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Blueprint Report:

Bridging the Skills Gap in the Semiconductor Sector

A coordinated approach and Call to Action for the semiconductor community

June 2024

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Executive Summary

This Blueprint represents a comprehensive report on the current state and future outlook of the skills gap within the semiconductor industry in Europe. Developed through a collaborative effort involving selected stakeholders from industry and research, the Blueprint has been crafted through an open consultation process to identify key challenges, gaps, and future recommendations in the semiconductor workforce landscape.

The community of stakeholders involved in the Blueprint has identified seven recommendations:

Recommendation #1 - **Appoint a neutral umbrella organisation, that is recognised by the entire community, that may coordinate all joint initiatives and efforts aimed at bridging the skills gap in the semiconductor industry, effective from July 2024.**

It is recommended to appoint a neutral umbrella organisation, recognised by the entire semiconductor community, tasked with aligning and synchronising the collective efforts of participating organisations. The coordinating umbrella organisation will establish a central office to gather information and success stories, develop a comprehensive shared calendar of events and summer schools, facilitate regular communication among stakeholders to ensure alignment, and pursue EU funding to support talent development initiatives in line with the objectives of the European Chips Act.

Recommendation #2 - **Create joint coordinated awareness campaigns with relevant stakeholders (associations, consortia, industry...) around the skills gap in Europe.**

The campaigns which shall include multimedia content, events and workshops and educational kits, will target European students and young people, educating them about the various career opportunities in the semiconductor industry, dispelling misconceptions, encouraging reskilling, combating gender stereotypes and biases, and highlighting the importance of STEM education.

Recommendation #3 - **Sponsorship, Financial or In-Kind Support to Future Summer Schools and Vocational Schools.**

Recognising the critical role of Summer Schools in nurturing talent and addressing the skills gap in the semiconductor industry, this recommendation proposes a coordinated approach involving industry leaders and universities. This approach includes specifically allocated budgets, funding opportunities, and access to training facilities and resources.

Recommendation #4 - **Support on the job and Lifelong-learning opportunities.**

The recommendation asks for collaborative efforts between academia, research organisations, and industry to develop micro-credential courses. These efforts will be complemented by industry and research organisations facilitating placement opportunities through internships, traineeships, and apprenticeships. In addition, expanding technician training opportunities is crucial to address the need for upskilling and reskilling workers, particularly those transitioning from other industries.

Recommendation #5 - **Develop an official cohesive strategy that unites universities across Europe and their specialised courses in semiconductor education.**

Stakeholders acknowledge the need for a unified strategy to align European universities specialising in semiconductor education. This strategy aims to standardise curricula, providing a recognised educational pathway, thus enhancing student mobility and employability across the EU. It is recommended to integrate accreditation requirements into a shared official education strategy endorsed by both European and national governments.

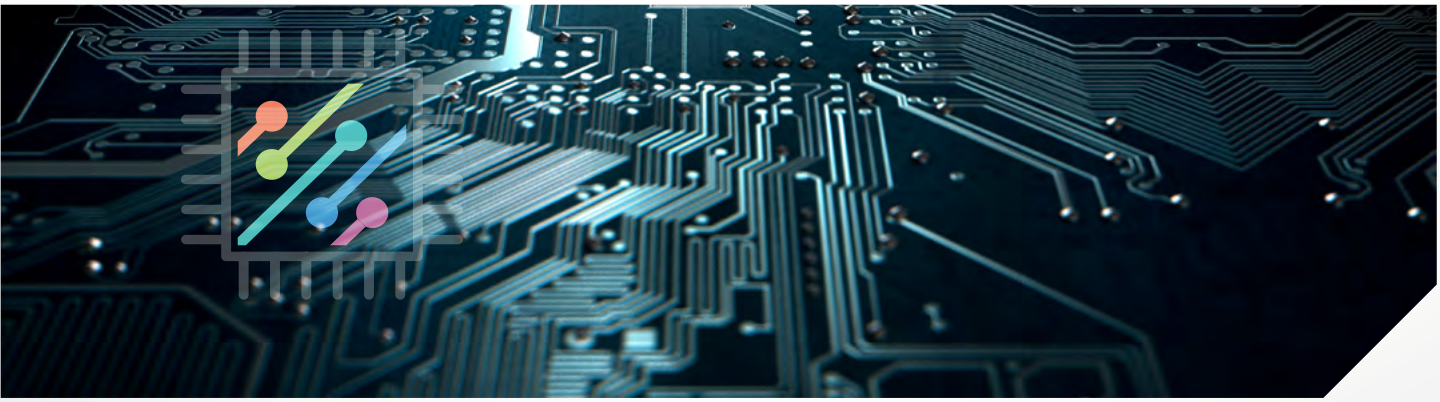
Recommendation #6 - **Strengthen collaborative efforts between Governments, Member States, Regions, and the Semiconductor Ecosystem.**

Member States, national governments, and regional authorities should play a key role in shaping and supporting the semiconductor workforce. This involves providing funding access, creating supportive policies, and enhancing education and university partnerships.

Recommendation #7 - **Facilitate international cooperation and student exchange programmes.**

The recommendation calls for the commitment of Member States, governments and regions in establishing and supporting exchange programs with key semiconductor hubs like Japan, Singapore, and the US, fostering international collaboration. The final aim will be the creation of robust exchange programmes that combine academic learning with hands-on industry experience.

Upon the forthcoming official launch of the Semiconductor Industry Alliance, the Blueprint and its recommendations will be suggested to the dedicated Skills Working Group as preparatory work to steer future actions.



1. Introduction

The semiconductor industry stands as the backbone of modern technology, underpinning innovations across sectors ranging from telecommunications to healthcare. However, amidst the industry's exponential growth and technological advancements, a critical challenge threatens to impede its trajectory: the widening **skills gap**. Across the globe, the semiconductor industry faces a dire shortage of skilled professionals equipped with the specialised knowledge and expertise required to drive innovation and sustain growth. From semiconductor design and fabrication to testing and packaging, the demand for highly skilled talent continues to outpace the available supply, leading to talent shortages and escalating competition for qualified individuals.

In the European Union (EU), the skills gap in the semiconductor industry presents a particularly pressing concern. Despite the EU's strong presence in semiconductor manufacturing and research, the region grapples with a mismatch between industry demand and workforce capabilities. This misalignment not only hampers the industry's ability to maintain competitiveness but also jeopardises its capacity to capitalise on emerging opportunities in areas such as artificial intelligence, Internet of Things (IoT), and advanced manufacturing. Without a robust talent pipeline to fuel research, development, and commercialization efforts, the industry risks falling behind competitors and relinquishing its leadership position on the world stage. The urgency of addressing the skills gap is underscored by the strategic significance of the semiconductor industry in key policy areas such as national security, technological sovereignty, and environmental sustainability. From ensuring the security of critical infrastructure to fostering homegrown innovation and reducing reliance on external supply chains, **a skilled semiconductor workforce is indispensable** to safeguarding the EU's strategic interests and promoting resilience in an increasingly interconnected world.

These challenges call for concerted and collective action. **Collaborative efforts between industry, academia, and government** are needed to identify the root causes of the skills gap, develop targeted interventions, and implement sustainable solutions. By investing in education and training programmes, promoting industry-academia partnerships, and fostering an innovation-friendly regulatory environment, stakeholders can work together to cultivate a skilled semiconductor workforce capable of driving prosperity and progress in the EU and beyond.

The semiconductor industry must **upskill its workforce** to align with new technologies, ensuring production continuity and preventing supply chain disruptions. Emerging technologies like quantum computing necessitate careful planning, particularly in staffing, to avoid disruptions. The industry must recruit and upskill professionals to fill emerging competency gaps, as data processing infrastructure evolves. **Seamless interdisciplinary collaboration** among engineers, physicists, chemists, and materials scientists is crucial for innovation and efficiency. Emphasising data analytics and machine learning is essential for optimising semiconductor processes, so companies must train and recruit specialised data professionals, recognizing the competition for such talent.

Understanding industry-specific trends and maintaining close connections with end-user customers will enable the development of better, customised semiconductor products. In summary, the semiconductor industry requires a holistic, integrated approach, focusing on emerging technologies, interdisciplinary collaboration, and specific industry use cases to stay competitive and innovative. The following sections will develop these

1.1 ALLPROS.eu and the Thematic Working Group on Semiconductor, Microsystems and Photonic engineering Skills

At the core of ALLPROS.eu lies the call for greater cooperation between actors of the microelectronics value chain in the European Union and the need to increase the EU's competitiveness in such a complex and strategic sector. With this in mind, ALLPROS.eu strives to bring together stakeholders in the industry, including academia, research and technology organisations as well as users, ultimately reinforcing Europe's role in the global microelectronic sector. While building on the European Commission's Chips Act, supporting its efforts to double EU's share in the global market to 20% by 2030, the project also addresses the pressing challenges of skills shortages within the semiconductor industry, helping the European Commission to enhance workforce capabilities and bridge the gap between industry demand and the available pool of skilled professionals.

Against this backdrop, ALLPROS.eu has launched a skilled workforce to effectively support the Pact for Skills in microelectronics, chips, and semiconductors across the entire supply chain. This workforce is organised in a

Thematic Working Group (TWG) that prioritises the importance of diverse talent, with a special focus on supporting teachers, schools, and students in addressing the shortage of skilled individuals in key areas such as CMOS design, mixed signal technology, RF engineering, analogue and mixed-signal design, as well as front-end and back-end semiconductor manufacturing processes. Additional attention is directed towards testing, simulation, system integration, material science, physics, chemical engineering, and more, aligning with the set objectives.

1.2 Purpose, Scope, and Structure of the Blueprint Report

One of the key results and responsibilities of the TWG is the design, development, and publication of this Blueprint report containing recommendations derived from industry/market needs, aimed at influencing governmental decisions addressing the skills gap in the semiconductor sector.

Conceived as a collaborative effort between the semiconductor industry, the research community, and a number of EU research & innovation projects, the Blueprint Report investigates the skills gap in the EU semiconductor industry and provides practical guidelines to tackle the issue from the industry, education and government perspective. Through this "**Triple-Helix**" approach, Academia provides concrete actions on cutting-edge research and educational resources, while industry offers real-world recommendations, guiding curriculum development and ensuring relevance and adherence to the actual needs of Europe's semiconductor sector. Policy-makers' involvement, on the other hand, is essential for policy support and funding opportunities to drive initiatives forward. Together, these stakeholders create a dynamic ecosystem conducive to talent development, innovation, and sustainable growth, ultimately strengthening the semiconductor industry's competitiveness and resilience in the EU and beyond.

The Blueprint report is structured along five main sections:

- Section 1 provides the introduction to the Blueprint Report, comprising background information related to its inception and the objectives of this document, as well as the methodology used to create it and the key facts and figures to understand the skills shortage in this industry.
- After a short introduction presenting the key trends, facts and figures related to the semiconductors skills shortages in Europe, Section 2 analyses the current needs and corrective actions in place (in the EU and in other relevant regions) from an industrial, educational and governmental perspective.
- Section 3 deals with the strategies that are available for addressing skills shortages leveraging the expertise of European contributors but also investigating inspiring initiatives conducted in other regions.
- In section 4, real-life examples and case studies illustrate in practice how skills gaps in the semiconductor industry arise today and how they are being met with corrective actions.
- Finally, the key recommendations and call to action highlighted in the report are presented in section 5.

1.3 Methodology

A mix of primary and secondary research methods underpin the production of the Blueprint Report. Extensive desk research on available public sources from EU institutions, academia, research centres and national and supra-national statistical research offices will inform the presentation of the key trends, facts and figures, as well as the analysis of the state of the art of the semiconductor skill shortages in Europe in terms of needs and corrective actions. This is complemented by existing IDC research on digital skills by leveraging IDC European Skills Practice focusing on IT talent, skills development, skills mapping and identification of key competences in core areas of technology and by further tapping into IDC's infrastructure research, which covers the semiconductor value-chain from both the supply and the demand perspective.

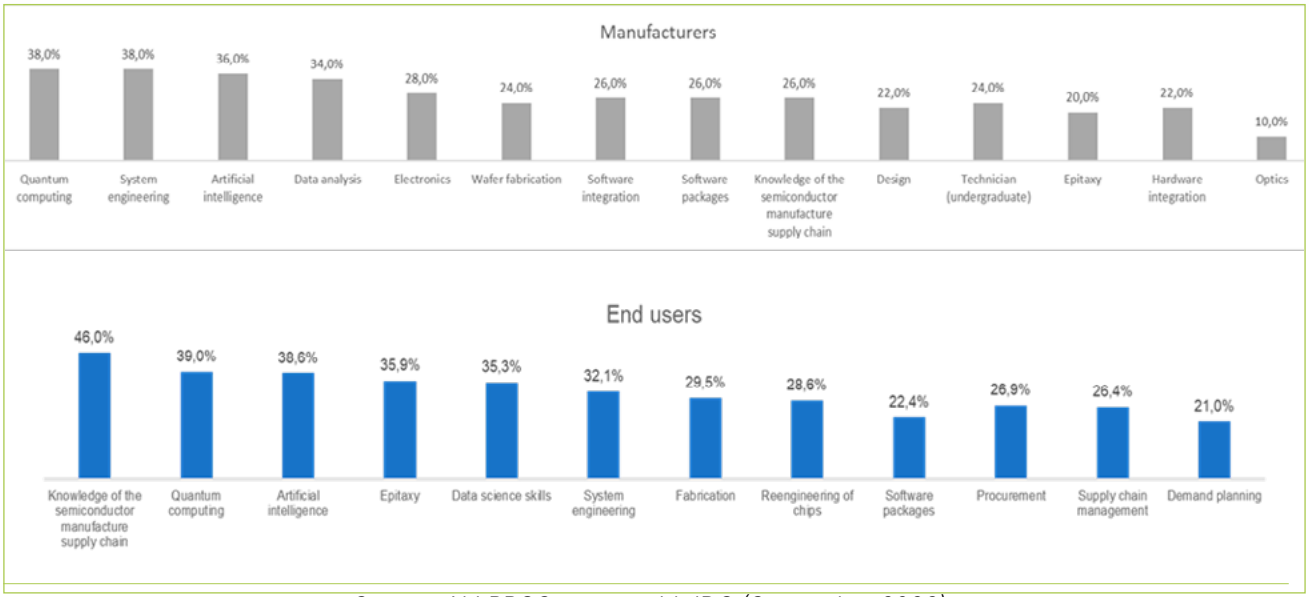
Further data points and evidence are drawn from the two semi-structured surveys that ALLPROS.eu organised in 2023 to capture the skills needs, shortage and gaps in the semiconductor industry in Europe. IDC (International Data Corporation) has interviewed 50 representatives of the chip manufacturers as well 580 end-users of semiconductors across all industry sectors in the European economy. For the chips manufacturers survey the methodology consisted of Computer-Aided Telephone Interviews (CATI). The end-users were interviewed through a hybrid mix of Computer-Aided Web Interviews (CAWI) supplemented by Computer-Aided Telephone Interviews (CATI) to ensure both respondents' response rate and accuracy of responses. All interviews were based on a semi-structured questionnaire and conducted in English and/or local language for a total length of approximately 20 minutes.

The strategies for addressing the skills shortages, as well as the use cases covered in sections 3 and 4 respectively, are the result of a collaborative effort involving industry, academia, research and technology organisations that were mobilised by ALLPROS.eu with the support of the European Commission. Extensive desk research, real-life examples and selected interviews with experts were the basis for the collection of data and intelligence, followed by a collective effort of analysis and recommendations.

1.4 Semiconductor Skills Shortage: Key trends, facts and figures

1.4.1 Key Skills Gaps: Technical, Advance Manufacturing, R&D Skills

The skills shortage within the semiconductor industry is an issue affecting both semiconductor manufacturers and end user industries alike. Results from the ALLPROS.eu's survey reveal that **over the past year, 53% of manufacturers and 57% of end users in the sector have encountered challenges stemming from a lack of skilled professionals.**



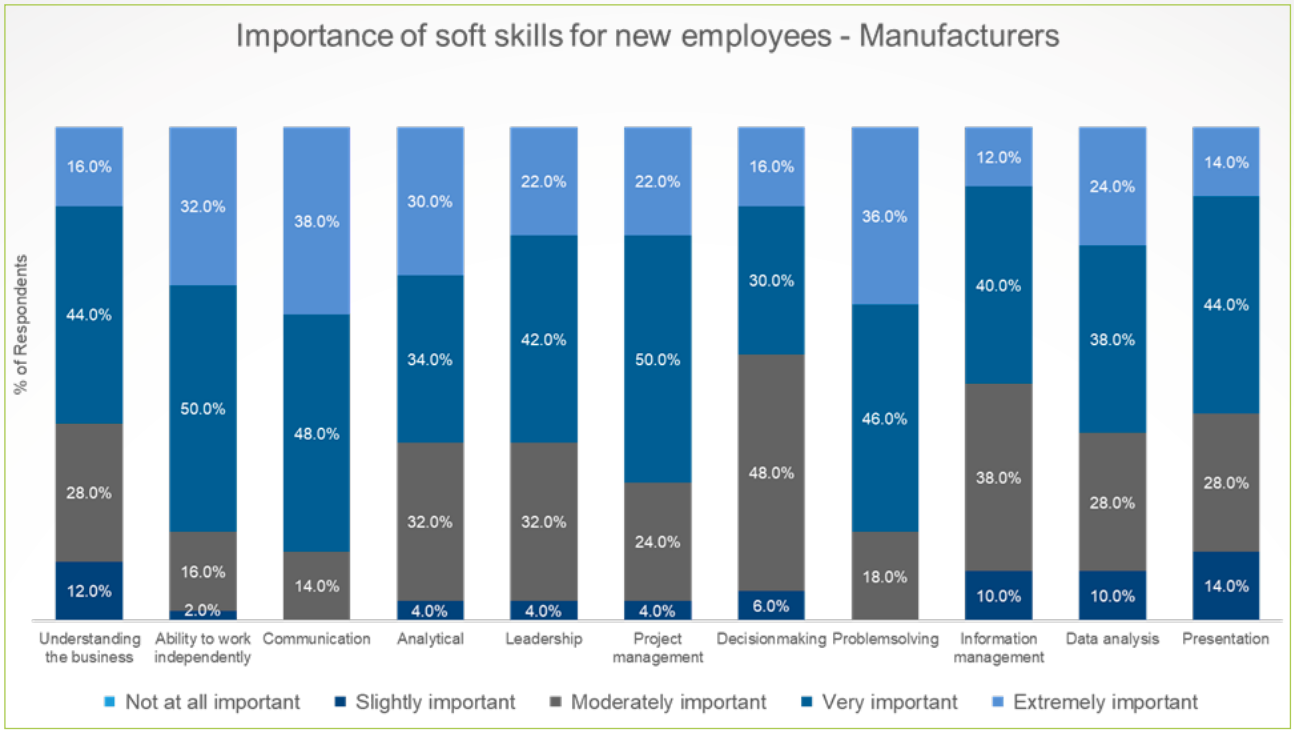
Source: ALLPROS survey with IDC (September 2023)

Notable technical skill gaps were identified in key areas, including AI, system engineering, quantum, and data science, affecting both semiconductor manufacturers and end user industries. A closer examination reveals that manufacturers encounter greater challenges in skills related to **software and hardware integration**, exacerbated by a shortage of technicians within their workforce.

On the other hand, end user companies seem to be facing distinct hurdles, particularly in managing relationships with manufacturers. Skill shortages are evident in areas crucial for **effective collaboration, such as procurement and demand planning of semiconductors.** These skill disparities emphasise the need for targeted interventions and strategic skill development initiatives to address industry-wide challenges.

The biggest primary drivers of staff shortage in the semiconductor industry, affecting both manufacturers and end user industries, include a scarcity of applicants, insufficient practical and theoretical knowledge, and a lack of work experience.

Furthermore, 27% of end user respondents highlight a lack of cultural fit within the company as a significant hurdle in the recruitment of semiconductor workers. This additional insight underscores the multifaceted nature of the staffing challenges, emphasising the importance of not only addressing technical skill gaps but also aligning organisational culture with the expectations of potential candidates.

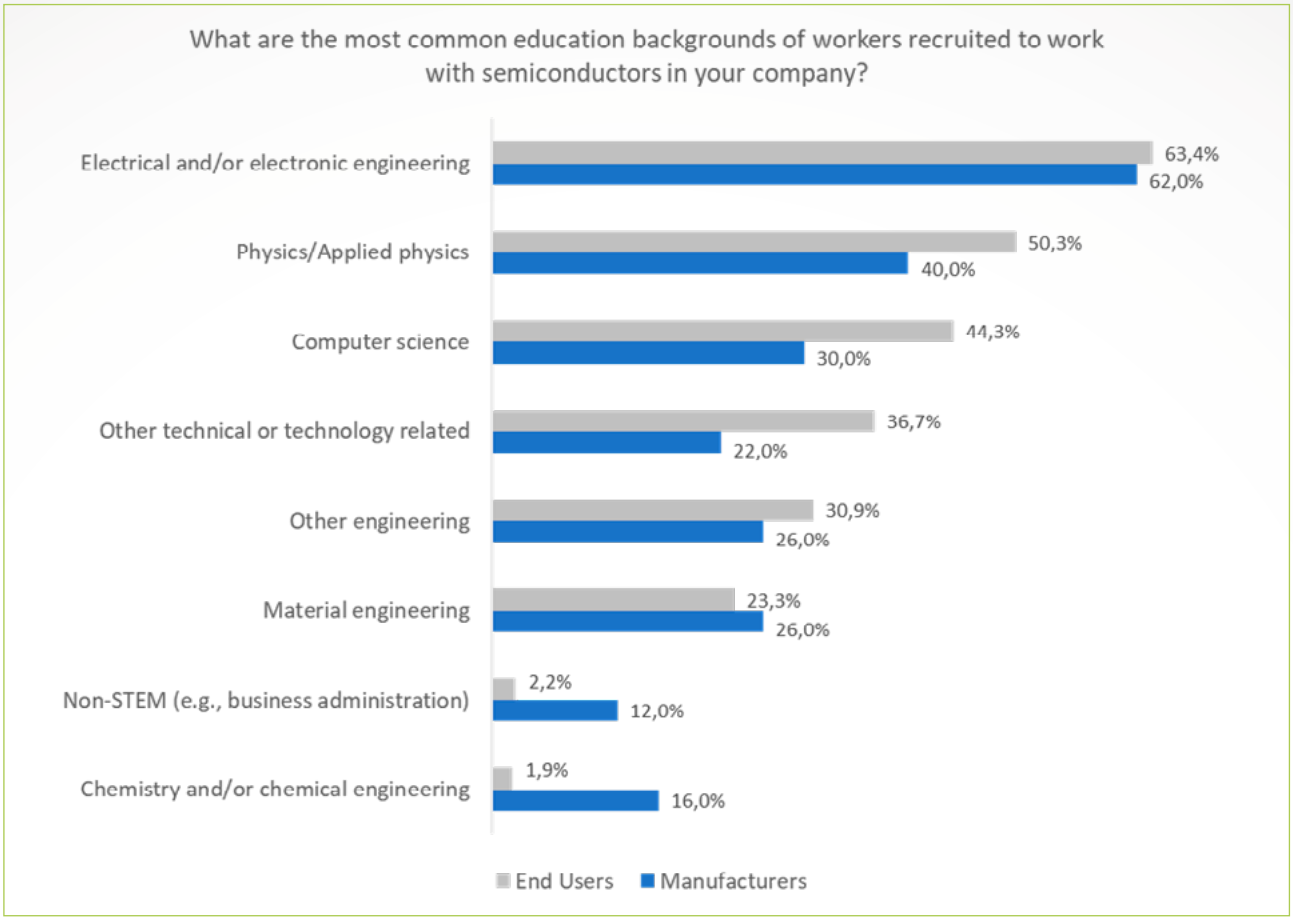


Beyond technical skills, the importance of business and soft skills such as communication, problem-solving, project management was also highlighted during findings of the ALLPROS.eu project and considered pivotal attributes to work in the sector. This signals the necessity for a comprehensive approach to skill development across the semiconductor value chain looking beyond manufacturing skills and understanding the liaison between technical and business capabilities so workers in the sector can develop all the needed skills.

As recruitment in the semiconductor industry is heavily biassed towards STEM backgrounds (especially Engineering, Physics and Computer Science), certain business skills such as data analysis and problem solving may be better covered than others during Higher Education.

However, soft skills such as communication, project management, presentation, leadership and the understanding of the business may not be necessarily emphasised during certain STEM courses and should be internally developed further by the companies during the employee's tenure.

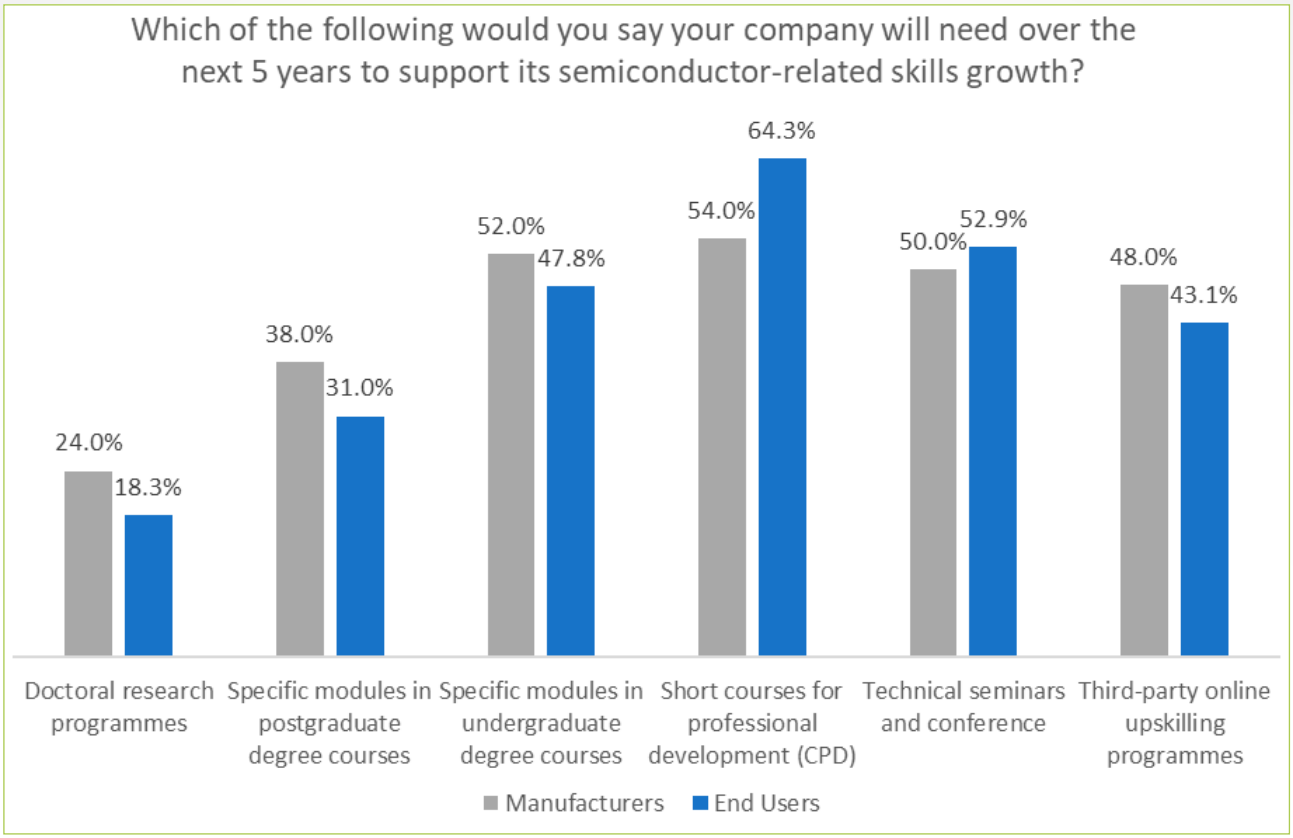
1.4.2 Key Skills Gaps: Educational, Industrial, Mobility Factors



Electrical/Electronic Engineering is the most common and sought after background to work in semiconductors, followed by Physics and Computer Science. This trend holds true for both pure manufacturers and those in the end user industry, pointing at a potential saturation of talent in these specific fields. Interestingly**, individuals with non-STEM backgrounds are less prevalent among semiconductor workers,** despite the industry's increasing demand for business and soft skills. This sheds light on the industry's current landscape and the skills that are highly valued within it.

Not surprisingly, the industry shares the belief that the types of **degrees obtained in formal education, particularly at the Bachelor's, Master's, and Doctoral levels, significantly influences the level of workforce readiness** candidates bring to their roles in the semiconductor industry. This consensus underscores the perceived correlation between academic qualifications and the preparedness of individuals entering the semiconductor workforce.

Furthermore, regardless of the degree level attained**, it typically takes an average of up to one year to fully acclimate new workers to their roles in the semiconductor industry.** This suggests a general onboarding time frame that spans various educational backgrounds and the need for more continuous learning after the onboarding is concluded.



Regarding the bridge between industry and academia, both manufacturers and end users in the semiconductor industry are placing their bets on various paths for professional development. **Short courses such as Continuous Professional Development (CPD), technical seminars, specific modules in undergraduate courses, and third-party online upskilling programmes are identified as key methods for upskilling in the coming years for both sectors.**

Manufacturers, especially, exhibit a higher propensity to invest in postgraduate and doctoral research programmes. This inclination suggests a strategic focus on advanced research and innovation, potentially positioning manufacturers to harness cutting-edge technologies and maintain a competitive edge in the rapidly evolving semiconductor landscape.

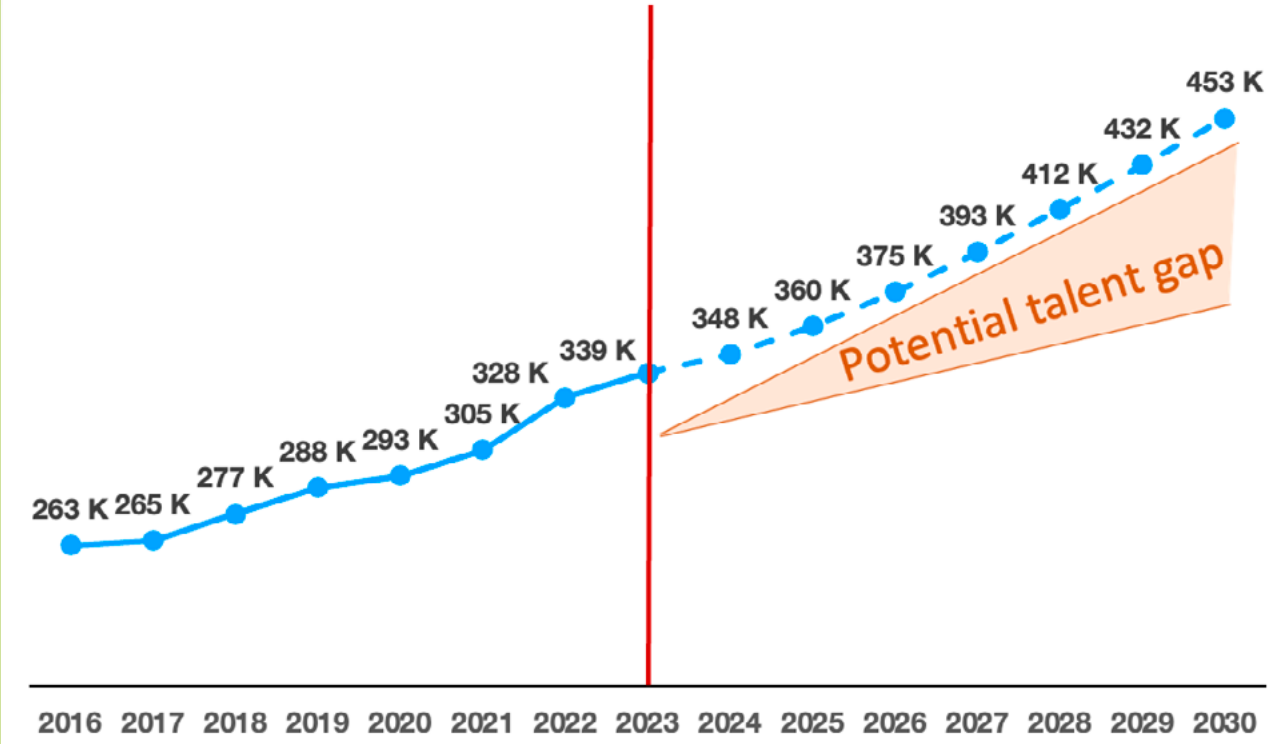
1.4.3 Semiconductor Skills Shortage: Quantifying the Gap

In 2023, the semiconductor industry employed around 340,000 people, a figure that has been growing steadily in recent years. Even before the implementation of the European Chips Act, the EU semiconductor workforce has been growing steadily, with an average annual growth rate of 3% between 2016 and 2021. The demand for semiconductors in the main end-user markets (ICT, industrials & consumer, automotive, etc.) and the resulting production growth have driven this expansion. After the peak reached in 2022 (+7.6%), the growth rate of the workforce slowed down in 2023, mainly due to the market downturn.

Over the next few years, employment growth is expected to accelerate significantly, in line with the implementation of the European Chips Act. By investing in production capacity through targeted investments and taking into account robust end-market demand forecasts, a transformative impact is expected that could lead to significant growth in semiconductor production volumes, resulting in annual employment growth of 4.5% until 2030. This growth trajectory could result in the addition of around 113,000 employees over this period across all segments of the value chain, leading to a remarkable 33% increase in the EU semiconductor workforce.

The strong growth in demand in the semiconductor labour market could exacerbate labour shortages in the EU. Previous studies carried out within the METIS project have shown that the shortage of skilled workers in the

semiconductor sector will exist at least until 2020 and will worsen over the years. Unless the number of graduates with the critical skills needed in the semiconductor industry increases significantly in the coming years, the expected growth in labour demand will exacerbate the shortage. The ongoing research[1] indicates that the labour shortage could affect all main technical job profiles, particularly engineers, technicians, and data specialists.



Sources : preliminary figures, DECISION Etudes & Conseils

EU semiconductor workforce (2016-2030)

1 To be published in October 2024 under the European Chips Skills Academy

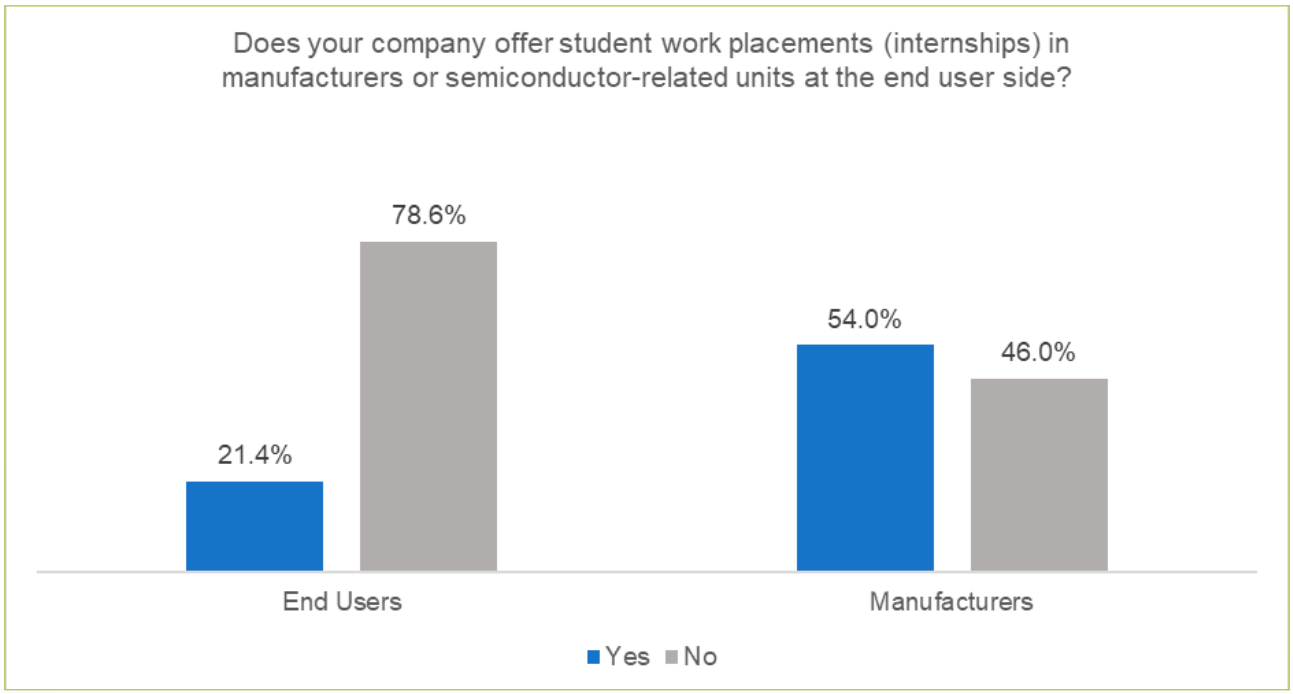
2. Analysis of Needs and Current Corrective Actions

2.1 The Industry Perspective and Industry-Led Initiatives

The talent pool within the semiconductor sector is falling significantly short of demand, acting as an **industry bottleneck**. While the scarcity of applicants is the primary hurdle for end-user companies of chips, pure manufacturers face the secondary challenge of attracting qualified individuals to fill critical roles. Concurrently, the pressure mounts for more semiconductors across the board with the rise of AI and need for higher computing power across the board, putting the spotlight and pressure for finding qualified talent in a timely manner.

Meanwhile, both end-user companies and manufacturers, important pillars for the semiconductors industry, find themselves looking for talent in the same limited pool, with the competition exacerbated by their shared criteria for desirable backgrounds and skills, intensifying the ongoing war for talent. Despite the competition, end-user companies heavily rely on semiconductor manufacturers for the development, production, and deployment of finalised products and oftentimes are not able to significantly verticalise production and have a more independent semiconductor divisions within their organisations, even if they so wish.

Although there is awareness of the urgency in developing talent, the lack of Industry-led educational initiatives for semiconductors shows a **gap in preparedness** between end-user companies and manufacturers to develop the right courses, content, and frameworks for workers to be upskilled into the sector.



While manufacturers are more proactive in implementing in-house upskilling programmes, end-user companies are still in the early stages of developing specialised departments and formalising training programmes for newcomers. Overall, manufacturers lead in frequency and depth of upskilling initiatives as this is their core business. However, end-user companies of semiconductors predominantly rely on unstructured forms of upskilling, such as formal and informal mentoring and coaching.

To address the skills shortage in the sector, collaborative efforts and targeted strategies are essential. It is also important to mention that early-stage interventions like dedicated internships and work placements, alongside a focus on nurturing business and soft skills alongside technical competencies.

One of such industry-educational sector collaboration examples can be seen in Sachsen-Anhalt, Germany, where Intel is investing over €30 billion to construct two chip fabrication facilities near Magdeburg, set to be operational by 2027 or 2028. The initiative is expected to create 3,000 permanent jobs, with 70% dedicated to technicians, 25% to engineers, and 5% to support roles. To meet this demand, Intel has forged partnerships with six local universities, allocating €1.2 million towards talent development, while also leveraging Germany's vocational training system for on-the-job education.

The commitment from Intel highlights the significance of securing skilled labour in the semiconductor industry. By collaborating with regional universities and embracing Germany's vocational training system, Intel aims to ensure a steady pipeline of talent for its future operations and enable the semiconductor industry to better navigate talent shortages, fostering a resilient workforce conducive to sustained growth and innovation.

2.2 The Educational Perspective and Educational / Training programmes

The Chips for Europe Initiative, a cornerstone of Pillar I in the European Chips Act, aims to boost technological capacity and innovation within the Union by bridging the gap between advanced research capabilities and their practical application in industry. Notably, the initiative places a strong emphasis on fostering educational collaboration between universities and industry partners.

At the core of the Chips for Europe Initiative lie five key operational objectives. These include establishing a Design Platform, enhancing existing pilot lines, advancing capacities for quantum chips, creating a network of competence centres, and implementing a Chips Fund to facilitate financing for start-ups and SMEs. In terms of management and funding, the Chips Fund will be overseen by the European Innovation Council and InvestEU, while the bulk of the Initiative's activities will be under the purview of the Chips Joint Undertaking, formerly known as the Key Digital Technologies Joint Undertaking. Financial support is also provided through Horizon Europe and the Digital Europe programmes.

The efforts include various initiatives aimed at streamlining access to pilot lines and design platforms, providing training and skills development opportunities, and assisting in securing investments. It seeks to engage with relevant industries, offering services in an open, transparent, and non-discriminatory manner.

A central focus of the Chips for Europe Initiative is the reinforcement of skills within the semiconductor industry. This involves enhancing the visibility and attractiveness of the sector, as well as strengthening the development of tailored higher education and vocational training networks specifically geared towards the semiconductor domain.

Back in 2021, NXP solidified its collaboration with TU Eindhoven through a Memorandum of Understanding (MoU). This agreement builds upon a longstanding partnership characterised by various forms of collaboration, including part-time professorships, sponsorship of PhDs, joint research projects, and internships for students.

The MoU stems from a project initiated in 2019, focusing on artificial intelligence and perception technology in mobility, which led to the establishment of the EAISI Mobility ICAI lab. This lab serves as a platform for further expanding the partnership, with recent agreements facilitating the addition of eight new PhD students, indicating significant growth in the joint lab's activities. The collaboration between NXP and EAISI centres on AI for edge computing, particularly emphasising smart mobility applications. The joint programme aims to undertake projects that leverage AI solutions to enhance traffic safety, efficiency, and vehicle comfort, with the ultimate goal of implementing tangible outcomes in these areas.

2.3 The Government Perspective and Government Policies & Incentives

2.3.1 Educational and Training Initiatives supported by the European Commission

On regional initiatives, an example of EU-funded educational and training initiative within the semiconductor domain is METIS. The project was established in 2019 and is formed by 20 key partners drawn from various sectors, including start-ups, small and medium-sized enterprises (SMEs), and large corporations, as well as national and EU industry associations, educational institutions, and regulatory bodies specialising in accreditation and certification within the microelectronics domain.

In short, METIS aimed to:

- **Develop a Microelectronics Sector Skills Strategy** using a methodology to assess, anticipate, and monitor the evolution of skills, competencies, and occupations in the field.
- **Define and refine occupational profiles based on existing competence frameworks** and the ESCO classification system, adapting to technological and occupational changes.
- **Introduce innovative, modular VET curricula jointly developed by industry and education**, tailored to both new entrants and incumbent workers.
- **Benchmark and align METIS curricula and training with ESCO, EQF, and EQVET principles** to ensure quality and relevance.
- **Enhance the visibility of the microelectronics sector as a career option** and address gender disparities in employability.
- **Establish the Microelectronics Observatory & Skills Council** to ensure lasting impact and sustainability beyond EU funding.

Among partners were companies such as Infineon Technologies and the Technical University of Graz (Austria), IMEC from Belgium, and DECISION from France. Additionally, the consortium included large organisations like Bosch, Silicon Saxony from Germany, and Arcelik from Turkey.

SEMI served as the coordinating entity for the consortium, facilitating collaboration and synergy among the stakeholders. The industry association drove innovation within the semiconductor sector across North America, Asia, and Europe, and led the 18-partner consortium to drive the second phase of METIS, with EUR 4m in funding to develop the European Chip Skills Academy.

With the development of the European Chips Act, the Chips Joint Undertaking (Chips JU) was also created in November 2023 to tackle innovation challenges within semiconductors. Chips JU functions as a hub for innovation, leveraging resources from multiple sources. It benefits from support from the European Union, using programmes such as Horizon Europe and the Digital Europe Programme. Moreover, it engages in collaboration with Member States, third countries associated with Union initiatives, and private sector partners. This collective pooling of resources forms a solid groundwork for the progression of semiconductor technologies.

Although Chips JU spans beyond training, it does include key objectives knowledge transfer and learning, such as:

- **Support Research and Development**: Invest in establishing design and production capabilities for strategic areas, fostering specialised learning.
- **Launch Portfolio of Projects**: Initiate projects to transfer technologies from research to industry, enabling upskilling across different scales.
- **Foster Union-wide Ecosystem**: Cultivate a dynamic ecosystem based on digital value chains, ensuring simplified access and continuous learning.
- **Enhance Critical Infrastructures**: Support R&D to improve critical infrastructures, offering education in cutting-edge technologies.
- **Mobilise National Resources**: Encourage national resource mobilisation, coordinating programmes for cross-border collaboration and learning.

3. Strategies for Addressing Skills Shortages

This section details strategies that are already being used to address skills shortages. Real-world examples, as contributed by experts from the European semiconductor industrial, academic, and governmental organisations, demonstrate the methods for successfully implementing these strategies. The effectiveness of these strategies is further supported by the outcomes that these examples have achieved.

3.1 Enhancing STEM Education and Outreach

3.1.1 Early Education Programmes

Successful early education programmes create a foundation for other skills shortage strategies to build from. Making children aware of the semiconductor industry, and developing their relevant skills earlier in school, provides critical exposure that supports their understanding, confidence, and enthusiasm towards considering a career in semiconductors. With the EU expected to require up to 20 million ICT Specialists by 2030, it is imperative to prepare children with the mindset of lifelong learning and skills to address future challenges. Professionals in the EU in the STEM field can earn an average salary of €55K to €120K annually depending on the skills, seniority, and location. Gender stereotypes in ICT hinder women's entry into the field from an early age, with 1 in 10 boys expected to work in ICT compared to just 1 in 100 girls.

EU Member state activities

At the national level, EU member states are applying the following strategies in their early education programmes for STEM skills development:

- **Messaging frameworks**, such as media campaigns to increase schoolchildrens' awareness of semiconductor career paths.
  - An example is the #STEMhelden 'STEM heroes' Belgian media campaign by the Flemish STEM platform, as part of the EU STEM Coalition. This campaign explores STEM disciplines and their relation to particular societal challenges through short episodes aired on public television and social media, which show STEM professionals working together to solve a problem relevant to today's society, such as recycling plastic or making cars safer and more environmentally friendly. The programme aligns with school curriculum topics for the age group, and aims to be sensitive to gender in language and images, given the shortage of girls pursuing STEM education from the age of 15 onwards, as part of its aim to encourage girls to pursue STEM.
- Investing in education by **designing and trialling new school subjects**, curriculum updates, and lesson plans, and ensuring teachers have sufficient training and teaching materials.
  - The Teknologiforstaelse 'Technology Understanding' Danish pilot programme is implemented by the Danish ministry for Children and Education under the EU STEM Coalition and aims to develop students' critical ability to use and shape technology, rather than merely consuming it.
  - The ProgeTiger programme in Estonia has delivered innovative technology education by teaching children in kindergarten and schools about different areas of technology following plans created by teachers and shared through the ProgeTiger portal, whereby teachers can adapt the material to their own and the children's interests, and the equipment available.
- **Investing in digital infrastructure** to complement other early education strategies.
  - The Tiigrihüpe 'Tiger Leap' programme, initiated by the former President of Estonia, provided access to digital resources to schools, and prioritised information technology training for educators. Estonia has a higher than EU average adult engagement in lifelong learning and has the highest number of female students in ICT. Estonia

has pioneered the digital transformation not just through its education but implementing 99% of state services online, thereby integrating technology that impacts society through governments, residency, elections, taxes. This provides an appropriate societal context to support children's technology education, by highlighting the importance of technology and digital solutions in everyday life.

Private company activities

Examples of private company activities in early education programmes for semiconductor skills can focus on outreach events, such as workshops and educational days. Industrial and academic institutions in the EU are using the following strategies:

- **Creating and sponsoring workshops** and challenges open to school teams and individual students.
  - Melexis Belgium regularly organises Early Education events, such as its Robot workshop aimed at 6-12 year olds in groups of up to 30. This is a hands-on, practical event for children to learn about using simple electronics equipment, problem solving, the applications of microelectronics, and about algorithms through basic programming with pre-programmed commands. Learning is reinforced through assembling the robot and using it to follow instructions for games afterwards.
  - The Intel Mini Scientist competition is an annual science fair designed to promote an interest in STEM among young students. Primary school students in the 4th, 5th, and 6th classes in Ireland are challenged to create projects on a scientific topic of their choice as teams or individuals, logging details in a project book as they work, and are encouraged to plan their investigations, make observations, ask questions, predict outcomes, and conduct experiments to test their ideas and draw conclusions. The students therefore develop scientific and investigative skills, while designing and making solutions to solve practical problems.
- **Career talks from semiconductor professionals**, which can be delivered through on-site visits to schools, as offered by e.g. ESIA companies.
  - During working hours, Melexis also allows employees to work as "technology mentors" and share their knowledge at academies in Flanders. This is as part of Melexis' collaboration with the STEM academy coordinated by Technopolis®, to support initiatives that provide education in areas such as woodwork technology, electronics and electricity, and robotics. The STEM academy network is aimed at children and young people from the age of 5 to 18.
- **Connecting industry professionals with schools** to deliver curricular or extracurricular teaching material in-person at schools, which the organisation Silicon Saxony e.V is putting resources towards in addition to creating STEM teaching materials for schools.
  - Since 2016, the Silicon Saxony e.V project Programming with Calliope Mini has made available the microcontroller "Calliope mini" and teaching material as a class set, introducing primary school children from the 3rd grade onwards to programming in a playful way. German schools can pay dedicated volunteers from Silicon Saxony members and apply for funding to purchase materials such as a class set of "Calliope mini." The project aims to facilitate STEM offerings for interested children at 100 elementary schools in Saxony within the next two years.
- **Creating MOOCs and online curricula** for school students, such as Intel's AI for youth, and BrightLab.
  - The Intel AI for youth programme introduces AI to high school students, targeting the 13-19 age group more broadly. 200 hours of age-appropriate, hands-on learning content designed by Intel is delivered to school students through AI labs with local training partners who are able to customise the content as needed. The 3 AI domains covered are computer vision, natural language processing, and statistical data, with multiple entry and exit points throughout modules for flexibility in the programme's implementation alongside national curricula.
  - Brightlab is a Belgian non-profit organisation that trains the teachers of students aged 6-18 on how to make STEM education attractive. They have created a MOOC which explains the most advanced semiconductor processing technology in a way that is understandable by and appealing to students, assisting them in their decisions towards higher education studies. They also design, fabricate and distribute Brightboxes that allow children to experiment with electronics, magnetics and optics in a fun and didactically well-underpinned manner.

- Creating non-profit organisations to **offer volunteer-run clubs** for children, e.g. CoderDojo for children aged 7-17 to learn programming skills, and Dwengo, offering a variety of teaching content and activities (online courses, hands-on workshops focussed on disadvantaged regions, with open-source materials, software, and documentation).

3.1.2 University-Industry Partnerships

The cooperation between University and Industry is critical to ensure the development of a curriculum that empowers students with the market skills to tackle challenges. The rapid pace of technological innovation needs to be accompanied by a highly skilled workforce, which in turn requires a curriculum that empowers learners to to deal with real world challenges. In addition to technical skills, the workforce needs to be empowered with skills related to leadership, project management, communication, and interpersonal skills. Curricula must therefore evolve dynamically to combine industry standards related to STEM, university expertise in delivering content, continuous knowledge sharing flow between all partners (university, industry, learner, training providers), to adequately provide students with exposure to real world challenges and insights.

Strategies being implemented in European university-industry partnerships include:

- **Forming networks for coordination** of STEM education research and initiatives.
  - The METIS project brought together a large consortium of industry and academia, which delivered an EU Microelectronics Sector Skills Strategy, learning-outcome-based curricula jointly developed by industry and education, occupational profiles of the future semiconductor industry, and a long-term action plan underpinning the Pact for Skills in Microelectronics. The European Chips Skills Alliance will carry out the long-term action plan, and among its expected activities, it is expected to establish a Skills Observatory for constant analysis and monitoring of trends in semiconductors, facilitate employability across the border through establishment and mutual recognition of micro-credentials, providing joint training to support harmonisation of curricula through the European Chips Skills Academy, and creating new degree programmes according to industry needs.
  - The European Chips Skills Academy is a network of industrial companies, universities, Vocational Education and Training (VET) providers, national competence centres, and other actors in microelectronics education and training. Networks such as ECSA can organise series of events, such as the April 2024 Student Forum hosted by TU Delft on 24/04. As well as launching the ECSA Student Ambassador programme, this conference aimed at undergraduates features presentations from industry leaders, presentation of undergraduate research, and networking opportunities.
  - The CHIPS of Europe project will bring together industry and academia partners to address the shortage of workforce in the EU semiconductor industry. Activities will include a secondary schools talent pipeline, updating curricula and microcredentials on cutting edge topics in chips design, manufacturing, and packaging, interactive teaching and learning methods (e.g. summer schools at fabs and virtual labs), and partnering with the Multimedia University of Kenya to focus on talent mobility beyond Europe.
- **Summer schools and internships** for university students, such as the upcoming ECSA summer school and the Melexis academy Bulgaria.
  - The ECSA 2024 Summer School offers talks delivered by representatives from university, research, and industry, and career testimonies delivered by young engineers. It covers semiconductor technology, integrated circuits design, digital systems and embedded intelligence and integration. It is open to undergraduate students from all STEM fields, who are both enrolled in a university based in the EU or an associated county, and considering or planning to pursue a graduate degree.
  - Melexis Academy Bulgaria: this academy organises summer schools and internships for students in STEM. The programmes have focussed on participants gaining practical experience through individual work, teamwork, and group sessions. Over 60 participants have joined Melexis since 2014 after taking part in the academy, reaching team lead positions and becoming technical experts, also enabling the company to hire for difficult-to-fill positions as a benefit of upskilling the academy participants, who gained experience and skills in electronics.

- **Developing practice-based microcredentials** for upskilling or re-skilling STEM professionals and graduates is another strategy that can be successfully implemented by private companies, when taking concrete actions in partnership with universities to address the skills gap. Partnerships between universities and industry to this end can offer professional development opportunities that enable individuals to continuously update their semiconductor skills and stay competitive in a rapidly evolving STEM landscape.
  - An example is the KU Leuven Micro-credential on Chip Layout, Development, and Design. The partnership between KU Leuven (Belgium) and the semiconductor companies present in Belgium (Melexis, ICsense, Sofics, Caeleste, Omnivision & Cyient) delivered 4 modules face-to-face by industry professionals, for STEM professionals and graduates. Participants gained practical skills in chip design and had access to career opportunities through the participating companies, with the companies increasing visibility and accessing a qualified talent pool.
- Private companies partnering with universities by **supporting student start-ups and research projects** with industry products. This type of partnership, when focused on student projects, provides educational and financial resources for students and visibility for the companies. An example is Melexis Belgium & US providing Products for Electric Car Development Projects Run by Students.
  - The Engineering students from KU Leuven and Thomas More University use Melexis products for pedal, tires, current, and thermal management in their electric Formula Student race car. Students in Brazil used Melexis temperature and pressure sensors to analyse tire wear, brake disc temperature, and aerodynamics performance in their Formula SAE car.
- **Lifelong learning opportunities** in the form of self-standing educational modules, to allow those in the workforce to keep their skills up-to-date after they have graduated. These can be delivered entirely remotely online, or through short in-person courses.
  - This is one of the objectives of the GreenChips-EDU project, which is being enacted by a consortium of 15 partners. The project aims to address skills needs in the microelectronics industry, particularly focusing on green chips and applications. MOOCs, short courses, microcredentials, and a Modular Programme on green electronics composed of short courses are the proposed formats for self-standing modules for professionals, which will award a Green Electronics Certificate upon completion.
- Degree courses and accredited institutions **conceived jointly by academic and industrial institutions**, to ensure that in-demand skills are covered.
  - An example is the EIT Digital Master programme, which is taught in its first year at one European University among seventeen participating into the Master Programs, the second year at another European university, with thematic summer schools between the two years. It focuses on 8 Master's programmes to-date in collaboration with 17 top technical universities in Europe. The programmes are focused on STEM skills in subject areas like Embedded Systems, Fintech, Cybersecurity, Data Science, Autonomous systems and intelligent robots, Cloud and Network Infrastructure, and Human Computer Interaction and Design.Other projects between academia and industry to jointly conceive university degrees include SPECTRO, EMAI4EU, RESCHIP4EU, the Master's programme in "Power Electronics Devices and Technologies" offered by STMicroelectronics and the University of Catania (UniCT).
  - The GreenChips-EDU project also proposes novel bachelor's, master's, and MBA programmes designed by its university-industry-research partnership towards the microelectronics industry's need for green chips and applications. More specifically, the proposed programmes are:
    - A new bachelor's programme, BSc in Green Electronic Engineering.
    - An enhanced single degree master's offered by all HEIs involved, with the same Green Chips and Applications content in a substantial amount, offered as an MSc + Green Electronics University Certificate.
    - The option to base an MSc thesis based on industry or research experience on Green Electronics, carried out at a partner institution.
    - A new double master's degree in Green Electronics, based on existing master's programmes at partner universities with a Green Chips focus.
  - Edu4Chip brings together five universities, one research institute, and three SMEs, along with associated partners, to jointly develop and improve new and existing advanced circuit design master-level course

programs at the university level. The project includes amongst its objectives "strengthening existing chip design and microelectronic master programmes at four HEI partners and providing a new master programme in chip design at one HEI, to teach students the required skills to design modern digital, analog, and mixed-signal integrated systems in harmonised programmes, with hands-on experience in chip design as well as with excellent theoretical lectures." This will help to close the skills gap by providing students with the theoretical and practical skills to become chip designers entering the European labour market. Students at Edu4Chip partner universities will also benefit from the opportunity to carry out internships, final thesis projects, and capstone projects in collaboration with industry.

- As a result of its partnership towards redesigning educational programmes, the Edu4Chip project also releases most of the produced educational chip design materials as open-source. Sharing materials in this way creates the possibility for future educational programmes to benefit from this material, and as an accessible resource can potentially be simplified to form the basis of early education programmes.
- Reinforcing Skills in Chips Design for Europe (RESCHIP4EU) aims to support the excellence of EU higher education in the area of embedded systems design in a holistic way, from silicon via System-on-Chip design and manufacturing to smart and safety-critical platform and application software. The holistic nature of the program is essential for innovation and provides a unique competitive edge to program graduates to design, analyse and innovate smart, green and safety-critical embedded systems in Europe. RESCHIP4EU will achieve this goal by designing and delivering a double-degree master's programme (ISCED Level 7, 120 ECTS) in Embedded Systems Design with several specialisations related to the holistic design of embedded platforms safer, greener, smarter, and more efficient and a minor in Innovation and Entrepreneurship. The master's programme will be designed and delivered by 9 higher education institutions from 5 different countries with the collaboration of Semi.org, the global industry association representing the electronics manufacturing and design supply chain, ST Microelectronics, a global semiconductor company, 1 innovative SME expert in delivering education program, communication and dissemination, 1 ASBL (Association internationale sans but lucrative), and EIT Digital, a pan-European organisation with experience in delivering education programmes in advanced digital skills across Europe.

3.2 Workforce Development and Reskilling Initiatives

3.2.1 Apprenticeship programmes

Apprenticeship programmes stand as a cornerstone in developing a skilled workforce. Member states across Europe, notably Germany, have long recognised the value of apprenticeship programmes in cultivating a skilled workforce. With a rich history in the German education system, apprenticeships are hailed as a global success story, contributing significantly to workforce development and employment retention. In 2020, a staggering 72% of apprentices continued working in the companies where they completed their apprenticeships, underscoring the effectiveness of these programmes in fostering long-term employment relationships.

However, the apprenticeship programme strategy in Europe faces several challenges, including scalability issues for SMEs that lack resources to develop comprehensive programmes, and the need for continuous curriculum updates to keep pace with evolving industry standards, particularly in high-tech sectors. Finally ensuring consistent quality across different regions and sectors also remains a significant challenge, with geographical disparities limiting access to apprenticeship opportunities in less industrial regions, compounded by the non-mobility of the vocational workforce.

EU Member State activities

Programmes contributing to the upskilling of the future workforce, organised at a national level, include regional networks between students and opportunities.

- FIT, Fastrack into Information Technology, is a representative organisation of the technology sector committed to growing Ireland's tech talent pipeline. Through regular skills needs analysis with its industry partners, FIT determines skills needs based on emerging technology trends, and designs training programmes to meet industry demands in accordance with the standards of the National Qualifications Framework. As an example of one of its programmes, the NFQ Level 6 FIT Manufacturing Technician Maintenance Skills programme, in County Meath Ireland, aims to increase the number of manufacturing technicians needed to support the intended growth of advanced semiconductor manufacturing. This 48-week course designed in collaboration with Intel, including a

12-week industrial work placement, has been successful with students coming from non-technical backgrounds, and has also successfully run as an all-female course. In addition to enabling apprenticeships across Ireland, FIT also works on relevant technician training programmes (classroom, lab and work) in this one-year programme. This has been instrumental in providing upskilling and reskilling opportunities to the workforce in Ireland.

- The zdi.NRW "Future Through Innovation" initiative in North Rhine-Westphalia, a regional STEM network that networks MINT (Mathematics, Computer Science, Natural Sciences, and Technology) research training opportunities with young people. This is a decentralised network, with University, School, Industry, and Political partnerships, for which regional offices support contact between students and opportunities and coordinate the allocation of grants. The network helps the reach of existing STEM training programmes and opportunities by promoting them to young people and schools.
- The Dresden Chip Academy collaborates with regional stakeholders, including companies, the employment agency, and the Saxon State Ministry for Economic Affairs, to engage individuals starting their careers in the semiconductor industry through adult qualification pathways.
- The European Alliance for Apprenticeships unites governments and key stakeholders with the aim of strengthening the quality, supply, and overall image of apprenticeships across Europe and implementing the European Framework for Quality and Effective Apprenticeship. Together they have pledged over 1 million training and job opportunities to support the next generation of skilled workers. Several projects have been supported by Erasmus+ to improve their skills and quality of apprenticeships and other types of work-based learning.

Private company activities

Strategies being implemented by private companies in collaboration with educational institutions include:

- ST offers diverse apprenticeship programmes aimed at deepening apprentices' understanding of the semiconductor industry. These programmes go beyond traditional formats, emphasising mobility and international collaboration. With multiple sites across the EU and beyond, ST facilitates talent mobility and knowledge exchange among apprentices by providing opportunities to work with international teams.
- Germany's dual learning system for technicians offers a unique blend of academic education and practical apprenticeships. Students spend 50% of their time in school and 50% in paid apprenticeships in companies. This system fosters a seamless transition to full-time employment, with many graduates continuing to work in the same company where they completed their apprenticeships.
- Another example is the collaborative training offered in Dresden for the professions of mechatronics technician and microtechnologist. Theoretical instruction takes place at the local vocational school, practical input is provided by the respective partner company, and part of the practical training takes place at the Dresden Chip Academy, which has the appropriate premises and takes on some of the practical training that is difficult for the respective companies to implement in-house.

3.2.2 On-the-Job Training and Continuous Learning

The world of work is evolving, necessitating a culture of on-the-job training and continuous learning to remain competitive and adaptive. Transferable skills such as teamwork, communication, leadership, and project management are equally vital for success. Digital skills are at the forefront of workforce development, with the rapid growth of jobs in digital technologies like AI, Machine Learning, and Information Security. However as highlighted by Future of Job report 2023, only 54% of Europeans aged 16-74 possess basic digital skills, highlighting the urgency for upskilling initiatives. Micro-credentials, nanodegrees, and distance learning programmes have emerged as crucial tools to accommodate professionals who cannot commit to lengthy educational programmes due to personal circumstances.

EU Member State activities

- **Vali IT**, Estonia: for adults who did not receive an education in technology, this programme equips them with software development skills. 14-week retraining courses are offered, composed of 6 weeks of contact or virtual learning, followed by an 8-week internship. This provides a flexible alternative route into a software developer career for candidates who have not taken a traditional educational path towards this career, thereby helping to fill market gaps by providing another source of candidates.

- **ECWT (European Centre for Women and Technology):** ECWT is involved in Pact for Skills in Microelectronics and Pact for Skills in Digital, in the framework of the Women4IT EEA and Norway Grants co-financed project. ECWT has trained 1000+ women in 7 countries (EL, ES, IR, LT, LV, MT, RO) between 2019-2023. Following this, 13 new countries and regions would like to replicate the very successful re-and-upskilling for digital jobs of the future. All educational resources exist in 7 languages as OERs and are supported by a Women4IT Mentoring Community.
- **Microelectronics Academy:** This initiative represents a government-funded effort to address the shortage of skilled workers in micro and nanoelectronics in Germany. The programme is part of the Federal Ministry of Education and Research's Framework Programme for Microelectronics and focuses on three thematic pillars: Resource-conscious ICT, Practice-oriented semiconductor engineering and technology, and design of microelectronic circuits and systems. By providing certification courses and promoting hands-on learning, the Microelectronics Academy seeks to improve the quality of training for professionals in the field and address the growing demand for skilled workers.

Private company activities

- STMicroelectronics engages in initiatives to reach out to students and young people at school to introduce them to the semiconductor industry and associated careers. For instance, partnerships have been established with the Grenoble Academy, Grenoble INP - Phelma, the Vaucanson high school in Grenoble and the Thomas Edison high school in Echirolles. The ST Tech Academy, one of the outcomes of those partnerships, has already been set up, with two classes offering training leading to a diploma in maintenance professions.
- SEMI University offers a range of education and training programmes tailored to the semiconductor industry's needs. These programmes cover various aspects of semiconductor manufacturing, technology, and innovation, providing participants with the knowledge and skills required to excel in their roles. The expanded curriculum is designed for technicians, engineers, and non-technical staff, catering to both new hires and experienced workers. The courses encompass subjects such as front-end and back-end manufacturing operations, principles of chip design, and emerging technologies like AI, MEMS, and advanced packaging.

3.3 Policy Recommendations

3.3.1 Immigration and Mobility Policies

Just as talent attraction is one of the first steps towards bridging the skills gap, talent retention is equally important for maintaining and increasing Europe's industrial capabilities and competitiveness. Understandably, building an effective policy for attracting a skilled workforce requires an understanding of skills shortages in Europe, inviting talent to aid in building a sustainable Europe, and identifying the challenges faced by skilled international workforce in terms of onboarding, work culture, integration, and lifestyle. In addition to attracting external talent, there is also a need to strengthen talent competitiveness among countries in Southern and Eastern Europe through reskilling, upskilling, boosting economic conditions and investing strategically in innovation and research for sustainable growth.

Recommended measures submitted as priorities for Europe to increase its skilled labour include:

- **Skills-based immigration programmes with fast-track visa processing**. At the member state level, this could include streamlined application processes with clear guidelines to attract skilled professionals, reducing the wait time and speeding up the integration of needed talent into the workforce. An initiative targeting skills-based immigration, Digital Explorers is a consortium of private companies based in the Baltics that works to connect Nigerian, Kenyan, Armenian and Iraqi ICT specialists with opportunities in the Baltic region. As an EU project targeting greater mobility, GreenChips-EDU aims to increase vocational education and training, as well as student mobility within partners' microelectronics university programmes. It brings together schools and business partners from across the EU, including less-represented Italy, Portugal and Croatia, as well as an international partner (Burkina Faso).
- **Credential recognition**: ensuring that skilled immigrants can immediately contribute to the industry without facing unnecessary barriers. For example, EU Chips Skills Alliance seeks to promote solutions on both the demand and supply side, focusing on facilitating employability across the border through establishment and mutual recognition of micro-credentials, as well as knowledge exchange between regional clusters for better inter-regional cooperation.
- **Orientation, integration, language, and cultural training**: helping new arrivals adapt to the EU's work environment, cultural norms, and societal expectations, leading to better retention and satisfaction rates among skilled immigrants. In taking such measures, companies can ensure that employees from diverse backgrounds enjoy a safe and well-integrated environment both within and outside their place of work. For example, Melexis Bulgaria employs many Filipinos. Due to cultural differences, the company carried out a training workshop in the office to ensure smooth communication, covering: what is culture, high and low context cultures, understanding Filipino historical context, and Filipino workplace values that should be accounted for to drive workplace engagement.
- **Recruitment and job matching services**: streamlining the hiring process to ensure that the right talent is placed in roles that are the best fit. As an example of this type of service, **EURES** is piloting an EU Talent Pool project among 7 Member States (including countries from under-represented Central and Southern Europe), with the aim of closing the skills shortage gap and facilitating employment in the EU among people fleeing the war in Ukraine. Similarly targeting job matching, EIT Digital launched the (d)Academy, a global initiative which will bring together experts from industry, education, and research to develop modular learning programmes on topics from cybersecurity to data analytics to machine learning. Programmes range from online courses to blended learning and hands-on training. The EIT Digital (d)Academy Platform supporting the initiative will utilise data-driven skills mapping to unite learners, educators, and employers, tailor learning journeys, offer a sophisticated real-time job-matching system, and identify learners' skills and the market skills gaps.
- **Incentives and support for employers**: implementing financial incentives, providing training resources and establishing recognition programmes for qualifications.

3.3.2 Funding and Investment in R&D

EU Member State activities

In addition to funding and investment in R&D for the technology and green sectors, respondents recommended that greater communication between R&D and technical education would further aid in closing the skills gap, while making good use of R&D funding. Investments in workforce development are imperative to support these R&D endeavours. As such, respondents recommended directing funding towards the following activities:

- **Collaborative university-industry research initiatives**: targeted apprenticeship programmes and continuous learning opportunities are essential for equipping the workforce with the advanced skills needed for the high-tech challenges of the semiconductor industry.
- **Scalable training methods**: ensuring seamless transitions from VR-based offline training to AR-based in-factory training.
- **Industry-Embedded PhDs**: supporting more PhD positions within companies or RTO environments to foster practical research experience and industry collaboration.
- **Recognition Programmes**: Public recognition and awards for companies excelling in workforce development to enhance their reputation and attract potential employees.
- **Outreach and engagement programmes**: Promoting STEM careers to younger generations can address the skills shortage from the ground up.

Moreover, in Germany, academic semiconductor science is supported by the German Research Foundation (DFG), which funds special research topics. This national scheme could serve as a model for long-term support for groundbreaking semiconductor R&D.

Funding programmes

CHIPS JU: Launched in November 2023, the CHIPS JU is a cornerstone of the European Chips Act. It focuses on strengthening collaboration and knowledge exchange among key actors in the European research and innovation ecosystem. This initiative aligns European, national, regional, and industrial research strategies, creating critical scales of investment on common priorities and boosting private investment in R&D.

IPCEI: Additionally, the IPCEI on Microelectronics and the Second IPCEI on Microelectronics and Communication Technologies support extensive R&D and industrial application activities. These initiatives extend benefits to a wide range of entities through spillover effects, providing access to technologies and results developed within the IPCEI framework. This approach accelerates the journey from innovative ideas to product development, particularly in IoT and microelectronics sectors.

The Horizon Europe programme (2021-2027): this is a major source of investment in R&D, with a budget of €95.5 billion. It supports a wide array of projects, including those in the semiconductor industry, aiming to bolster the industry's innovation capacity and global competitiveness.

Additional programmes

Other notable programmes that provide R&D funding are Xecs, placing a strong emphasis on industrial applicability, ECoVEM dedicated to talent development for non-academic vocational students, and Intel Capital which invests in innovative technology companies worldwide.

Respondents suggest that the above programmes should expand their activities to include material science and "deep tech" in manufacturing, ensuring a better balance between research, technological innovation and practical application. It is important to direct sufficient R&D investments toward developing new semiconductor substrates that enhance chip performance and energy efficiency, particularly in the following areas:

- **Advanced chip packaging techniques**: to produce more powerful and efficient semiconductors.
- **Design innovation**: specifically software tools and methodologies to manage the growing complexity of semiconductor devices, including AI and ML algorithms for chip design, testing, and system integration.

- **State-of-the-art labs**: to increase access to simulated production environments, such as cleanrooms and similar applications, allowing private companies to train employees on the latest technologies at lower costs.

3.3.3 Incentives for Private Sector Engagement

By fostering strong public-private partnerships, investing in training facilities, supporting educational initiatives, and actively participating in curriculum development, the private sector can play a pivotal role in developing a skilled workforce.

Research undertaken by member state organisations recommends that communication strategies to incentivise private sector engagement in semiconductor skills development include messages related to education. By undertaking incentives that contribute to education, the private sector helps to form the future workforce, provides opportunities between companies and skilled individuals, and gets a chance to shape educational curricula to better fit the industry's realities.

Examples of public-private cooperation which take advantage of applying these incentives for private sector engagement in skill development are exemplified by the EU STEM Coalition. The Coalition is an EU-wide network that works to build better STEM education in Europe, and includes several semiconductor-related programmes. It also provides direct support to member states by utilising lessons learned and expertise from its expansive network of European STEM platforms, as well as associated European projects. Some of the programmes include:

- **Dutch Centres of Expertise**: The Dutch Centres of Expertise are sector-specific initiatives that unite educational institutions and private companies to innovate the educational curriculum and the way it is delivered. They form part of Katapult, a network of more than 550 partnerships between education and business in Europe and beyond.
- **ESTCube**: This public-private funded programme aims to promote Estonian tech and to tackle technical challenges while promoting science in schools and among the public. Since 2013, it has allowed students to contribute to satellite development by launching two nanosatellite missions.
- **Jet-Net & TechNet** (**JNTN)**: A flagship programme of the Dutch national STEM platform (PTvT), JNTN aims to increase STEM uptake in secondary education through innovative, one-on-one partnerships between leading tech companies and secondary schools.

Similarly, the develoPPP funding programme established by the German Federal Ministry for Economic Cooperation and Development supports established companies investing in a developing country or locally expanding their business activities abroad. In 2022, 129 partnerships were successfully established with a project volume of 78 million EUR. Companies participating in develoPPP addressed the skills shortage through a series of different projects, which included:

- Orange Digital Centers: Orange has been rolling out a network of free and inclusive resources to support local start-ups and projects using digital technology across 17 countries in Africa and the Middle East. They offer coding schools, manufacturing workshops, and start-up support programmes.
- **Cybersecurity training programmes in East Africa**: SEC Consult GmbH and DEG mbH set up a trainer course to remedy the gaps in the cybersecurity skills of local IT staff. The program enabled 54 employees in African companies to become cybersecurity professionals, leading to increased resiliency to cyber attacks and improved market position of participating local companies.

Private company activities that have effectively addressed skills shortages

- SAP Digital Skills Centre: The project, which runs across the MENA region, reflects the company's commitment to closing the digital skills gap through a variety of initiatives, including the Young Professionals Program, the Dual Study Program (in partnership with universities), or the Digital Skills Training Program. Since its launch in 2012, SAP Young Professionals Program has trained over 1900 candidates in Africa alone.
- MINT to be: Silicon Saxony's project which aims to counteract gender stereotypes in STEM by introducing girls and non-binary people to a variety of high-tech professions and degree courses during the career orientation phase.

4. Case Studies

4.1 EU industry-education partnerships

Across the European Union, various initiatives have been established to foster partnerships that align educational programmes with industry needs, ensuring that graduates are well-equipped with the practical skills and knowledge required in the workforce. These partnerships not only enhance the employability of students but also help companies secure a steady pipeline of skilled professionals. Below are examples of successful industry-education partnerships from EU member states and private companies that highlight innovative approaches to skills development and vocational training.

EU Member State activities

Examples of industry-education partnerships to address skills development include:

- AkademijaIT in Lithuania: this initiative introduced fast-track, modular programmes in Vocational Education and Training in IT, lasting 10 months or worth 60 ECTS, consisting of more than 60% practice- and work-based learning. The success of this initiative is actively reducing the labour market demand-supply mismatch in Lithuania by continuing to provide graduates to the Lithuanian ICT sector.
- The Katapult network in the Netherlands: Public Private Partnerships are supported by this network in identifying their shared goals, activities, and their organisation. The network's support includes network maps, impact studies, stakeholder analysis, and peer reviews, and it identifies where best practices, initiatives, and policies can lead to success for a public partnership, based on lessons learned with partnerships in other sectors. The network is involved in the development of the Erasmus Centres of Vocational Excellence and facilitating the Community of Practice of CoVEs.
- The STEM Teacher Internship Programme: The Dublin City University has partnered with a number of industry companies (including intel and IBM) to provide a flexible, paid internship programme for students and educators, lasting 8-12 weeks. The DCU team looks after the full recruitment process and partners also with companies that do not have a dedicated internship programme, transforming it into a central hub for STEM education for both aspiring and accomplished teachers.

Private company activities

- Private Partnerships with **TU Graz:** The University's Institute of Electronics has industry partnerships with AMS Osram, Infineon, NXP, who have employees teaching at the university and offering training and internships at their company premises, or design and production workshops at company premises.
- Private Partnerships with KU Leuven: The University has developed a flexible suite of courses on chips in collaboration with Melexis, imec, and other industry organisations to foster the development of professional skills in students of different disciplines and levels of expertise. Industry provides expertise and professionals for the opportunity to increase their brand visibility and recruit programme graduates.

*The success of these partnerships comes from the **willingness of the companies to invest in university programmes** to attract talent and **implement modular vocational programmes** that emphasise practical, work-based learning.*

***Establishing paid internship opportunities for students and educators**, and managing the recruitment process to involve companies without existing programmes, strengthens these collaborations.*

***Integrating industry experts into teaching** by inviting professionals to conduct courses and workshops, along with offering internships at company premises, ensures students gain real-world experience.*

4.2 National Strategies on Semiconductor Workforce Development – Examples from Member States

The development of a skilled workforce in the semiconductor industry is a critical priority for EU member states. National strategies are being formulated and implemented to address the growing demand for semiconductor professionals. By examining successful initiatives and strategies from various member states, valuable lessons can be learned and applied to other regions. This section highlights examples of national strategies aimed at enhancing semiconductor workforce development, showcasing the efforts and innovative approaches taken by Estonia, Denmark, Bulgaria, Finland, Ireland, and Spain. These examples illustrate the diverse methods employed to align education with industry needs, promote cross-border cooperation, and foster a robust talent pipeline for the semiconductor sector.

EU Member State activities

- Estonia
  - Since 2012, the ProgeTiger programme in Estonia has delivered innovative technology education throughout the school curriculum in 3 major areas: engineering sciences, information technology and design & technology. Children in kindergarten and schools learn about different areas of technology following plans created by teachers and shared through the ProgeTiger portal, whereby teachers can adapt the material to their own and the children's interests, and the equipment available. The programme provides teachers with the training to deliver and create material for STEM skills teaching, and although its study is not compulsory, by 2021 99% of Estonian kindergartens and 98% of comprehensive schools had taken part in ProgeTiger's activities in one way or another. As of 2022, 10 years after the launch of the programme, 1 in 9 students in Estonia choose to study ICT at bachelor's or applied higher education level, and this ratio rises to 1 in 7 among students who pursue master's degrees. ProgeTiger is coordinated by the Education and Youth Board of Estonia. The programme is supported and funded by the Estonian government through the Ministry of Education and European Union (ESF).
- Denmark
  - The Teknologiforstaelse 'Technology Understanding' Danish pilot programme is implemented by the Danish ministry for Children and Education under the EU STEM Coalition. This programme trials a new Informatics subject in 5% of primary and lower secondary education (ages 6-16), aiming to develop students' critical ability to use and shape technology, rather than merely consuming it. The subject, being trialled in its pilot phase both as a stand-alone subject and being integrated into other subjects, focuses on four areas of competence: Digital Empowerment (how technology shapes lives), Digital Design and Design Processes, Computational Thinking, and Technological Competences. An advisory expert group of 20 university scholars, University Colleges, ministry learning consultants, and school teachers prepared the subject content, and the project is being funded and implemented by the Danish ministry for Children and Education.
- Bulgaria
  - In its Smart Specialisation Innovation Strategy for 2021-2027, Bulgaria placed "Mechatronics & Microelectronics" as the second priority sector, with emphasis on human capital development. Bulgaria promotes cross-border cooperation and workforce development in the microelectronics sector through the involvement of Bulgarian clusters in European networks and support initiatives. In particular, the Cluster of Microelectronics and Industrial Electronics Systems (CMIES) focuses on competence building and training in nanoelectronics, microelectronics, and industrial electronics.
- Finland
  - "Chips from the North": Finland has launched a strategy for 2024-2035 aimed to increase the number of employees in the sector from 7,000 to 20,000 by 2035. The plan envisages the cooperation between government, industry and academia to raise the quality and quantity of microelectronics higher education with degree programmes co-created by industry and academia, innovative research funding mechanisms, fostering of vocational education and training, scalable programmes for upskilling and reskilling talent, campaigns to promote semiconductor-related studies, coordinated international talent pipelines to Finland from abroad.

- Ireland
  - Human Capital Initiative: investment programme aimed to increase the capacity in higher education in skills-focused programmes. The programme focuses on increasing skills development in the fields of emerging technologies; providing upskilling and reskilling opportunities through lifelong learning, incentivising innovation in the educational programmes.
- Spain
  - PERTE Chip: programme aiming to boost the value chain of the Spanish microelectronics and semiconductor industry. The plan envisages the allocation of 80 million euros for the creation of a Spanish semiconductor training network to address the human capital deficit.

Recommendations on how Member States can positively impact to the skills development

- Align educational curricula with industry needs and increase investment in education and vocational training
- Simplify regulations for public-private partnerships to develop a technical talent pipeline at all educational levels
- Provide financial support to RTOs and universities to develop tailor-made curricula for industrial employees
- Offer competitive incentives to retain top talent and implement policies that facilitate the immigration of skilled professionals
- Invest in communication campaigns at national level that dispel myths about the semiconductor industry and increase interest in it among the young generation

4.3 Company-Led Innovations in Training and Development

The Private sector highly benefits from the presence of a skilled workforce. However, companies need to view training as an investment and a way to keep employees engaged, and not as a cost. An abundant skillful workforce offers employers and businesses the chance to hire the right talent for their needs. As examples of how this is already being achieved, this section showcases company-led training and development opportunities in Europe and beyond, whether internally or in partnership with other organisations.

- Infineon, as part of the European Semiconductor Industry Association (ESIA), is a global semiconductor leader in power systems and IoT, that develops solutions for green and efficient energy, clean and safe mobility, as well as smart and secure IoT. Headquartered in Germany, Infineon offers various training opportunities spanning the stages of their employees' and trainees' career journeys. Offering multiple points of entry for the workforce maximises flexibility for potential employees, irrespective of their career path. This allows for greater inclusion of both traditional and non-traditional career paths into a semiconductor career, and results in the continual development of trainees and employees, as well as increasing the company's avenues for hiring.
  - Development opportunities with Infineon begin with apprenticeships and dual study programmes offered to high school students, to pursue once they finish school.
  - Apprenticeships: high school students seeking vocational training can apply for a technical or commercial apprenticeship with Infineon. These 3-4 year programmes offer practical teaching and training, whereby apprentices can reinforce what they learn by immediately applying it on-the-job. Many trainees receive an offer of employment upon completion of the programme, and during the programme receive a monthly salary, have access to training courses and workshops, while following structured learning to prepare them for working in the position.
    - Technical apprenticeships include: Application Development - Coding, Double apprenticeship in electrical engineering and metal, Electronics Technician for industrial engineering, Electronics Engineer for devices and systems, Specialists in water supply technology, Production Mechanic, Mechatronics Engineer, Microtechnologist, Process and Electrical Engineering (combined with a BSc degree in Systems Engineering

at the Carinthia University of Applied Sciences), Production Technologist, and IT Specialist in system integration.

- Dual Study: high school students who would like to combine formal study with learning can apply for a dual study programme with Infineon in partnership, among others, with the South Westphalia University of Applied Sciences in Soest. These programmes alternate theoretical and practical phases of study, and last 3-4 years. The theoretical study at the university lays the foundation for practical work undertaken in the chosen area of work, giving students work experience, reinforcement of their studies, a salary, and the chance to work on projects and a thesis.
  - Bachelor of Engineering (B.Eng.) programmes include : Digital Technologies, Electrical Engineering, Electrical and Information Engineering, Embedded Systems, Intelligent Systems Engineering, Mechanical Engineering, Mechatronics, Industrial Engineering, Vehicle Development, and Service Engineering.
  - Bachelor of Science (B.Sc.) programmes include : Computer Science, Artificial Intelligence and Data Science, Microsystems Technology, Technical Computer Science, Business Informatics, Business Informatics and Business Intelligence, Design & Project Management, Physics, and Materials Science.
  - The Dual Study programme also offers a Bachelor of Arts (BA) in Business Administration, and 4 Master's programmes: in Electrical and Microsystems Engineering, Electrical Engineering, Mechanical Engineering, and Physics.
- University students who have already commenced their studies can pursue development with Infineon as part-time working students, as interns (either a mandatory internship if part of their course requirements, or a voluntary internship before, during, or after their course of study), or by choosing to complete a project or bachelor's/master's thesis while temporarily employed by Infineon for this purpose.
- After graduating, Infineon offers an International Graduate Programme to support new employees at the beginning of their career, following an 18-month structured rotation with attention to individual development.
- Alternatively, graduates looking to continue their studies in research can apply for the PhD programme while studying at a university of choice, either working on a 3-year research contract with Infineon in parallel with doctoral studies after completing master's degree studies, or by writing an Infineon-specific doctoral thesis as part of a university research project. Following the PhD completion, Infineon offers progression to employment.
- Training opportunities for Infineon employees throughout all career stages include access to LinkedIn learning, mentoring and coaching programmes, and training delivered through virtual, blended or face-to-face mediums. This provides flexible training opportunities that can be tailored to the employee's learning plan and desired career trajectory.

- The European Chips Skills Academy (ECSA) project, which began in October 2023, brings together a consortium of 18 government, academic, and industry institutions to coordinate a programme of events for reskilling, upskilling, and job matching, guided by data on skills shortages.
  - The alliance's specific objectives focus on anticipating skill needs, innovating education methodologies, institutionalising the Pact for Skills for Microelectronics, and sustaining the innovation, competitiveness and growth of the microelectronics ecosystem. The ECS-Academy consortium will offer curricula, training content, courses, internships and summer school covering the key topics in Microelectronics. The design and execution of ECS-Academy training is achieved through industry cooperation with VET and higher education. Through this combined expertise in semiconductors, the training is adapted to emerging occupational profiles and skills in microelectronics
- STMicroelectronics partners with public institutions, schools, and universities.
  - Lectures, hackathons, workshops, and site visits are organised through these partnerships to increase student interest in STEM and semiconductors. By creating early engagement when introducing students to STEM and semiconductor fields, they are more likely to become interested and pursue careers in these areas, resulting in a larger, more qualified pool of candidates for the future workforce. STMicroelectronics distributes **"Vitta Science" educational kits to school students**, such as Mars robot, Connected plant and IoT development kit. Kits are developed and integrated using various IPCEI technologies and products (MicrocontrollerS, sensor MEMS and imagerS, RF, protection and power components). ST also distributes several boards to a wide range of schools and universities. This access not only prepares students for the technical demands of their future roles but also inspires new ideas and approaches to challenges within the field.

- At universities and technical institutes, ST experts deliver lectures and seminars, which are also delivered to partnered schools. Higher education students, such as those studying at partnered institution Politecnico di Milano among others, have internship opportunities with STMicroelectronics, and the company also sponsors and co-authors joint Master's degrees with universities. In doing so, ST encourages the **design of degree programmes that target a broad range of skills demanded by the industry**. This strategy addresses the issue of university curricula either falling behind the rapid innovations in the semiconductor industry, or being too theory-focused for students to develop practical skills directly required by current semiconductor jobs.
- Globally, **ST opens joint labs at university facilities** to enhance collaboration with students and academia. In other cases, ST hosts joint labs, co-led with universities and research organisations, at its premises. The establishment of joint labs is part of the company's formation of a network of skills, with centres of excellence in public and private institutions. ST partners with these research centres through both research contracts, and participation in significant research programmes funded by national and European institutions.

The following case studies highlight a selection of what companies are doing beyond Europe to create and offer training and development opportunities:

- Intel, US:
  - Intel has launched 3 K-12 education initiatives, 5 programmes at the community college and university level, all of which are created with a semiconductor focused curriculum. Intel has committed to invest $50 million in education with higher education institutions in Ohio.
  - In partnership with Intel, Central State University is addressing the skilled workforce shortage in the semiconductor industry through the Semiconductor Education and Research Program (SERP). Started in 2022 with Intel's funding, the SERP aims to support 100 certificate and associate degree graduates over the period of three years. The programme offers a blended learning approach. It combines an online programme covering robotics and automation, semiconductor device physics, and a selection of 10 electives. Students gain practical experience through paid internships and gaining on-the-job training in microfabrication and simulation labs set up by the university. Intel has also partnered with higher education institutions to offer scholarships for women and underrepresented minorities.
  - Intel has invested $20 billion in 2 chip factories in Ohio in 2022, which is expected to create 3000 high-tech jobs and 7000 construction jobs and more to support a community of suppliers and partners.
  - In 2022, NSF announced a $10 million partnership with Intel to provide funding to support the workforce development in the manufacturing semiconductor industry via 2 programmes: the Advanced Technological Education program, and the Scholarships in STEM program.
- Micron, US:
  - In partnership with the US National Science Foundation, Micron launched a multiyear public-private partnership of $10 million **to support STEM education focusing on semiconductors**. One of the initiatives aims to fund the design of semiconductor learning materials for higher education institutions with the aim of building skills for the semiconductor manufacturing workforce.
  - Through the CHIPS and Science Act, Micron's investment in New York and Idaho's history, and will create over 70,000 jobs, including 20,000 direct construction and manufacturing jobs and tens of thousands of indirect jobs.
- Infocomm Media Development Authority (IMDA) in collaboration with industry, Singapore:
  - IMDA's Company-Led Training (CLT) programme aims to accelerate the professional development of tertiary graduates and mid-career professionals, including mature PMETs, through an on-the-job training programme. This helps them achieve competencies for jobs in demand by industry, especially those that support the digital economy sector transformation efforts.
  - IMDA's CLT programme aligns to the Skills Framework of ICT and focuses on developing tech skills. Trainees can apply for a wide variety of tech job roles for on-the-job learning in 5G, Internet of Things (IoT), Cloud Computing, Product Development, Software Engineering, Cybersecurity, Data Analytics, and more.
- Powerchip Semiconductor Manufacturing Corp. (PSMC), Taiwan:

- PSMC participates in Taiwan's Semiconductor Academy Program, through which it donates to the leading 4 universities for graduates progressing to a career in semiconductors (National Taiwan University, National Cheng Kung University, National Tsing Hua University, and National Yang Ming Chiao Tung University). PSMC plans to invest NT$100 million annually to support the operation of the four universities' semiconductor colleges, targeting to support the development of more than 5,000 semiconductor professionals for Taiwan in the next 12 years, equally leveraging this opportunity for company recruitment and contributing to the wider semiconductor industry. In 2022, PSMC signed contracts with these 4 universities to collaborate on a total of 46 research projects with the semiconductor colleges of the four universities, with a total investment of over NT$40 million, and to provide scholarships for outstanding students from the sponsorship fees totaling NT$7 million in 2023.

5. Future outlook

5.1 Emerging Skills Needs and Technological Trends

With the rise of new technologies and components, the semiconductor industry will need to prepare to upskill its existing and upcoming workforce to align production with new needs for skills. It is important to remember that, as the process to manufacture a semiconductor involves various specialised materials, equipment, and steps, disruptions in one part of the process can impact the entire supply chain. Therefore, any introduction of emerging technologies must be well planned before implementation, especially when it comes to staffing so no disruptions occur.

Quantum computing, for example, although still an embryonic area of ICT, has a huge potential to disrupt the way the industry manufactures and interacts with semiconductors. Once promising quantum computing use cases emerge and gain traction, the infrastructure behind processing of data may substantially evolve. Although it is unlikely that silicon data storage will suddenly disappear, the industry will need to ensure it has access to enough qualified professionals in the area through recruitment and robust upskilling of its existing workforce to fill competency gaps.

Beyond emerging technology areas, the increasing complexity of semiconductor technologies will **depend on seamless collaboration across multiple disciplines**. Integrated teams of engineers, physicists, chemists, and materials scientists significantly enhance overall efficiency and drive innovation. For organisations wanting to improve efficiency in their semiconductor production, a comprehensive analysis of the roles and contributions of different specialists within the field should take place so the right skills and tasks are performed by the right professionals. The semiconductor industry is progressively dependent on this interdisciplinary approach, particularly with the advent of interconnected technologies such as the Internet of Things (IoT) where ICT skills merge with industry specific knowledge for use cases to be developed.

Also, the importance of data analytics and machine learning for applications in the semiconductor industry cannot be overstated. Although a skill of the present, companies should continue to intensify their focus on training and recruiting specialised data professionals to enhance yields, optimise processes, and accelerate time-to-market over the next few years, remembering that multiple industries will be fighting for the same candidate profile so competition will be fierce.

Overall, cross-dependency also means semiconductor companies will increasingly need to look at advancements and dependent industries to upskill their workforce. Industry specific use cases in areas such as healthcare, finance and automotive will also push for specialised skills in chips manufacturing both for end-user companies and pure semiconductor players so supply for these markets can be customised enough to serve specific purposes. Therefore, the more connected semiconductor professionals are with their end-user customers and industry-specific trends, the better products can be developed.

In summary, emerging skills in semiconductors goes beyond specific technical competencies and a more holistic, integrated view of the microelectronics value chain, looking not only at emerging technologies, but also collaboration across multiple departments and specific industry use cases that will emerge.

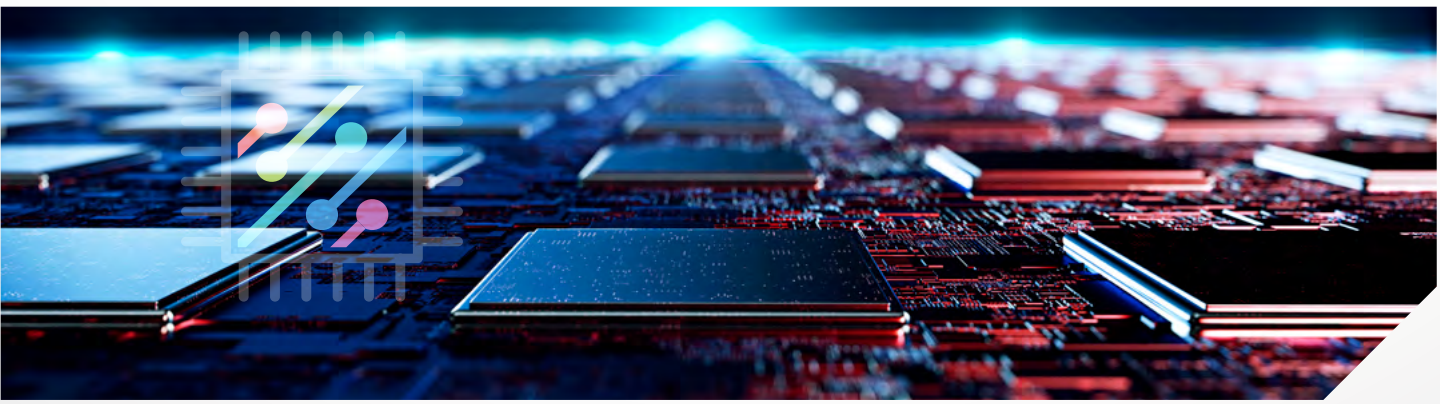
5.2 The Role of Automation and AI in Shaping Workforce Requirements

On the manufacturing side, automation and AI will be essential for advancing the semiconductor industry by improving areas such as design efficiency, manufacturing precision, quality control, supply chain management, energy consumption, innovation, customer experience, and sustainability. AI and automation have the potential to deeply change how data is processed and collected within manufacturing, meaning that more complex metrics with an increased flow of data may be created to better understand production efficiency.

On the application side, semiconductor companies can also use generative AI technologies to remove obstacles in the way of skill requirements by automating menial tasks and freeing up time from certain roles to focus on added value work. One example is AI being used to significantly increase productivity among software developers who might be able to finish their coding tasks at twice the rate they currently do and having more time to perform Quality Assurance and focus on more complex pieces of code.

Such optimisation will require multiple roles within semiconductor companies, from technical (such as engineers, data scientists and developers) to line of business (such as finance and HR) to acquire an understanding on how to operate AI tools, grasp AI analytics and get acquainted to having AI systems as co-pilots on their day to day.

It is important to mention that, as the AI race for use case development will be happening across the board, semiconductor manufacturers will be fighting for the still limited pool of AI talent with multiple other industries so competition for specialised roles to develop AI will be fierce. That said, it is imperative for the industry to align their AI adoption roadmap with upskilling by including AI training within their current learning & development strategy at all levels so they can ensure to have the necessary competencies to accelerate adoption of new automated tools and systems instead of only relying on recruiting from the market.



6. Call to Action for Stakeholders

The following **seven actions** are looking to be implemented as early as July 2024 and are a result of the various contributions received from the stakeholders and are endorsed by them.

Recommendation #1 - **Appoint a neutral umbrella organisation, that is recognised by the entire community, that may coordinate all joint initiatives and efforts aimed at bridging the skills gap in the semiconductor industry, effective from July 2024.**

This recommendation is a direct outcome from the contributions of stakeholders in the Blueprint arising from the recognition that while numerous initiatives across Europe are already addressing skills development, the lack of coordination can lead to confusion and fragmentation of efforts. Stakeholders have identified the need for a centralised, coordinating body to streamline these efforts and foster a more cohesive approach.

This recommendation aims to establish a central coordinating entity tasked with aligning and synchronising the collective efforts of participating organisations through:

- The establishment of a **recognised**, **central coordinating office** that gathers related information, activities and success stories;
- The **development of a comprehensive shared calendar of events** and summer schools around Europe;
- The **facilitation of regular meetings and communications** among all stakeholders to ensure alignment and cooperation.
- The **pursuing of EU funds to supplement the financial commitments provided by stakeholders** to secure funding support specifically dedicated to talent development initiatives, aligning with the objectives of the European Chips Act.

Recommendation #2 - **Create joint coordinated awareness campaigns with relevant stakeholders (associations, consortia, industry…) around the skills gap in Europe**

The campaigns should target European students and young people to educate and inform them about the diverse career opportunities available within the semiconductor industry, dispelling misconceptions, considerations around reskilling, combating gender stereotypes and biases and highlighting the importance of STEM education.

The campaigns should consider:

- Creating multimedia content, including posters, videos and infographics, to effectively communicate key messages about semiconductor careers and educational opportunities.
- Leveraging **student ambassadors** to act as representatives, promoting semiconductor careers and educational opportunities within their communities and networks.
- **Creating and distributing educational kits to students** providing hands-on learning experiences, inspiring new ideas and approaches to challenges.
- **Organising events such as MINT/STEM Camps and Girls Days** to encourage participation from underrepresented groups.
- Implement **professional development programmes to equip and educate primary and secondary school teachers** with workshops, seminars, and curriculum materials with the information and tools necessary to nurture students' interest and aptitude in STEM subjects.

Recommendation #3 - **Sponsorship, Financial or In-Kind Support to Future Summer Schools and Vocational Schools**

Stakeholders have acknowledged that Summer Schools play a crucial role in nurturing future talent and addressing the skills gap within the industry. While acknowledging existing initiatives, stakeholders have recognised the importance of enhancing support to ensure the sustainability and effectiveness of these educational programmes.

The initiative seeks to establish a **coordinated approach to support future Summer Schools, facilitated by both industry leaders and universities.**

- Industry leaders will allocate **specific budgets to sponsor Summer Schools** dedicated to semiconductor education, ensuring that these initiatives receive the necessary financial support to operate effectively.
- Industry leaders will provide **training facilities and resources to support university faculty and students participating in Summer Schools**. This includes access to state-of-the-art laboratories, equipment, and materials necessary for hands-on learning experiences.
- Policymakers should explore opportunities for leveraging funding dedicated to Summer Schools coming from different programmes such as Chips JU and Erasmus+.

Recommendation #4 - **Support on the job and Lifelong learning opportunities**

The semiconductor industry is marked by rapid technological advancements, which demand a continuous learning mindset among professionals. Traditional education pathways alone are not sufficient to equip individuals with the specialised skills required in this fast-evolving field.

- **Academia Research organisations and Industry will collaborate to develop micro-credentials courses,** offering students but also industry professionals the opportunity to acquire specialised skills and credentials relevant to the semiconductor industry. These courses will be tailored to address specific skill gaps and emerging trends within the industry and needs to be accredited by an overarching official education strategy (see also Recommendation #5).
- **Industry and Research organisations will facilitate placement opportunities through internships, traineeships, and apprenticeships,** providing industry professionals with hands-on experience and on-the-job training within the semiconductor industry.
- **Expand technician training opportunities to address the need for upskilling and reskilling of workers**, particularly those transitioning from closing industries. Establish localised training locations, especially in regions where greenfield semiconductor projects are underway, to provide accessible training opportunities for individuals seeking to enter the semiconductor field or transition within it.

Recommendation #5 - Develop an official cohesive strategy that unites universities across Europe and their specialised courses in semiconductor education

Stakeholders recognised the need for an **official cohesive strategy that unites universities across Europe** specialising in semiconductor education. This approach aims to **standardise the curricula and ensure a recognised educational pathway for students, enhancing mobility and employability across the EU.** Unify universities and their specialised courses in semiconductor education to create a standardised European curriculum.

- **Incorporate accreditation requirements into an official education strategy endorsed and shared by European and national governments** to ensure standard, quality and trust and enhance the mobility and recognition of qualifications, both domestically and internationally.
- Industry to collaborate with academia to **create part-time teaching roles in universities for industry professionals**, facilitating the transfer of practical knowledge and real-world experience to students.

Recommendation #6 - **Strengthen collaborative efforts between Governments, Member States, Regions, and the Semiconductor Ecosystem**

Member states, national governments, and regional authorities should play a key role in shaping and supporting the semiconductor workforce. This involves providing **funding access, creating supportive policies, and enhancing education and university partnerships**.

Some support mechanisms that have been identified are based on the following:

- Establish dedicated funds and loan schemes at both the national and regional levels to provide SMEs and startups with the **financial resources they need for R&D, training, and operational expansion.**
- Implement a **points or credits system** that rewards large enterprises for field-testing proof-of-concept (PoC) products from SME facilitating the **validation and scaling of new technologies and innovations**.
- Encourage regional clusters and innovation hubs to facilitate **partnerships between large enterprises and SMEs**, creating a supportive ecosystem for collaboration and knowledge sharing.
- **Develop and fund educational programmes that align with industry needs, including specialised degrees and vocational training**. Foster partnerships between semiconductor companies and universities to ensure curricula are updated with the latest technological advancements and industry requirements.

Recommendation #7 - **Facilitate international cooperation and student exchange programmes**

Member states, governments, and regions should work together to establish and support international student exchange programmes with key semiconductor hubs such as Japan, Singapore, Taiwan, South Korea and the US.

The initiative should focus on the following:

- Develop **policies that streamline visa processes, accreditation, and recognition of academic credits** to facilitate smooth exchanges and reduce bureaucratic obstacles.
- Encourage partnerships between universities and semiconductor companies across different countries to create robust **exchange programmes that combine academic learning with hands-on industry experience**.
- Provide **financial support and scholarships** to students participating in exchange programmes to ensure accessibility and reduce financial barriers.

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