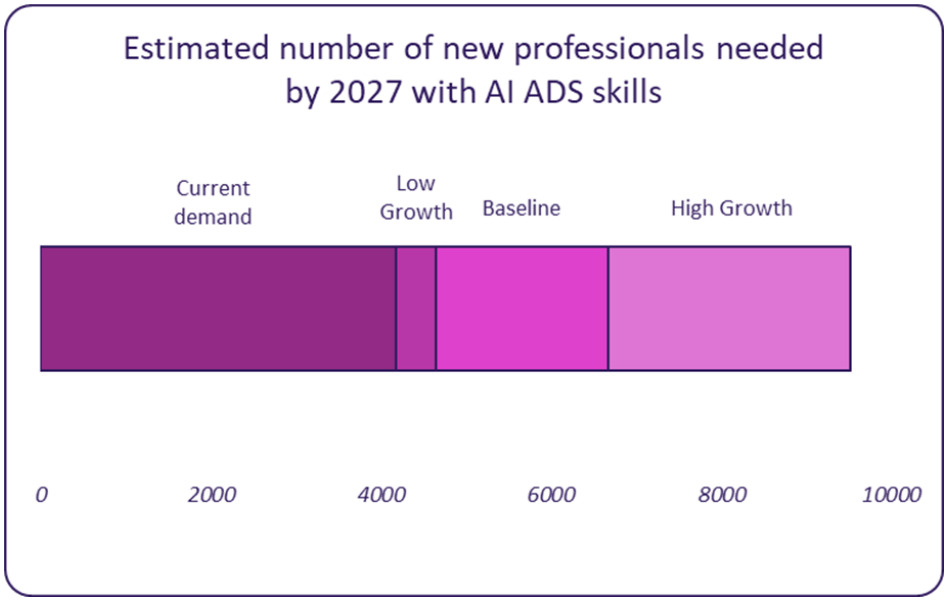

Figure 14. Estimations of new professionals required by 2027 with AI Skills

To meet the future industry demand, it is expected that between 500k and 2.8m citizens will need to pick up AI ADS skills in Europe over the next five years. The latter would represent over 20% of all graduates in Europe being upskilled in advanced AI (from a total of 3m graduates per year according to Eurostat). Therefore, as the current total supply of talent to the market is limited, it is possible that a big proportion of the upskilled workforce into AI will consist of professionals that are already out of the university and currently active in the job market. For existing professionals to be upskilled with ADS skills of the future, training programmes outside the university will play a major role in their instruction.

AI GAP Analysis preliminary conclusion

With the increasing need for workers with AI skills and the limited coverage that the topic currently has in the education sector, universities and third party/public VET providers should aim to not only introduce the topic in existing courses but to also create new courses so the demand can be met.

As in-class Bachelor, Masters and PhD have a limited capacity of students, the expansion of online VET courses may help to mitigate the gap in AI skills due to their higher reach and also enable current professionals to more easily learn ADS AI skills. However, according to our survey, the industry still perceives HEI courses to be important to the development of AI professionals, so the area should not be neglected.

With that in mind, HEI degrees on the topic should still be rolled out and increase in numbers to meet the demand and cover the ground level knowledge of AI but should potentially be complemented by continuous education at work.

3.2.2 Internet of Things (IoT)

Within the LEADS framework, IoT related advanced skills are grouped into four key skills groupings/pockets (Analytic skills, Application skills, Modules and Sensor skills, Connectivity Skills and Embedded software and hardware skills).

IoT and the related skills pockets and skills details considered within the activities of LEADS, present one of the more dynamic tech areas. While IoT reached peak prominence in the

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previous decade, advancing from machine-2-machine protocols and cyber-physical systems to a consolidated technology in itself, in the past 5 years, the scope of IoT has taken a large leap forward due to advances in intelligent networks, efficient sensors, and sophisticated platforms and systems.

This is evident from the significant and continued investment that is forecast to occur for IoT within European organisations by 2026, with spending on IoT in 2022 at EUR 172.3 Bn[10]. While this is larger than the same numbers for investments on Public Cloud, the European IoT market will grow at half the rate as cloud and behind the emergence of Edge.

Top expected business outcomes behind the growth of IoT include proving efficiency and productivity, better customer experience, and providing the necessary data for better decision-making. Challenges, though, include primarily the cost of deployment, given the embedded nature of devices, security concerns and the complexity of the deployment. The lack of the skills is only reported to be a challenge by 22% of respondents, coming in 5th place[11].

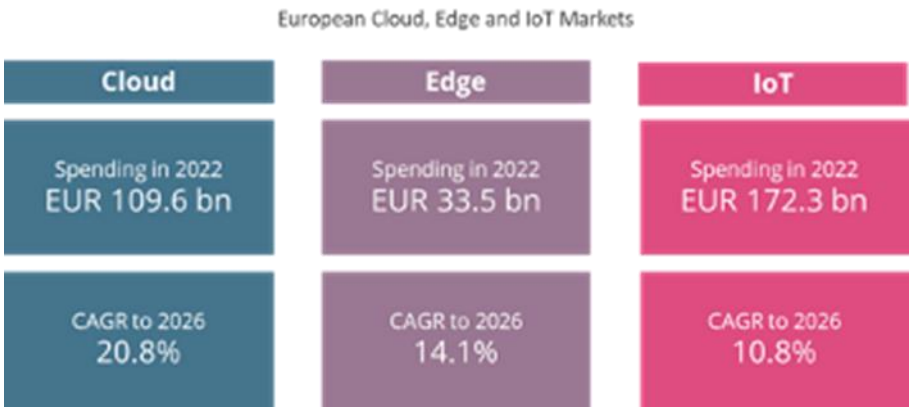

Figure 15. Spending and growth of the European Cloud, Edge and IoT Markets

Source: UNLOCK-CEI

[10] D1.2 Cloud-Edge-IoT Demand Landscape (2023), UNLOCK-CEI

[11] UNLOCK-CEI Survey, March 2023

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Figure 16. Scenario-based demand forecast of IoT Skills

Results from the LEADS education data collection show that only 11% of analysed specialised HEI and VET courses currently cover the IoT in an advanced manner (83 out of the 971 courses analysed). This represents the second to lowest ADS advanced coverage of the technology areas scoped within this study (only underperformed by supply on Cloud skills). When differentiating

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ADS but HEI and VET the relative coverage of IoT Skills remains still as the second least covered following Cloud Skills.

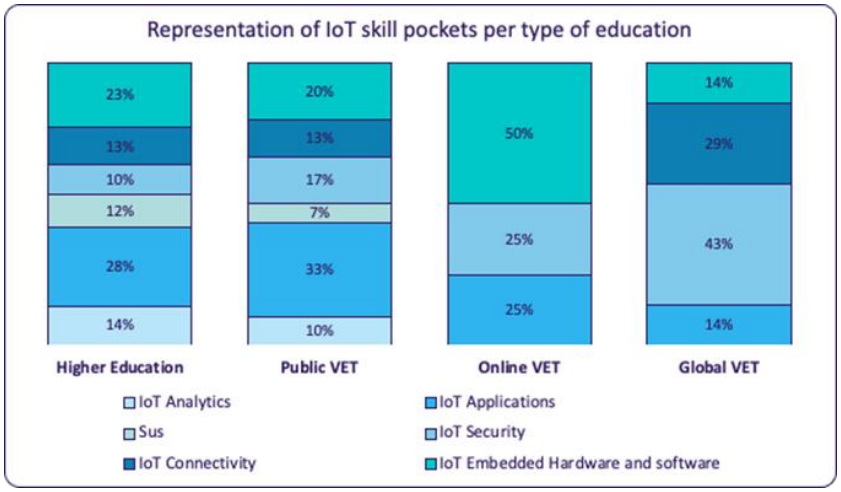

Figure 17. Coverage of IoT Skills by different types of courses

Moreover, when analysing coverage of skills per type of education we find that all IoT skills pockets are not represented evenly. On the contrary, the relative presence of courses on specific skills pockets changes particularly when comparing the HEI courses and the Global VET courses. While in HEI IoT Application is the most dominant skill pocket, it becomes the less popular one in VET offer, with IoT Security becoming the most dominant.

This relative change in skills pocket specialisation could be interpreted as a greater need in IoT security skills to be developed within active workers as opposed to it being a current teaching priority at university level. This could be a response to the current increase in complexity of complying with security standards in an ever more integrated IoT environment and the subsequent need for workers upskilling in IoT Security related proficiency.

When analyzing the projected demand, the three scenarios - baseline, high growth and low growth scenario- show an equal effect on each of the skills pockets, consequently it could be inferred that neither of the pondered factors and variables taken into account for the scenario building affect a specific pocket beyond the general effect.

IoT security presents one of the highest current market demands in terms of ADS and presents the second highest demand increase potential (197%) only surpassed by the expected increase (high growth scenario) of IoT Analytic Skills (354%)

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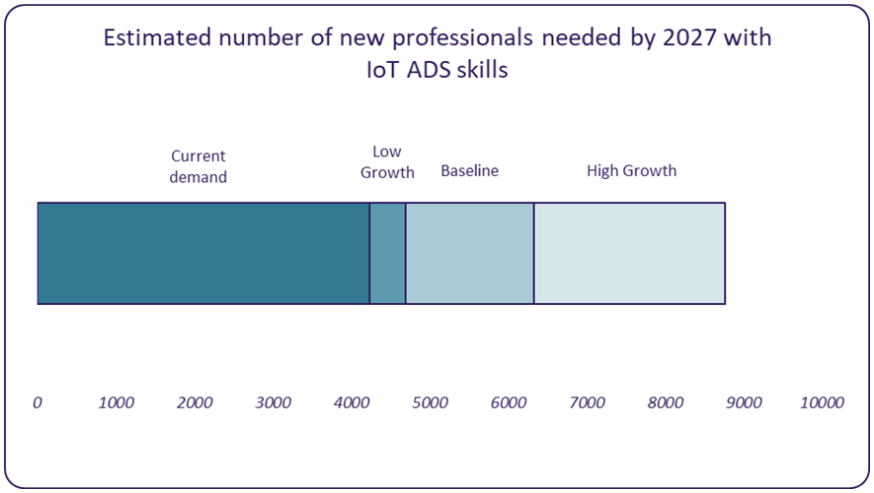

Figure 18. Estimations of new professionals required by 2027 with IoT skills

3.2.3 Cloud

Cloud solutions/technologies encompass remote servers accessed via the Internet, along with the software and databases operating on these servers. These cloud servers are distributed across data centres globally. The use of cloud computing eliminates the need for users and companies to manage physical servers themselves or run software applications on their local machines.

LEADS consortium formally defines cloud services based on a checklist of key attributes that must be present for end-users. "Public" cloud services are shared among unrelated enterprises and consumers, open to a wide range of potential users, and designed for the broader market rather than a single enterprise. Public cloud services are based on a utility computing environment, where different customers share common software managed and hosted by ISVs (Independent Software Vendors) or hosted in the cloud.

Cloud solutions/technologies skills encompass a wide range of abilities related to working with and managing cloud-based systems. Skills relevant to cloud solutions/technologies cover services, software, and hardware associated with both public cloud and private cloud environments.

The LEADS framework categorises Cloud-related advanced skills into four main groupings or pockets (Cloud solutions - software development, Cloud solutions - software architecture, Cloud solutions – infrastructure, Cloud integrations and APIs).

According to the data collected through the LEADS project, the results indicate that only 5% of analysed specialised HEI courses currently cover the Cloud in an advanced manner (47 out of the 971 courses analysed). Out of the totality of courses covering Cloud, there is a relatively even distribution in the coverage of all four groupings of skills. Concerning VET, around 10% of the courses analysed cover on average or fully the Cloud in an advanced level (28 out of the 271 analysed), which is double the percentage of the responding ADS courses offered by HEI. Therefore, one could claim that Cloud technologies skills are more served by VET than by HEIs. This can be attributed to the fact that the relevant skills are more related to software technologies that need to be acquired through continuous education and hands-on practice.

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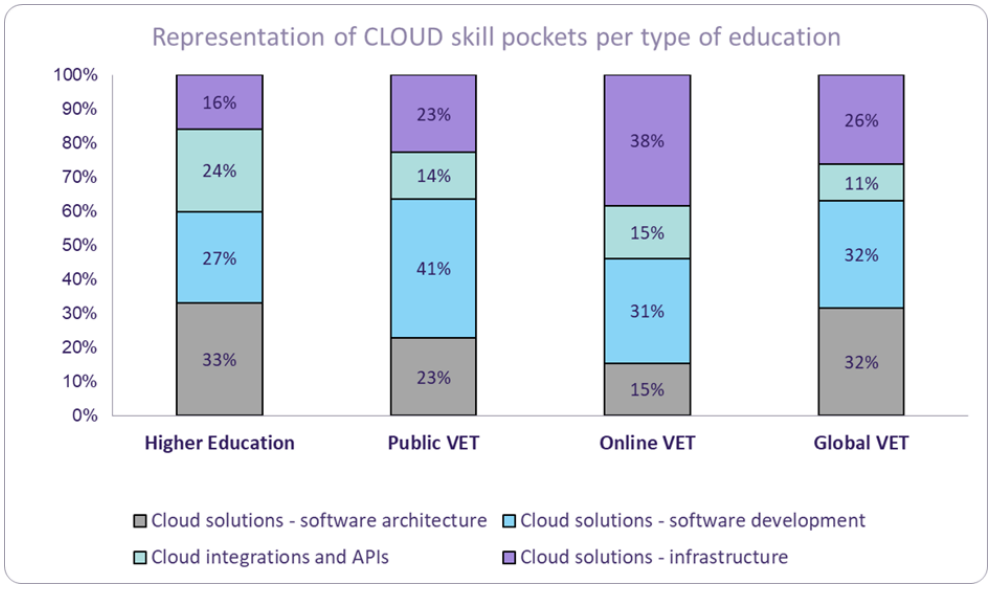

Figure 19. Coverage of Cloud Skills by different types of courses

It is worth mentioning that the difference in the results with respect to the offering of cloud skills by HEIs and VET providers is similar to the different skills pockets, i.e. for each 1 HEI ADS course covering a cloud-related skills pocket, there are 2 ADS VET courses covering the same skills pocket (fully or average).

Figure 20. Scenario-based demand forecast of Cloud Skills

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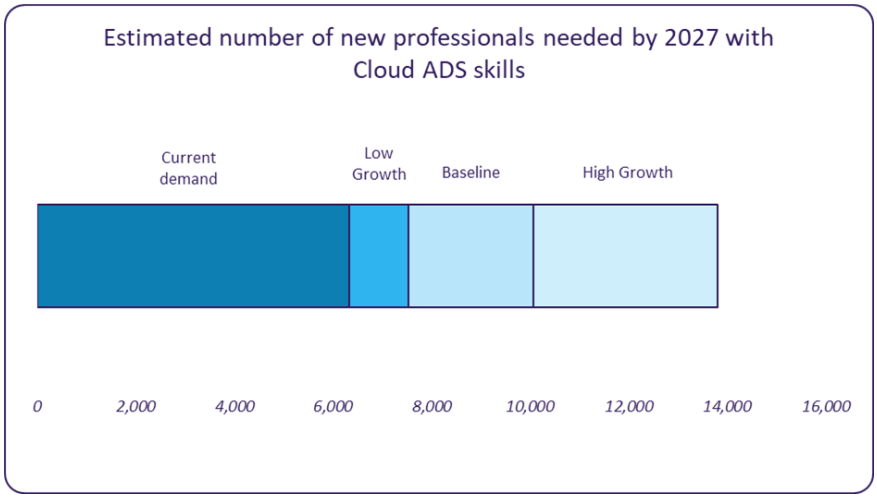

Figure 21. Estimations of new professionals required by 2027 with Cloud Skills

In response to the rising industry demand, it is projected that approximately 1.2 million to 3.7 million individuals in Europe will be required to acquire Cloud ADS skills within the next five years, as seen in figure 20 above. Due to the limited coverage of this topic in the education sector, both universities and third-party/public VET providers should focus on incorporating Cloud skills into existing courses and developing new courses to effectively meet the increasing demand for skilled workers.

Currently, the offer is not adequate in order to develop specific skills in this area; when crossing results from the LEADS ADS skills demand analysis and skills supply data collection, there are indications that all the different cloud-related areas, and especially the high demand growth areas for the next five years (such as the Cloud integrations and APIs, the cloud solutions - infrastructure, even the Cloud-solutions - software development) are currently not being covered adequately.

Since these areas address a rapidly changing landscape and the need for efficient use of highly specialised software tools, higher education institutes need to accelerate the pace of introduction of these tools in their course's curricula design. Furthermore, the cross-disciplinary nature of specific topics in this area (e.g., solutions design for customised evolving infrastructure architectures and applications, including specialised coprocessors like GPUs or even FPGAs and DSPs) need to be respectively addressed during course curriculum design.

Cloud GAP Analysis preliminary conclusion

While cloud technologies have appeared and matured during the last decade, new disruptive technologies raise the demand for appropriate digital skills in this area. The cloud technology field is still evolving rapidly, expected to generate an impressively high demand that can exceed in the most aggressive scenario by more than 50% the currently expected number of graduates at a European level (potentially generating an additional demand that amounts to almost 20% of the number of graduates at a pan-European level). Course design should focus on addressing new specializations that can keep up with technological advances in this area exposing students to cross-disciplinary subjects ranging from infrastructure design to efficiently managing modern DevOps toolchains and software design practices. In this respect complementary actions should be planned between HEIs and VET providers to cover the complete spectrum of demand. Hands-on practice is highly required in all cases since this technology area is tightly related to application of new software tools and software design methodologies for the cloud application domain.

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3.2.4 Cybersecurity

Security technologies and services encompass a comprehensive approach to strategising, designing, implementing, and overseeing information security throughout an organization's IT infrastructure.

Skills associated with security technologies involve planning and creating robust security measures for applications, information, and data. This includes utilising a diverse range of technologies to bolster the security of an organisation's network infrastructure, including computers, information systems, internet communications, networks, transactions, personal devices, mainframes, and cloud-based services. These skills also contribute to providing advanced value-added services and capabilities aimed at enhancing overall security measures.

The LEADS framework categorises Cybersecurity-related advanced skills into seven main groupings or pockets (Endpoint security, Security analytics, GRC and Forensics, Identity, Information and data security, Network security).

According to the data collected through the LEADS project, the results indicate that 36% of analysed specialised courses currently cover Cybersecurity in an advanced manner (420 out of the 1169 courses analysed). Out of the totality of courses covering security, there is a relatively even distribution in the coverage of all four groupings of skills.

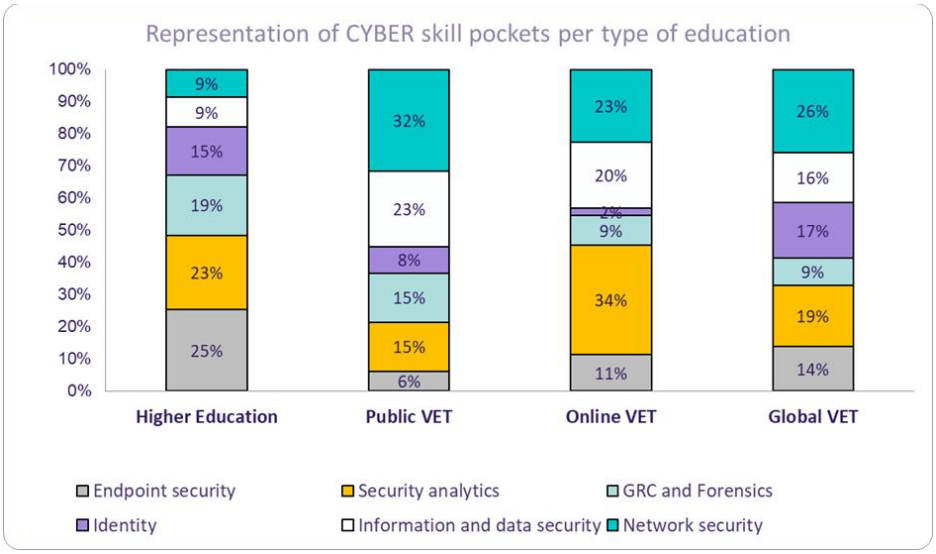

Figure 22. Coverage of Cybersecurity Skills by different types of courses

In the realm of Security courses, a significant portion is dedicated to security analytics skills and network security skills, as these areas are anticipated to experience the highest growth in demand within the Security domain. The topic seems to have a wider distribution within HEI (23%) and is still not widely covered in VET.

Subjects such as network security and information & data security have a stronger coverage outside HEI. The reason behind this trend may be related to the fact that these subjects count with a stronger practical component behind its learning vs the more theoretical approach taken by HEI.

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Figure 23. Scenario-based demand forecast of Cloud Skills

The graphs above show the expected development of ADS skills demanded by skills pocket within cybersecurity over the next five years. According to LEADS WP1 estimates, Identity management related skills are expected to register one of the fastest growths in demand within cybersecurity, followed by security analytics.

However, the teaching of such topics still seems to be limited to universities and conducted mainly on professional courses and at online learning platforms. The discrepancy in coverage across different course types within cybersecurity showcases that not all subjects are covered equally, and some of the fastest growing areas may not be addressed proportionately to its expected growth in demand.

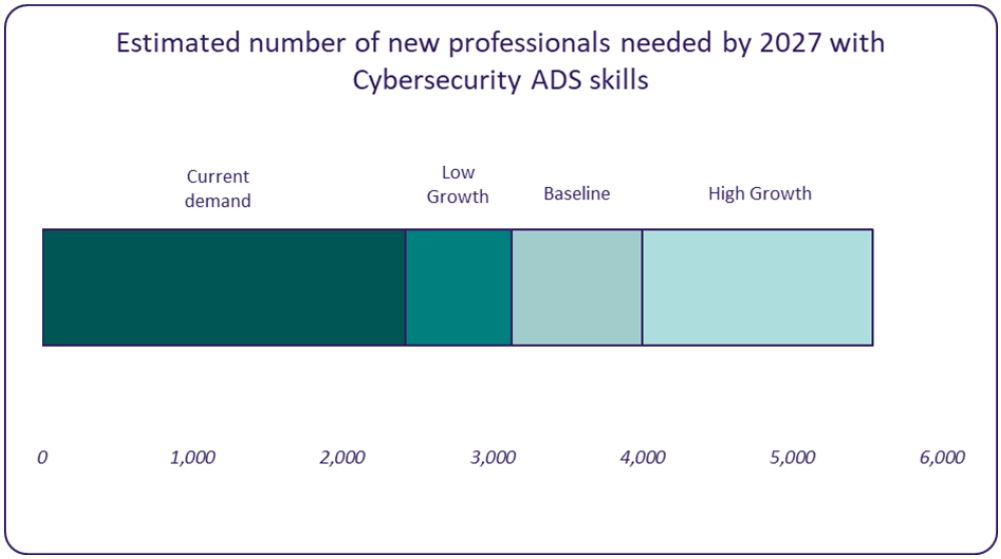

Figure 24. Estimations of new professionals required by 2027 with Cybersecurity Skills

Cybersecurity has been a technology area demonstrating a stable growth. However, there is still a gap between the expected number of skilled graduates and the demand for specific skills

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especially in new evolving topics like identity management and endpoint security. While some topics seem to be well targeted by postgraduate courses offered by HEIs, the demand for these specialised skills should be taken into account since an overall gap higher than 50% of the expected number of total postgraduate students is expected to appear in the next five years.

The upcoming demand for specialised skills in the domains of intelligent security analytics coupled with cross-disciplinary topics including identity management and forensics should be carefully planned appropriately expanding current curricula design to incorporate them.

3.2.5 BI/Data Science

Business Intelligence (BI)/ Data Science skills relate to the strategies and technologies used by enterprises for the data analysis of business information. BI technologies provide historical, current, and predictive views of business operations, and relate to, and often use, technologies within Big Data and Analytics (BDA).

The LEADS framework categorises skills into four skill pockets: i) Data Analysis, ii) Data management, iii) Implementation process specific and iv) Business related data management.

According to the data collected through the LEADS project, the results indicate that the distribution in the coverage of all four groupings of skills is uneven. According to the supply analysis the higher number of courses being offered correspond to those in relation to data analysis with a total of 168 out of the total which represents the 17% while business-related data management shows the less coverage in accordance with the fact that programmes are not actually covering the business-related part of the skills. In the graph below (Figure 25) one can see that the expected demand will be also much higher for the case of data analysis. If we analyse the number of VET courses, it also happens that data analysis is the most demanded area and with the demand expected to grow the number of courses (6) is sufficient to cover the highly demanded sector.

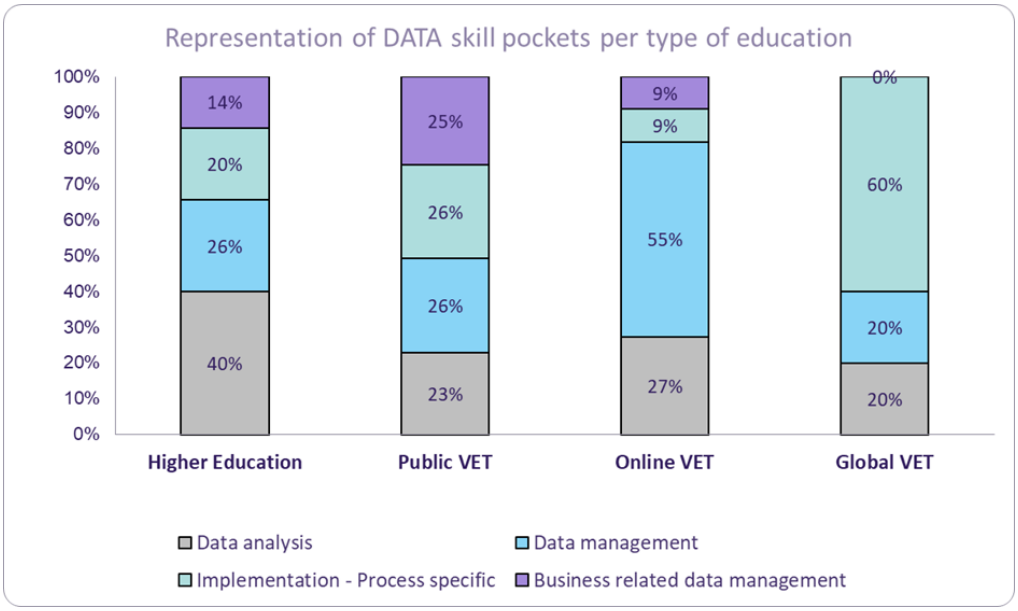

Figure 25. Coverage of BI/Data Science Skills by different types of courses

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Going deeper into the demand analysis one can observe that the only skill pocket that for the specific case of data analysis courses being offered are insufficient to cover the demand. The need of data analysis professionals comes hand in hand with the need of AI application experts. In fact, as it has been stated in the demand analysis it is a fact that as technologies will establish the need of data management will decrease but still data analysis demand will grow. On the other hand, it was also clear that Business related data management is well covered with VET courses, which is not so much the case for the rest of pockets. In the particular case of data analysis, HEI courses will not be able, as we have already analysed, to cover the entire demand and VET courses either official or private ones, will have to help to address the increase of demand.

Figure 26. Scenario-based demand forecast of BI/Data Science Skills

In fact, when one analyses further the projected demand, it is clear that under any assumption the data analysis capabilities are the ones to increase having a multiplying factor of 3 or even 4 with respect to the current demand. These will be only covered with flexible courses that help to up/reskill people assisting the current HEI and VET offer in the training of the new professionals.

Data management skills demand will in the worst-case to double in the next period. Once again there is room for improvement in the case of the VET offer to help the training of professionals.

To end with, the skills pockets in which the market has a longer tradition, business related data management and implementation process specific, is clear that demand will experience

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only a small increase when compared with the rest of skills. In this case VET courses have still room to provide with re/up-skilling together with a slight increase of HEI courses in which the emphasis should be put on practical use cases.

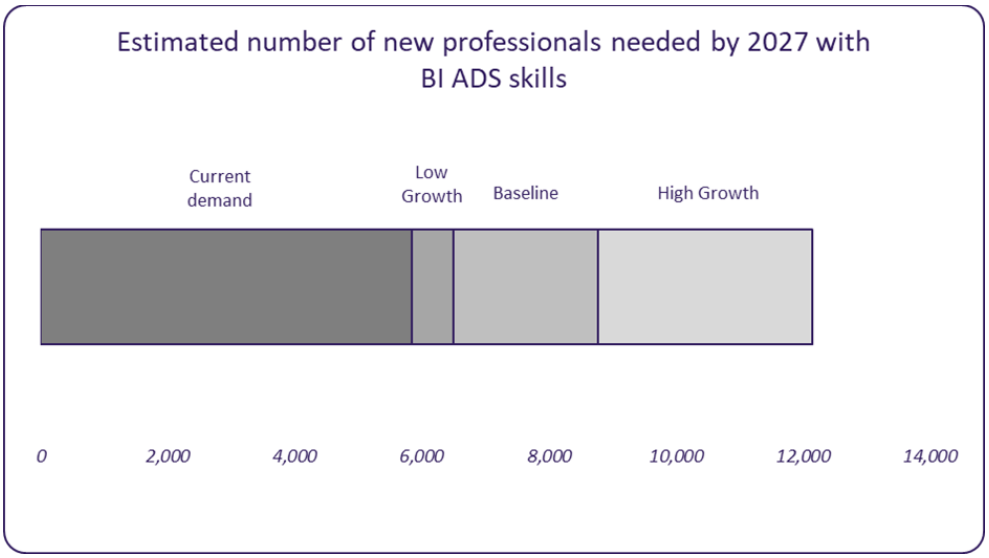

Figure 27. Estimations of new professionals required by 2027 with BI/Data Science Skills

When we analyse the number of professionals that will be required it is expected that between 658K citizens and 3.7m citizens will need to be trained in BI/Data Science skills in Europe over the next five years. These numbers mean that the supply is limited and that university alone, as it has been stated, will not be able to respond to the demand and VET courses will have to increase to help professionals in upskilling/reskilling. On the other hand, one can see that HEI programmes seem to be more focused on the theoretical side of the BI/Data Science skills and there is a need to adapt curricula to map the business and sector specific needs.

3.3 Validation Workshop Insights

3.3.1 Roundtable 1: Skills Gaps across Technology Areas

The first roundtable hosted by IDC and BluSpecs was centred on the validation of the GAP Analysis assessment of LEADS and in particular such gaps across technology areas. During the session, key data from this report was shown to the panellists prior to the publication of this report, and questions were asked on whether the analysis aligned with their expectations and knowledge of the market. The following are the main takeaways from the roundtable.

General agreement with the results of the study

In the discussion, participants explored the study's findings on AI, IoT, Cloud, BI and security and their implications for education. One perspective highlighted the perceived alignment between AI's potential and the current theoretical framework in education. The speaker emphasised the importance of recognizing the underlying value of AI while noting a general lack of comprehensive understanding in the field.

Panellists also shared insights from a sector-specific viewpoint, focusing on different sectors such as tourism. They pointed out the adaptability of AI-related insights across different

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sectors, emphasising that certain skills highlighted in the study are consistently in high demand, especially those related to data analysis. Participants also expressed concern over a projected fourfold increase in demand for data analysis and the lack of European commission data policies in place to mitigate this gap. They also discussed the challenge of attracting skilled professionals to the tourism sector despite its global significance. This is a view shared by other sectors, too.

Another participant acknowledged the significance of the fourfold increase in AI demand and attributed this trend to the intrinsic value of AI itself. This perspective underscored AI's pivotal role and its growing importance across various domains.

Lastly, a short-term strategy was presented, involving a blend of higher-level academic degrees and specialised professional training. The aim of this strategy is to address the immediate need for skilled professionals in the AI field, taking advantage of the current enthusiasm and interest in AI-related pursuits.

Impact of Technology Convergence on Skills

The participants collectively discussed the concept of "T-shaped" individuals, individuals with a specialised skill set as well as a broad perspective. They shared the idea that companies are increasingly seeking professionals with multifaceted expertise, which poses a challenge for universities to adapt their programmes to nurture such skills. This shift demands universities to be highly adaptable and agile in designing curricula that can equip students with diverse capabilities.

The trend of convergence in various technologies was highlighted, emphasising the growing importance of creativity and a wide range of skills alongside technical knowledge. The participants acknowledged the evolving landscape where companies are addressing complex challenges across the data cycle, necessitating creative contributions beyond traditional technical roles. While the automation of certain tasks by AI platforms was acknowledged, there was a collective feeling that the demand for creativity, including from individuals such as designers and artists, should increase to provide unique value that automated platforms cannot replicate. This perspective underscores the need for a holistic approach that values not only technical proficiency but also creative and diverse skills.

Gap Analysis Across Sectors & Change in Future Technologies

In a shared perspective, the participants emphasised the critical role of specialised skills in specific sectors, particularly those reliant on data. One participant noted that certain sectors like IoT and healthcare are increasingly dependent on data-driven approaches, highlighting the importance of knowledge in data management and data privacy. Another participant echoed this sentiment, revealing that the tourism sector's advancement in digital skills is closely tied to data analysis, machine learning, cloud computing, and at times, AI. However, there was a recognition of the challenge in attracting professionals to work in the tourism industry due to certain constraints.

Regarding the topic of future technologies, a collective opinion emerged. While immediate significant changes were not anticipated, one participant mentioned the presence of startups engaged in quantum computing. Additionally, there was a shared emphasis on the significance of general skills, particularly efficient writing to articulate requirements for AI systems. This

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perspective underlined the timeless importance of foundational competencies in shaping and utilising emerging technologies.

Final Remarks

One of the central concerns highlighted was the critical role of collaboration between educational providers and industry leaders. This collaboration was emphasised as crucial to bridge the existing gaps and to ground educational offerings in robust data and insights. While such interactions were acknowledged to some extent, participants noted the necessity for more effective and structured dialogues between universities and corporations. A shared consensus was reached on the significance of addressing these challenges head-on to foster a more agile and responsive educational system.

Another focal point was the alignment of industries with policy frameworks. There was a recognition of the evolving landscape in fields like data analysis, with one participant expressing concern over potential shortages in the tourism sector. It was emphasised that as the European Commission encourages data sharing economies, alignment with these policies is vital, necessitating a thoughtful prioritisation of areas that require attention.

Moreover, the discussions underscored the importance of cultivating business skills alongside technical expertise, particularly for future entrepreneurs spearheading AI applications. Furthermore, the necessity of addressing the skills gap and creating sustainable career opportunities resonated throughout the discourse, emphasising the importance of a balanced approach to nurturing talent and fostering innovation.

3.3.2 Roundtable 2: High-level Education or Vocational Education and Training?

The second roundtable hosted by Trinity College Dublin was centred on the roles of higher education and vocational education and training (VET) in meeting the demands of ADS. The lively discussions yielded fruitful inputs on the alignment of industry needs and the provision of skills. The following are the main takeaways from the roundtable.

Higher Education

Learning to Learn

At an undergraduate level, we should be training students how to think and how to adapt and learn quickly different kinds of technologies. We should not focus on specific technologies, but rather on foundational issues, theories e.g. concepts of AI so that they understand the foundations and they are good at learning.

Educator Agility

As technology is advancing constantly, education should ensure the application and relevance of skills on an ongoing basis when designing educational activities. Education institutions should instil agility in programme planning and how the programmes are offered to bring education closer to industry needs. The teaching style, the content and the delivery must be changed at a faster pace. Gamification of education is a great way to include fun activities while learning and conceiving the technologies working behind the scenes. Short-term programmes such as micro-credentials and a mix of different teaching techniques are

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currently offered in higher education, but more actions need to be taken to ensure the flexible and agile response of universities in meeting the ADS demands.

Industry, Educator, and State Cooperation

Internships and work placements, which were mentioned several times, should complement the development of students in long-term courses, highlighting the importance of better bonding between industry and universities or other third-level providers across Europe. Not only is this a preference of employers, but it is also a strong preference of students today. Higher education providers should also intervene in industry discussions by identifying the type of skills required to deliver on future technological development. Furthermore, a concerted effort between the industry, the government and higher education to discuss the opportunities for varied ICT and ADS job roles has increased the number of postgraduate students in the fields of ICT and advanced technologies. Students today are seeing the types of careers There needs to be a close-knitted relationship between all three parties.

Transversal Skills

The experts indicated that being equipped with ADS is not enough nowadays. Third-level institutions along with the pre-third level need to start to develop these e.g. presentational and analytical skills. Data analytics is not only analysing but also visualising in a conceivable way for the users to understand. Psychological resilience is critical as well for individuals to be adaptable to all kinds of changes that will take place in the future.

Vocational Education and Training

Agile Thinking

Within VET, the linkage between education and industry across business sectors highlights the importance of agility and agile thinking. SMEs are creative and innovative, and we should identify their radical approaches to skill development that may be useful for others. These creative settings can provide a sandbox from which others can learn. We have to recognise too, that VET is not just about 'industry', it is broader than that.

VET Providers

Multinationals such as Google offer their certifications and they are broadly accepted by other organisations. However, for SMEs, it is often difficult to choose a suitable reskilling/upskilling programme due to the immense offerings online. Essentially, SMEs are recommended to integrate or work closely with universities so that the VET certificates have a higher value as employees migrate to other workplaces. This highlights again the integration of industry with the university system. Moreover, VET initiatives are dynamic responses to specific demands at a specific time for a specific country's audience. Therefore, the challenge today is how to look at broader industry needs and international trends to identify longer-term solutions.

Skills Identification

It is often challenging for employers, employees, and those who are not employed but wish to learn, grow, and develop to identify the exact skills that a VET course will produce. It is

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consequently suggested that a better articulation of the actual ADS required across all jobs be produced to ensure the compatibility of skilled workers and advanced technical jobs.

Conclusion

Skills are dynamic and industry needs are evolving daily. A job description probably won't be necessary in the future. Instead, future graduates should possess a portfolio of digital, transversal, and social skills to ensure employability. Furthermore, this change requires agile cooperation between higher education, industry players and government agencies, and constant encouragement for individuals to learn, upskill and develop.

3.3.3 Roundtable 3: Can we scale current activities to the needs of Europe?

The third roundtable hosted by Polytechnic University of Madrid was centred on how to scale activities to the needs of Europe. The lively discussions yielded fruitful inputs on the quantitative aspect associated with the number of professionals needed and the capacity of current offering to scale. The most important aspect that guided the discussion was on the impact of activities to fulfil the goals in terms of ADS. The following are the main takeaways from the roundtable.

Impact

- Have a clear target. To be able to measure impact targets must be defined.
- Despite the global EU view of ADS needs when designing new curricula contextualise programmes to fill specific needs also.
- Promote collaboration among all stakeholders, HEI, public sector, private sector in a sustainable way.
- Train the trainers. The implementation of curricula levers on the trainers and it is important to be able to scale to have policies to train the trainers.
- Create awareness in the society of the need and benefits of getting skilled in ADS. New generation is born digital but only 55% understand ADS.
- Strategies should be adaptable and flexible to catch up with the rapidly evolving framework. Focus not only on new professionals but on re-up/skilling options. In this sense micro-courses vs long masters will
- Follow up the investment results. There is a need to focus on quality and impact not on quantity.
- Mind the public sector. The importance of getting the public sector digital is paramount.
- Not only big programmes. Emphasis on micro credentials.
- Foster partnerships with industries to design tailored training programmes.
- Establish mentorship programmes and role models to inspire learners.
- Recognise and reward achievements in ADS training with valuable certifications.

Where to Invest

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- Inclusive policies. Women in ADS. The LEADS educational supply data examined the estimated coverage of advanced skill sets within five different technology areas offered by programmes in Global VET, Public VET, and Higher Education (HEI). The results reveal considerable variation in the level of coverage by technology type overall and within HEI and VET.
- While security technologies receive the highest coverage in Global VET Courses their coverage in Public VET Courses and HEI programmes is lower.
- Cloud technology skills have moderate coverage in Global VET Courses however, Public VET Courses and HEI programmes provide comparatively lower coverage.
- Artificial Intelligence skills have significant coverage in higher education with low coverage in Public VET and Global VET.
- Business Intelligence and Data Science skills have significant coverage in Public VET Courses with moderate coverage in higher education. Global VET Courses offer a low coverage of these skills areas.
- Official education in HEI and VET will not be able to cover the existing gap. Collaboration of Academia and companies is crucial.
- Promote the creation of **flexible learning pathways** in well recognised training institutions. For example, through formal degrees in HEI for skilling and short high-quality courses for up-skilling and reskilling.
- Provide with a “rapid” **framework to certificate teaching and training** in different levels (bachelor, short courses, …). This is important so students and institutions can know which training is trustable.
- Promote actions to **raise the awareness about the relevance of ICT** and the need to be trained and adapt to the new technologies, at all the levels, individuals, public sector, society in general.
- Sector specific ADS awareness and training.

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4 CONCLUSIONS

4.1 Overview of Findings

The LEADS educational supply data examined the estimated coverage of advanced skill sets within five different technology areas offered by programmes in Global VET, Public VET, and Higher Education (HEI). The results reveal considerable variation in the level of coverage by technology type overall and within HEI and VET and the data highlights the different pace of evolution in the offering of these skills areas across VET and HEI.

The data revealed that whilst security technologies receive the highest coverage in Global VET Courses their coverage in Public VET Courses and HEI programmes is lower. Cloud technology skills have moderate coverage in Global VET Courses however, Public VET Courses and HEI programmes provide comparatively lower coverage. Artificial Intelligence (AI) ADS skills exhibit varying levels of coverage across the training courses with significant coverage in higher education and lower coverage in Public VET and Global VET. Business Intelligence and Data Science skills have significant coverage in Public VET Courses with moderate coverage in higher education. Global VET Courses offer a low coverage of these skills areas.

In summary, the results highlight variation of coverage of ADS across different technology areas with a distinct difference between coverage in Global VET, Public VET, and HEI programmes. The data provides insights into the priorities and trends of skill coverage within different educational settings, enabling stakeholders to identify areas of focus and potential gaps in programmes.

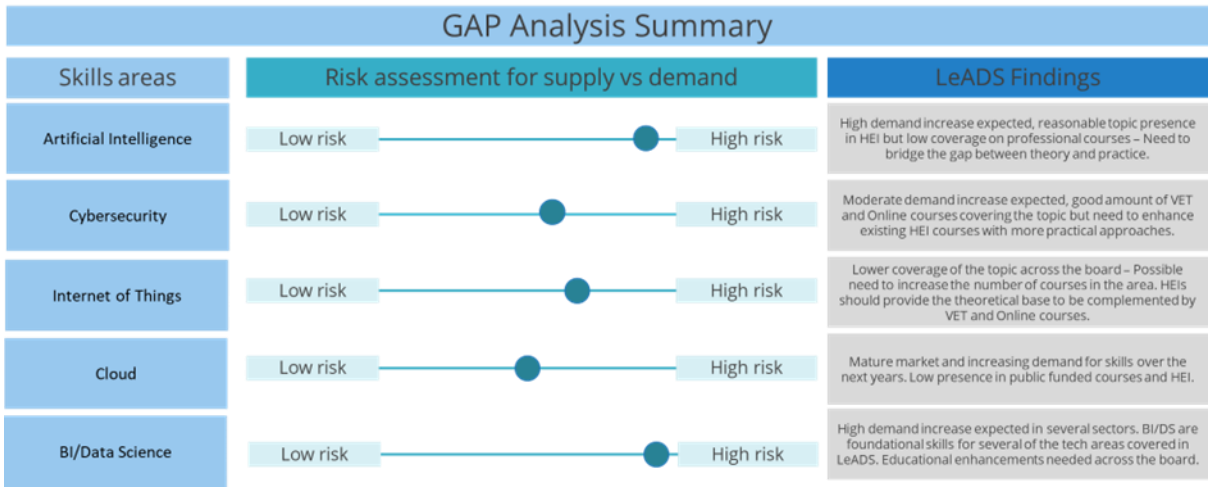

Figure 28. Summary of findings of the LEADS Gap Analysis

Overall, although the teaching of some highly demanded skill sets such as AI Application Development and Data Analysis exists across different specialised educational programmes, coverage of advanced skills across the board are lower than expected. Taking into consideration that only specialised ICT courses were analysed during LEADS WP2 skills supply data collection, around 78% of the 4000+ courses analysed are currently not addressing the teaching of advanced ICT skills, focusing solely on more basic skills and theoretical learning of concepts that, later on, will need to be complemented with practical training at work.

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Regarding training for specific skills, as it can be observed, some competencies that are also expected to grow quickly over the next five years such as Cloud Infrastructure skills and IoT Analytics are rarely present in training courses across Europe. Without a proper learning framework for such skills and given the current appetite of the industry, we can expect an increase in the skills gap in such areas considering the current market demand for AI, cloud, cybersecurity, IoT and Data Science skills.

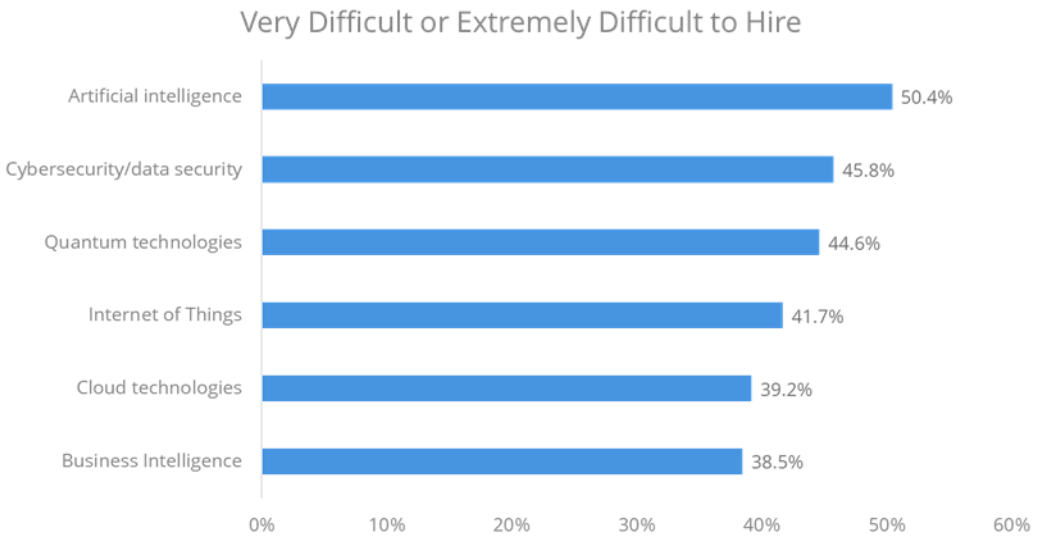

Figure 29. Difficulties declared by industry to hire profiles with ADS per technology area

From the perspective of industry and their demands, when asked about which advanced skill sets they think University graduates are lacking the most, security and cloud ADS skills were the most affected. Specific challenges are also creating bottlenecks in filling recruitment pipelines due to a combination of the lack of coverage in education/training and high demand for certain ADS skills. The LEADS Survey assessed the perception from industry respondents on their struggles with hiring talent and specific challenges emerged in the areas of AI, Cybersecurity and Quantum technologies. In addition, crossing results from the LEADS ADS skills demand analysis and skills supply data collection, there are indications that some topical areas for industry such as AI system Infrastructure and AI implementation skills, are currently not being covered in existing courses.

Our qualitative data collection through a series of roundtables with relevant experts provided further information. The purpose of these roundtables was to validate the data derived in the surveys. Regarding skills gaps across technology areas, the significance of AI in education and the challenges in meeting the increasing demand for data analysis skills was emphasised by the experts.

The trend of technology convergence was noted, requiring individuals with diverse skills and creativity. However, there was concern about convincing professionals to work in certain sectors, such as tourism, despite the high demand for digital skills due to data policy issues and a lack of interest from data scientists. No significant changes in future technologies in the short term was observed, but some startups have been exploring advanced digital technologies such as quantum computing. Collaboration between educational providers and industry leaders was emphasised as a crucial factor to address skill gaps effectively, with a

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specific focus on aligning with data policies, fostering creativity, and nurturing sustainable ADS career opportunities in the evolving landscape.

In higher education, the experts indicated that the focus should be on teaching students critical thinking and adaptability to rapidly evolving technologies, with a strong foundation in concepts like AI for continuous learning. This should also be supported by development in areas such as psychological resilience and developing skills that will teach students 'how' to learn. These types of soft skills can help them navigate their ADS career journeys within organisations. Furthermore, institutions should be agile in programme design to meet industry needs, embracing gamification of courses and offering short-term programmes and micro-credentials for flexibility. Collaboration between industry, educators, and the government is vital, with internships bridging the academic-job market gap. Transversal skills such as presentation, analytics, and data visualisation are also crucial for preparing students for future careers.

Similarly, in Vocational Education and Training (VET), agility and bridging the gap between education and industry are essential. Learning from innovative approaches in small and medium-sized enterprises (SMEs) can enhance VET programmes quality. Integrating VET certificates with universities can increase their value for employees transitioning between workplaces. VET initiatives have proven to address specific demands. Nevertheless, broader industry needs and international trends should also be taken into consideration for long-term solutions. Clear impact targets, contextualised curriculum, and collaboration among stakeholders are key to scaling activities in Europe. The experts emphasised the importance of training educators, raising awareness about ADS benefits, and prioritising adaptable strategies to cater to evolving demands. Investments in flexible learning pathways, trustworthy training options, and sector-specific ADS awareness were also recommended.

4.2 Implications

The gap analysis highlights the extent to which the forecasted LEADS skill pockets are mentioned in programmes and courses in Global VET, Public VET and Higher Education. It is important to note that the survey of the supply of ADS does not provide information on the depth of coverage. Nor does it provide assurance that a specific ADS is achieved through the programmes. However, the presence, and absence, of the ADS skills pockets in these programmes, provides us with an indication of those competencies currently being factored into programme design and delivery and those which are overlooked. The limitations of collecting data on programme supply mean that an absence of the language of the ADS skills pockets in educational documentation does not mean that there aren't valuable concepts and theories, directly and indirectly related to ADS, covered in these programmes. This may mean that, despite the apparent gap, there is some capacity to build specific ADS skills on top of foundational knowledge already included in the programmes and courses.

While local conditions vary and the implications of the findings are unlikely to be the same for all member states, the LEADS project is now beginning to identify some common factors underpinning the gap observed which allow us to identify some general implications of the findings.

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- The results highlight that meeting the demand for ADS is a 'wicked' problem. By this we mean that it is complex, dynamic and linked to actions across a wide range of policy areas and stakeholders. The implication is that addressing the ADS gap will require collaboration, cooperation and coordination across stakeholders and policy areas. For example, the survey and validation workshops highlight the importance of healthy, reciprocal partnerships between industry and education. As a wicked problem, meeting demands for ADS is a moving target and the implication is that solutions need to be flexible and adaptable so that we are not only 'solving' for today's gaps but building structures, relationships, processes and systems that allow us meet tomorrow's needs.
- The scale of the forecasted demands for ADS means that a combination of new hires, upskilling and reskilling will be needed, requiring action across both the higher and vocational education systems. As digital skills are practical skills, the implication is that applied and creative learning approaches are necessary. While the findings highlight that it is certainly possible for higher education to utilise applied learning approaches, more theoretical approaches tend to be standard in programme design and implementation. By contrast in vocational education it is possible for courses to be overly applied, to one organisation's use of a technology for example, which could mean that the broad skill pocket itself has not been developed. The implication is that ADS presents a pedagogical challenge which must be addressed if the right level of skill is to be produced.
- The LEADS analysis has focused on ADS skill pockets in technology areas but it is evident that a wider array of skills and aptitudes must wrap around the ADS if an individual is to be effective. This was a clear finding from the validation workshops and helps to broaden our understanding of the supply challenge. It is also apparent that as technologies evolve so quickly, learning how to learn is a crucial skill itself. The implication is that transversal skills, creativity, ethical understanding and psychological resilience are all necessary complements to ADS development and that programme development must take account of this.
- While the LEADS analysis focuses on the supply of programmes and courses, it is self-evident that without individual people participating in these programmes the *supply of programmes* will not itself lead to a *supply of skilled people*. The promise of acquisition of a skill pocket is unlikely on its own to act as an incentive to participation in ADS programmes. The implication is that locating ADS within meaningful and sustainable careers is a necessary motivator for engagement in education and training programmes.

One overarching implication of the gap analysis, and further emphasised in the validation workshops, is that agile thinking, behaviour and systems are needed to address the ADS gap. Established approaches to topics such as programne development, pedagogy, accreditation, work experience, industry collaboration and the type of programmes offered all need a fresh look. Staff and systems need to become, and remain, nimble if this challenge is to be addressed. Without this agility, our ability to supply ADS is unlikely to align with demand.

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4.3 Recommendations

With the Gap Analysis report establishing the first diagnosis on demand and supply of ADS skills in Europe, below are recommendations for addressing the gaps and challenges related to advanced skill sets (ADS) in technology education based on our research findings:

Holistic Curriculum Redesign:

- Develop a comprehensive curriculum redesign strategy that integrates ADS skills within foundational and specialised courses across Global VET, Public VET, and Higher Education (HEI) programmes.
- Prioritise a balanced approach that combines theoretical knowledge with hands-on practical training, ensuring students are equipped with both fundamental concepts and real-world application skills.

Strengthen Industry-Academia Collaboration:

- Establish strong and sustained partnerships between educational institutions and industry stakeholders to co-create and update curriculum content in alignment with evolving industry demands.
- Organise regular industry advisory boards and collaborative projects to ensure that ADS skill coverage remains updated and relevant.

Promote Transversal Skill Development:

- Integrate transversal skills, such as critical thinking, adaptability, communication, and ethical understanding, into all ADS education programmes to foster well-rounded and versatile professionals.
- Incorporate experiential learning opportunities, team projects, and case studies to enhance students' ability to apply ADS skills in diverse contexts.

Flexible Learning Pathways:

- Develop flexible and agile programme structures that accommodate the fast-paced evolution of ADS technologies and industry needs both inside and outside HEI.
- Offer micro-credentials, short-term courses, and online learning options to enable learners to upskill and reskill in specific technology areas according to their career aspirations and industry demands.

Data-Driven Decision Making:

- Implement continuous data collection and analysis mechanisms to monitor the coverage and effectiveness of ADS skill delivery across technology areas and educational settings.
- Utilise insights from industry feedback, skill gap assessments, and employment outcomes to refine and optimise curriculum content and delivery strategies.

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Leverage Emerging Technologies:

- Embrace emerging technologies, such as virtual reality (VR), augmented reality (AR), and simulation tools, to enhance practical hands-on learning experiences for ADS skill development.
- Integrate innovative learning methodologies that promote creativity, problem-solving, and experimentation to prepare students for the dynamic ADS landscape.

It is important to mention that the above recommendations are based on the overall understanding of the current ADS skills educational situation in Europe and aims to provide a direction of travel to be developed further. Certain education institutions, providers and companies may be in different development stages with their upskilling/reskilling strategies. To make these points relevant within the microenvironment, education providers and industry should benchmark key findings of this study with their own strategies.

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