D2.1 Needs Assessment Report

5G-DiGITs

Cross-sectorial education and talent development for beyond 5G Digital and Green Industrial Technologies.

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Reviewer 2:	Marius Ablačinskas (TECHIN)
Contributors:	ENVOLVE, UPV, INFOLYSIS, KU, TUC, INERCIA DIGITAL, CNC, FINNOVA, A8, TECHIN, F6S

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Abbreviations

AI: Artificial Intelligence

AR: Augmented Reality

B5G: Beyond 5G

ICT: Information and Communications Technology

IEEE: Institute of Electrical and Electronics Engineers

IoT: Internet of Things

ITU: International Telecommunications Union

ML: Machine-Learning

PCP: Pre-Commercial Procurement

PBL: Problem-based learning

R&D: Research & Development

VR: Virtual Reality

WP: Work Package

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Executive Summary

This deliverable (D2.1) serves as a foundational analysis aimed at identifying critical skills gaps, industry expectations, and educational requirements necessary for the successful implementation of an advanced curriculum in Beyond 5G (B5G) and Green Industrial Technologies. The study, conducted through surveys and interviews with key stakeholders - educators, students, industry professionals, and policymakers - highlights several key findings and strategic recommendations.

The report identifies a significant gap between current university curricula and industry needs, particularly in hands-on training and interdisciplinary applications of 5G. Stronger partnerships between universities and industry stakeholders are required to ensure graduates are equipped with relevant, real-world skills. Students express a strong demand for more practical experiences, including internships, research collaborations, and access to 5G testbeds. Educators face difficulties in keeping pace with rapid advancements in 5G, necessitating continuous professional development programs. Policymakers recognize the need for increased funding and regulatory frameworks to support 5G workforce development and academic innovation.

To address these challenges, the report recommends enhancing curricula by developing modular, interdisciplinary courses that integrate, among others, Artificial Intelligence (AI), Internet of Things (IoT), and sustainability within the 5G framework. More testbeds, industry partnerships, and experiential learning programs should be established to bridge the gap between theory and practice. Faculty training programs should be implemented to ensure educators stay updated with the latest 5G technological advancements. Public-private collaborations should be encouraged through joint research initiatives, industry mentorship programs, and co-designed educational materials. Policy advocacy is also necessary to secure funding and modernize university infrastructure while facilitating industry-driven learning models.

The findings from this report will directly feed the development of subsequent deliverables (D2.2, D2.3, D2.4) on targeted actions specified in the project. By addressing the above challenges, the 5G-DiGITs initiative aims to equip students with future-ready skills, foster innovation, and contribute to Europe's digital and green transformation.

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1. Introduction

5G-DiGITs project is a collaborative initiative under the ERASMUS-EDU-2024-PI-ALL-INNO program. It aims to address the evolving needs of the digital and green industrial landscape by developing innovative educational frameworks that integrate Beyond 5G (B5G) technologies with sustainability principles. By fostering partnerships between academia, industry, and policymakers, 5G-DiGITs seeks to bridge the skills gap in emerging technological domains and equip learners with future-proof competencies. As industries transition towards digitalized, interconnected, and eco-friendly solutions, there is an increasing demand for a workforce proficient in advanced 5G, artificial intelligence (AI), Internet of Things (IoT), and sustainable digital infrastructures. The 5G-DiGITs project acknowledges these trends and strives to create a modular, interdisciplinary curriculum that enhances problem-based learning (PBL) and real-world industry engagement. This initiative aligns with European priorities on digital transformation, green energy, and workforce resilience by ensuring that educational offerings remain relevant and adaptive to labor market dynamics.

This deliverable, D2.1 “Needs Assessment Report”, represents a critical foundational step within Work Package 2 (WP2). It aims to systematically identify the skills requirements, knowledge gaps, and educational needs necessary for the successful implementation of an advanced curriculum in B5G and green industrial technologies. UOA leads this deliverable, with assistance and input from all partners, ensuring an evidence-based approach through comprehensive surveys, interviews, and data analysis involving key stakeholders. The report integrates insights from:

- Educators and academic institutions, to identify pedagogical challenges and opportunities.
- Students and trainees, to assess expectations and learning preferences.
- Industry professionals, to understand the latest technological and labor market demands,
- Policy makers, to align educational strategies with regulatory and funding frameworks.

By synthesizing this input, D2.1 will serve as the guiding framework for subsequent curriculum development efforts within WP2. It will provide recommendations for content structuring, learning methodologies, and competency-based education models, ensuring that the curriculum remains agile, industry-aligned, and future-proof. Ultimately, the findings from D2.1 will shape the project's subsequent deliverables, including D2.2 (Modular Curriculum Structure and Learning Materials), D2.3 (Real-World Problems and Case Studies), and D2.4 (Problem-Based Learning Implementation Guide). This structured, data-driven approach will enable 5G-DiGITs to develop an educational ecosystem that supports lifelong learning, cross-sectoral collaboration, and technological upskilling, contributing to Europe’s ambitions in digital innovation and sustainable industrial growth.

The document is structured as follows: Section 2 includes the description of the procedure followed in structuring the two main tools of the survey, i.e., the questionnaires and the interview questions for the four different participants categories (educators, students, industry representatives, and policy-makers). Sections 3 and 4 include discussion on the results of the questionnaires and interviews per category. Finally, section 5 provides conclusions and future steps.

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2. Stakeholder-Driven Data Collection: Surveys and Interviews for Needs Assessment

The data collection process for this study followed a structured, multi-stakeholder approach designed to identify key educational gaps and skill requirements in the domain of Beyond 5G (B5G) and Green Industrial Technologies. Recognizing the diverse perspectives necessary for a comprehensive needs assessment, the study targeted four primary stakeholder groups: **educators, students, industry professionals, and policymakers**.

To ensure a broad and heterogeneous dataset, **each project partner was responsible for gathering at least 10 completed questionnaires and conducting a minimum of 5 interviews** within their respective networks. This approach helped to **capture diverse viewpoints across different countries, institutional settings, and professional backgrounds**.

The research tools comprised **structured questionnaires** and **semi-structured interviews**, both tailored to the unique concerns and expertise of each stakeholder group. The questionnaires were designed to capture **quantitative insights**, measuring familiarity with 5G concepts, perceived skill gaps, industry expectations, and educational shortcomings. In parallel, the interviews facilitated **qualitative exploration**, allowing participants to elaborate on challenges, opportunities, and recommendations for curriculum improvements.

The methodological framework aligns with **mixed-methods research**, an established approach for **triangulating data**. Combining surveys with in-depth interviews enhances the **validity and reliability** of findings, enabling a richer understanding of both individual and institutional challenges in B5G education. Moreover, the study follows principles of **participatory research**, ensuring that stakeholders contribute directly to the curriculum design process, fostering **alignment between academic programs and labor market needs.** By integrating data from multiple respondent categories, this methodology provides a **holistic** perspective on the evolving educational and workforce requirements in the 5G ecosystem. The findings from this process directly inform the curriculum development efforts within WP2, ensuring that the future educational framework is both **industry-aligned and pedagogically sound**.

The questionnaires were designed to capture a wide range of insights from four key stakeholder groups. The development process involved several stages. Initially, a literature review and consultation with subject matter experts helped define the key areas of inquiry. The primary themes included current awareness and knowledge of 5G and Green Industrial Technologies, skill requirements for academia, industry, and policy development, gaps in existing educational programs, challenges faced in integrating 5G technologies into curricula, and the role of industry and public-private partnerships in skills development. Based on the identified themes, the questionnaires were structured into different sections. The first section covered demographic information to gather details on respondents' backgrounds, roles, and levels of expertise. The second section focused on current knowledge and engagement, assessing familiarity with 5G and its applications. The third section aimed to identify essential technical and interdisciplinary competencies needed for the evolving job market. The fourth section explored educational gaps and challenges, highlighting difficulties faced in academia and industry. The final section sought insights into the future outlook and recommendations for curriculum improvements and policy

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initiatives. To ensure a balance between qualitative and quantitative data collection, the questionnaires included **multiple-choice questions** for easy categorization of responses, **scale questions** to gauge levels of agreement or importance on specific topics, and **open-ended questions** allowing respondents to elaborate on their perspectives. A **pilot study** was conducted with a small subset of participants to test the clarity, relevance, and effectiveness of the questions. Feedback from the pilot was used to refine wording, eliminate ambiguity, and ensure the completeness of the questionnaire.

On the other hand, **structured interview questions** were created to facilitate in-depth discussions with key stakeholders. The interview process aimed to complement the quantitative data from the surveys with qualitative insights. The interview questions were **semi-structured** to allow flexibility while maintaining consistency across different respondents. The questions were tailored to each stakeholder group, ensuring relevance to their roles and experiences, and interviews were designed to last between 20 to 30 minutes to allow for detailed discussions without overburdening participants. Each stakeholder group had a **specific set of themes** guiding the interviews. Educators were asked about their familiarity with 5G concepts, challenges in integrating 5G into curricula, and the required institutional support. Students were questioned on their awareness of 5G technologies, learning preferences, and perceived gaps in university training. Industry representatives provided insights on the skills required for workforce readiness, challenges in hiring skilled graduates, and the potential for academic collaboration. Policymakers discussed the importance of 5G in economic and technological development, funding and policy initiatives, and public-private partnerships. Responses were anonymized to protect confidentiality, and interview recordings and transcripts were securely stored and used exclusively for the research objectives.

The final versions of the questionnaires and interview questions underwent a review process by all partners. The final instruments were designed to ensure reliability, with questions structured to yield consistent responses across different respondents. The content validity was verified to accurately capture key aspects of 5G skills and education gaps. Additionally, adjustments were made to ensure the language was accessible to respondents from different backgrounds and expertise levels. The structured approach to developing the questionnaires and interview materials ensured that the data collected would be comprehensive, reliable, and valuable for shaping the curriculum in Beyond 5G and Green Industrial Technologies. By leveraging both quantitative and qualitative methodologies, the 5G-DiGITs project has built a strong foundation for understanding stakeholder needs and designing targeted educational interventions.

3. Bridging the Skills Gap: Analysis of Questionnaire Responses

In total, the project partners **attracted 120 replies to questionnaires** from all stakeholders' groups, with diverse background, role and expertise, combining different points of view. More specifically, **29 educators, 44 students, 39 industry professionals and 8 policymakers responded**. Their replies provided an in-depth understanding of the perspectives and expectations of different stakeholders in the 5G and Green

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Industrial Technologies ecosystem. Graphs indicating the numerical results, as well as replies to open-ended questions, can be found in Appendix B to allow for a more detailed study per question. Instead, a comparative analysis in this section reveals significant overlaps, discrepancies, and points of convergence regarding skills requirements, challenges, and recommendations for curriculum development. This comparison aims to highlight the key takeaways from each group and offer insights into the broader implications for education, workforce readiness, and policy formulation.

3.1. Comparative Analysis of Questionnaire Responses - Inside view (Educators vs. Students)

The analysis of the questionnaire results from educators and students reveals a good understanding of the differing perspectives, needs, and challenges faced by these two critical stakeholders in the integration of 5G technologies within higher education. While both groups recognize the transformative potential of 5G, their experiences, expectations, and challenges highlight the need for a tailored, multifaceted approach to curriculum development and institutional support.

Educators generally demonstrate a moderate to advanced understanding of 5G concepts (Figure 5), with many actively engaging in research or teaching related to various facets of the technology, such as network architecture, IoT integration, and security (Figure 6). However, a notable portion of educators still possesses only basic familiarity with the subject. This variance highlights a critical gap in faculty expertise, which subsequently impacts the ability to effectively incorporate 5G topics into university curricula. The challenges faced by educators predominantly stem from the rapid evolution of technology and the associated difficulty in keeping course content up to date (Figure 10). The lack of access to specialized resources, such as lab equipment and real-world case studies, further exacerbates these challenges, limiting opportunities for hands-on learning (Figure 11). Additionally, educators often struggle with establishing meaningful industry partnerships, which are crucial for ensuring the relevance and practical applicability of their teaching materials (Figure 15).

In contrast, the student responses indicate a high level of enthusiasm and interest in 5G technologies. Many students possess a basic to moderate understanding of 5G, with a significant number expressing a desire to deepen their knowledge through further education and hands-on experiences (Figure 22 - Figure 24). Despite their enthusiasm, students face considerable barriers in accessing practical learning opportunities. While theoretical exposure to 5G concepts is present in some university programs, practical experiences such as internships, access to simulation platforms, and real-world projects are often lacking (Figure 29 - Figure 31). This gap between theoretical knowledge and practical application leaves students feeling underprepared for careers in 5G-related fields.

One of the most striking differences between educators and students lies in their perceptions of skill requirements for 5G proficiency. Educators tend to emphasize technical competencies such as network design, spectrum management, AI-powered network automation, and cybersecurity (Figure 8). These skills are viewed as essential for preparing students for the demands of the 5G industry. Additionally, educators recognize the importance of interdisciplinary skills, including

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problem-solving, critical thinking, and teamwork, especially as 5G technologies increasingly intersect with fields like AI, IoT, and sustainability (Figure 9).

Students, on the other hand, also acknowledge the importance of technical skills but place a stronger emphasis on interdisciplinary learning and real-world applications. They express a keen interest in understanding how 5G technologies intersect with AI, IoT, and smart city development (Figure 24). Many students highlight the need for hands-on learning experiences, such as internships, hackathons, and industry-sponsored projects, which they believe are critical for bridging the gap between theory and practice (Figure 29). Additionally, students emphasize the importance of understanding the broader societal implications of 5G, including its role in sustainability and digital transformation (Figure 25).

Both groups identify significant gaps in the current university infrastructure that hinder effective 5G education. Educators point to a lack of resources, such as dedicated 5G labs and access to advanced simulation tools, as major obstacles. These limitations prevent them from offering students the hands-on experiences necessary for developing practical skills. Similarly, students report limited access to industry collaborations and practical learning opportunities, which they view as essential for preparing for the workforce. The absence of structured internship programs and industry-led research projects contributes to a sense of disconnect between academic learning and real-world applications.

When considering solutions, educators and students share a common understanding of the importance of strengthening university-industry partnerships. Educators advocate for collaborative initiatives that provide students with exposure to real-world challenges and cutting-edge technologies (Figure 16). They suggest establishing internship programs, guest lectures from industry professionals, and joint research projects as effective means of bridging the gap between academia and industry. Additionally, educators emphasize the need for continuous professional development programs to help faculty stay updated on the latest advancements in 5G technology.

Students echo these sentiments, expressing a strong interest in industry-led learning experiences. They believe that internships, workshops, and access to 5G testbeds are crucial for developing practical skills and gaining insights into industry expectations (Figure 29). Moreover, students highlight the importance of interdisciplinary projects that allow them to explore the applications of 5G in diverse fields such as healthcare, autonomous vehicles, and smart cities. They also call for greater collaboration between universities and tech companies to ensure that academic programs remain aligned with industry trends and technological advancements.

Another key area of divergence between educators and students lies in their views on the integration of sustainability into 5G education. Educators recognize the importance of incorporating green industrial technologies into the curriculum but often face challenges in doing so due to limited resources and expertise. They acknowledge the need to develop specialized courses that focus on energy-efficient network design, renewable energy integration, and the environmental impact of 5G networks. However, these topics are often introduced only at the postgraduate level, leaving undergraduate students with limited exposure to sustainability-focused 5G applications.

Students, in contrast, demonstrate a strong interest in the intersection of 5G and sustainability. They view the integration of green technologies as essential for

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addressing global environmental challenges and believe that universities should place greater emphasis on teaching energy-efficient communication systems and sustainable digital infrastructure. Students also express a desire for more interdisciplinary courses that explore the environmental, social, and economic implications of 5G technologies.

The comparison of educator and student perspectives also reveals differences in their views on curriculum design and pedagogical approaches. Educators often favor traditional teaching methods, such as lectures and seminars, while recognizing the need for more interactive and hands-on learning experiences. They advocate for the adoption of modular and interdisciplinary course structures that allow students to tailor their learning paths according to their interests and career goals.

Students, however, express a preference for experiential learning methods that prioritize practical application over theoretical instruction. They suggest incorporating project-based learning, case studies, and real-world problem-solving exercises into the curriculum. Additionally, students emphasize the importance of peer-to-peer learning and collaborative projects that foster teamwork and critical thinking skills.

In conclusion, the analysis of the questionnaire results highlights both commonalities and differences between educators and students regarding 5G education. While both groups recognize the importance of 5G technologies and the need for practical learning experiences, their perspectives on skill requirements, curriculum design, and interdisciplinary learning differ in significant ways. Addressing these differences requires a collaborative approach that involves educators, students, industry professionals, and policymakers. By fostering stronger university-industry partnerships, investing in faculty development, and enhancing access to practical learning resources, higher education institutions can better prepare students for the evolving demands of the 5G industry. Additionally, integrating sustainability into 5G education will ensure that graduates are equipped to address the environmental challenges associated with digital transformation, ultimately contributing to the development of a more sustainable and technologically advanced society.

To summarize the key findings from the stakeholder questionnaires, the following table provides a comparative overview of educators' and students' perspectives on 5G education. The table highlights insights that help identify actionable recommendations for curriculum development, ensuring alignment between academic offerings and workforce needs.

Dimension	Educators' Perspective	Students' Perspective
Knowledge of 5G	Moderate to advanced understanding; most are engaged in research or teaching related to 5G but at varying depths. Some lack familiarity with emerging trends such as AI and sustainability.	Basic to moderate understanding; high enthusiasm but limited exposure to real-world applications. Strong demand for more hands-on learning.
Main Challenges	Rapid technological evolution makes it difficult to keep course content updated. Lack of lab	Theoretical learning dominates; students lack access to real-world

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	resources and limited industry partnerships hinder practical teaching.	projects, internships, and industry collaborations.
Required Skills	**Technical:** Network design, spectrum management, cybersecurity, AI-driven automation. **Interdisciplinary:** Problem-solving, teamwork, adaptability.	**Technical:** IoT integration, AI in 5G, cloud computing, cybersecurity. **Soft skills:** Business acumen, communication, project management.
Teaching Approaches	Rely on traditional lectures but acknowledge the need for more interactive and practical teaching. Advocate for modular and interdisciplinary courses.	Strong preference for experiential learning: internships, hackathons, case studies, and industry-driven projects.
Access to Resources	Limited availability of specialized 5G labs, testbeds, and simulation tools. Many rely on theoretical instruction due to infrastructure constraints.	Lack of hands-on experience and difficulty accessing 5G testbeds or industry-sponsored projects.
Industry Collaboration	Desire for structured partnerships with telecom companies, guest lectures, and co-designed courses. Difficulty establishing long-term industry collaborations.	Strong demand for internships, mentorship programs, and exposure to industry-led challenges.
Sustainability & 5G	Recognize its importance but struggle to incorporate it into curricula due to limited expertise and resources.	High interest in green industrial technologies, but sustainability in 5G is rarely covered in courses.
Recommendations	Faculty training on emerging 5G topics, investment in labs/testbeds, and stronger university-industry partnerships.	Expansion of industry-driven learning, interdisciplinary coursework, and certification opportunities.

Table 1 Comparative insights (Educators vs. Students)

Beyond the comparative insights provided in the previous table, the following summary highlights the **key similarities and differences** between educators and students regarding 5G education. This structured overview helps to identify common ground for collaboration while addressing distinct needs for curriculum development.

Category	Similarities (Common Ground)	Differences (Contrasting Perspectives)
Interest in 5G	Both recognize the transformative impact of 5G across multiple	Educators focus on the integration of 5G into curricula and research, while students emphasize career

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	industries and its relevance to future careers.	opportunities and practical applications.
Challenges in 5G Education	Both groups identify a lack of hands-on learning opportunities, limited access to 5G infrastructure, and challenges in keeping up with rapid technological advancements.	Educators cite **lack of faculty training, difficulty in updating course content, and limited industry collaborations**. Students struggle with **insufficient exposure to real-world applications, lack of internships, and absence of interdisciplinary coursework**.
Skill Development Priorities	Both agree that **technical skills** (network design, AI, IoT, cybersecurity) and **interdisciplinary skills** (problem-solving, critical thinking) are crucial.	Educators emphasize **network architecture, spectrum management, and AI for network automation**, while students highlight **entrepreneurial skills, project management, and industry-relevant certifications**.
Preferred Learning Methods	Both support a shift towards **more practical, industry-connected learning experiences**.	Educators rely more on **traditional lectures and structured coursework**, while students prefer **project-based learning, case studies, hackathons, and hands-on industry exposure**.
Industry Collaboration	Both recognize the **need for stronger university-industry partnerships** to enhance real-world learning.	Educators emphasize **faculty training, guest lectures, and industry-driven course design**, whereas students prioritize **internships, mentorship programs, and direct industry involvement in learning activities**.
Sustainability Awareness	Both acknowledge that **5G must integrate sustainability principles**, particularly in energy efficiency and green industrial technologies.	Educators see **challenges in incorporating sustainability topics due to limited resources**, while students express **high interest but lack structured courses addressing sustainability in 5G**.
Recommendations for Improvement	Both advocate for **faculty training, investment in testbeds, and closer industry-academia collaboration**.	Educators emphasize **the need for updated teaching materials and standardized curriculum frameworks**, whereas students push for **more hands-on training, interdisciplinary courses, and recognized certification programs**.

Table 2 Key similarities and differences (Educators vs. Students)

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3.2. Comparative Analysis of Questionnaire Responses: Outside view (Industry vs. Policymakers)

The analysis of questionnaire results from industry experts and policymakers offers valuable insights into their distinct yet complementary views on preparing the future workforce for the challenges and opportunities presented by 5G technologies. While both groups share a commitment to fostering a well-equipped talent pool for the evolving digital landscape, their priorities and focus areas differ based on their respective roles within the broader ecosystem of technological advancement.

Industry experts bring a pragmatic and market-driven perspective, emphasizing the immediate technical competencies required to thrive in the 5G sector. Their primary concerns center around the skills gap that currently exists between academic instruction and real-world application. Industry representatives highlight the critical need for expertise in areas such as network architecture, cybersecurity, AI, machine learning (ML) integration, and IoT systems. These technical skills are essential for the deployment and optimization of 5G networks, ensuring their security, efficiency, and scalability (Figure 37).

One of the main challenges identified by industry experts is the lack of practical experience among recent graduates. While theoretical understanding forms a solid foundation, it is not sufficient to meet the demands of the fast-evolving 5G industry. Industry stakeholders emphasize the importance of hands-on learning opportunities, such as internships, real-world projects, and direct exposure to 5G infrastructure. They also advocate for specialized training in emerging technologies like edge computing, private 5G networks, and advanced applications, including augmented reality (AR), virtual reality (VR), and autonomous vehicle systems.

Moreover, industry professionals underscore the importance of soft skills alongside technical expertise. Attributes such as effective communication, teamwork, critical thinking, and problem-solving abilities are viewed as essential for professionals navigating the complexities of the 5G ecosystem. The interdisciplinary nature of 5G technologies requires graduates to collaborate across various fields, integrating knowledge from sectors such as AI, data science, cybersecurity, and telecommunications (Figure 39 - Figure 48).

In contrast, policymakers adopt a broader, long-term perspective, focusing on strategies that ensure sustainable development and workforce readiness in the face of rapid technological change. Their emphasis lies in fostering systemic support through regulatory frameworks, investment in educational infrastructure, and the promotion of interdisciplinary learning. Policymakers recognize that technological advancement must be underpinned by supportive legislation, equitable access to resources, and sustainable practices to maximize societal benefits (Figure 60).

A key area of focus for policymakers is the encouragement of university-industry collaboration. They advocate for government-supported initiatives that foster partnerships between academic institutions and industry leaders, facilitating knowledge exchange and practical experience for students. Policymakers also stress the importance of funding research centers and establishing national centers of excellence dedicated to 5G education, ensuring that academic institutions remain at the cutting edge of technological development (Figure 64).

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Policymakers highlight the integration of interdisciplinary skills within university curricula as a vital component of workforce preparation. They emphasize the need for students to gain not only technical competencies but also a robust understanding of regulatory frameworks, ethical considerations, and the socioeconomic implications of 5G deployment. Issues such as data privacy, cybersecurity policy, and the environmental impact of digital infrastructure are considered essential areas of study (Figure 59).

Sustainability is another critical concern for policymakers, who advocate for embedding green industrial technologies into 5G education. Their goal is to ensure that future engineers and technology professionals are equipped with the knowledge and skills necessary to mitigate the environmental impact of 5G networks. This includes developing energy-efficient network designs, integrating renewable energy sources, and promoting eco-friendly communication systems (Figure 63).

Despite these differing focal points, both industry experts and policymakers share common ground on several issues. Both groups emphasize the importance of bridging the gap between theoretical knowledge and practical application through university-industry partnerships. While industry professionals focus on immediate skills development through real-world learning experiences, policymakers advocate for regulatory incentives and funding initiatives that encourage such collaborations.

Both groups also recognize the need for continuous professional development and lifelong learning, particularly given the rapid pace of technological advancement in the 5G sector. Industry experts highlight the importance of upskilling programs for current employees, while policymakers emphasize the role of government-supported training initiatives and certification programs designed to ensure that graduates meet global industry standards.

When it comes to the integration of sustainability in 5G education, industry experts tend to view it from an operational standpoint, focusing on energy efficiency and green practices within network infrastructure. Policymakers, however, adopt a more holistic approach, advocating for the inclusion of environmental considerations in all aspects of 5G education, from technical training to regulatory policy and digital ethics.

In conclusion, the comparison of industry experts and policymakers reveals both overlapping priorities and distinct perspectives on 5G education and workforce development. Industry professionals prioritize immediate, practical competencies and hands-on experience, aiming to equip graduates with skills directly applicable to the current job market. Policymakers, on the other hand, focus on long-term strategies, regulatory support, and the integration of sustainability and ethical considerations into the educational framework. To effectively prepare students for the challenges of the 5G era, a collaborative approach that blends industry-driven practical training with policy-driven strategic planning is essential. By fostering partnerships between academia, industry, and government, investing in infrastructure, and promoting interdisciplinary learning, educational institutions can cultivate a workforce capable of driving innovation and supporting sustainable technological advancement in the digital age.

The following table compares the perspectives of industry professionals and policymakers on the challenges, opportunities, and strategies for integrating 5G education into university programs.

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Dimension	Industry Perspective	Policymakers' Perspective
Main Concerns in Workforce Readiness	Graduates lack **practical skills and hands-on experience** in 5G, requiring additional industry training.	Universities lack **funding, regulatory frameworks, and infrastructure** to modernize 5G education
University Curriculum & Skill Gaps	University programs are **too theoretical** and do not match **current industry needs** in 5G deployment, cybersecurity, AI, and IoT integration.	Universities need **interdisciplinary approaches** that include **policy, ethics, and sustainability**, not just technical training.
Preferred Learning Methods	**Hands-on training, internships, and research collaboration** are essential for bridging the gap between theory and practice.	Support for **public-private partnerships** to fund testbeds, training programs, and research initiatives.
Role of Industry in Education	Industry should be more involved in **course design, internships, and co-developing curricula** with universities.	Policymakers should **create incentives for industry participation in education** through funding and regulations.
Sustainability in 5G Education	Important but **not the main priority**—focus is on **energy-efficient networks** and cost-effective deployment.	A **core concern**—universities should integrate **green technologies and sustainability principles** into 5G education
Policy & Funding Priorities	Industry needs **standardized certifications, training programs, and faster adoption of new technologies** in education.	Governments must **fund digital education programs, regulate workforce development, and ensure equal access to training opportunities**.
Recommendations for Improvement	Universities should **update curricula, provide more hands-on learning, and increase collaboration with industry**.	Governments should **support education modernization, fund university-industry partnerships, and integrate sustainability policies** into 5G training programs.

Table 3 Comparative insights (Industry vs. Policymakers)

While industry professionals and policymakers share the goal of preparing a workforce skilled in 5G and green technologies, their perspectives diverge in terms of priorities, challenges, and strategies. The following table highlights their **key similarities and differences**, helping to align educational strategies with both industry demands and regulatory frameworks.

Category	Similarities (Common Ground)	Differences (Contrasting Perspectives)
Recognition of 5G's Importance	Both view 5G as **critical for economic growth, digital transformation, and industrial innovation**.	Industry focuses on **immediate workforce needs and commercial applications**, while policymakers

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		emphasize **long-term economic strategy and regulatory governance**.
Challenges in 5G Education	Both identify a **disconnect between university curricula and workforce demands**, emphasizing the need for updates.	Industry sees the problem as **a lack of practical skills and outdated courses**, whereas policymakers focus on **insufficient funding, regulatory gaps, and regional disparities in access to 5G education**.
Key Skill Priorities	Both groups agree that **technical expertise in 5G, AI, and cybersecurity is essential**, along with **interdisciplinary knowledge**.	Industry prioritizes **hands-on, problem-solving, and commercial applications**, while policymakers emphasize **policy, regulation, and sustainability literacy**.
Collaboration with Academia	Both call for **stronger university-industry partnerships to bridge skill gaps**.	Industry prefers **internships, certification programs, and co-designed curricula**, while policymakers advocate for **policy incentives, funding programs, and standardized frameworks**.
Sustainability & Green Technologies	Both recognize the **growing importance of sustainability in 5G network design and digital policies**.	Industry sees sustainability as **a secondary priority to technical and market needs**, while policymakers **place sustainability at the core of 5G education and regulatory frameworks**.
Funding & Policy Support	Both acknowledge that **financial and policy support is necessary to modernize university programs**.	Industry wants **faster certification processes and skill development programs**, while policymakers push for **long-term investment in education and incentives for industry engagement**.
Recommendations for Improvement	Both propose **stronger collaboration between universities, industry, and policymakers to align education with workforce needs**.	Industry emphasizes **practical skills training and employability**, while policymakers focus on **creating sustainable policies, funding mechanisms, and regulatory structures to support digital education**.

Table 4 Key similarities and differences (Industry vs. Policymakers)

3.3. Cross-Comparative Insights and Recommendations

Below we provide the main points of cross-comparative insights and recommendations.

Bridging the hands-on learning gap: It is considered crucial by all stakeholders. Educators recognize their own limitations in expertise and acknowledge the need for continuous

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professional development programs to stay updated with the latest advancements. Students, meanwhile, emphasize the need for experiential learning, aligning with industry expectations that favor hands-on skills. Industry stakeholders call for university curricula to incorporate practical exposure through internships and lab-based training, while policymakers should prioritize funding initiatives to support infrastructure development for 5G education.

Interdisciplinary learning: All recognize that it must be strengthened to address the evolving landscape of 5G. Educators advocate for integrating AI, sustainability, and IoT within the curriculum, recognizing the growing intersection of these fields. Students demonstrate a strong interest in interdisciplinary subjects but often lack structured programs that effectively combine these areas. Industry professionals stress the increasing demand for cross-functional knowledge, particularly in AI and cybersecurity, which play integral roles in 5G advancements. Policymakers can support these efforts by developing policy incentives that encourage interdisciplinary training programs at the university level.

Stronger university-industry partnerships: They are necessary to ensure that educational programs remain aligned with industry needs. Educators require structured engagement with industry stakeholders to refine course content and make it more relevant to current job market demands. Students seek greater exposure to real-world 5G applications through direct collaboration with companies, a sentiment echoed by industry professionals who demand job-ready graduates. If provided with appropriate incentives, companies are willing to participate in curriculum development. Policymakers can facilitate these collaborations through regulatory support and targeted funding initiatives.

Sustainability considerations: They are identified as a core component of 5G education. Educators acknowledge the importance of sustainability in 5G applications but struggle with its implementation due to limited resources and expertise. Students are increasingly aware of the environmental impact of 5G technologies but declare that they lack access to structured courses that explore green industrial technologies in-depth. Industry players recognize sustainability as a key trend but prioritize immediate technical skills over long-term environmental considerations. Policymakers, however, emphasize the need for green industrial policies and advocate for integrating sustainability concepts within technical curricula.

Certification and standardization: In 5G education these are vital for ensuring workforce readiness. Educators and students recognize the value of industry-recognized certifications in making graduates more competitive in the job market. Industry professionals emphasize the necessity of global certification standards to ensure consistency in training and skills assessment. Policymakers support the development of standardized certification programs and propose incentives for universities that adopt these credentials, further bridging the gap between academia and industry expectations.

The above analysis reveals that while there is a shared understanding of the importance of 5G education, each stakeholder group approaches it from different perspectives. Educators focus on pedagogical challenges, students on experiential learning, industry on workforce readiness, and policymakers on regulatory frameworks. Addressing these varying concerns through coordinated efforts can significantly enhance the effectiveness of 5G-related education and training programs. By fostering collaboration between academia, industry, and government, stakeholders can ensure that future professionals are well-equipped to navigate

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the evolving 5G landscape, contributing to technological advancement and sustainable development.

The following table provides a **cross-comparison of the main insights from all stakeholders (educators, students, industry professionals, and policymakers)** regarding 5G education, aligning the different perspectives to identify common concerns and areas of divergence.

Key Challenge	Educators' Perspective	Students' Perspective	Industry Perspective	Policymakers' Perspective
Hands-on Learning Gap	Lack of access to **5G testbeds, industry labs, and real-world case studies**.	Desire for **internships, hackathons, and direct access to industry-grade 5G infrastructure**.	Need for graduates with **practical experience in network deployment, AI-driven 5G management, and cybersecurity**.	Universities lack **funding and regulatory support to modernize 5G training environments**.
Interdisciplinary Learning	5G education should integrate **AI, IoT, cybersecurity, and sustainability**, but faculty lack cross-domain expertise.	Students want **flexible, modular courses** that blend **technical and business skills**.	Employers need talent that understands **5G applications across multiple sectors (healthcare, smart cities, green tech)**.	Policymakers emphasize **the need for regulatory, ethical, and sustainability education alongside technical training**.
Stronger University-Industry Partnerships	Universities struggle to **secure long-term collaborations** with telecom and tech companies.	Students feel disconnected from **real-world industry challenges** and have limited exposure to mentors.	Industry sees **academic research as too theoretical** and wants **joint research projects and co-developed curricula**.	Policymakers stress the **importance of public-private partnerships** and propose incentives for industry-academic collaboration.
Sustainability Considerations in 5G	Green industrial technologies in 5G **are not well-integrated into curricula due to**	Students are **highly interested in sustainability** but lack	Industry considers sustainability **important but secondary to**	Policymakers insist that **5G education should prioritize energy-efficient**

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	lack of expertise and materials.	structured courses that focus on **5G energy efficiency**.	**technical and commercial needs**.	**networks and green industrial policies**.
Certification and Standardization	No **common framework** exists to standardize 5G education across institutions.	Students see **certifications as critical for employability** but struggle to access industry-recognized programs.	Industry prefers **certified graduates who meet global 5G workforce standards**.	Policymakers advocate for **EU-wide certification programs to align university training with industry demands**.

Table 5 Cross-comparison of the main insights from all stakeholders

To address the challenges identified in the previous table, the following table summarizes the **recommendations proposed by each stakeholder group.**

Key Challenge	Educators' Recommendations	Students' Recommendations	Industry Recommendations	Policymakers' Recommendations
Hands-on Learning Gap	Establish **5G testbeds, virtual labs, and industry-led case studies**.	Increase access to **internships, real-world projects, and industry mentorship programs**.	Create **work-study models where students gain real-world experience in network operations**.	Provide **funding for universities to develop state-of-the-art 5G labs and simulation environments**.
Interdisciplinary Learning	Develop **cross-domain courses combining AI, IoT, and cybersecurity with 5G**.	Offer **flexible, modular programs that allow students to specialize in different 5G applications**.	Encourage universities to teach **business and regulatory aspects alongside technical skills**.	Introduce **national guidelines promoting interdisciplinary training in 5G education**.
Stronger University-Industry Partnerships	Establish **co-designed courses and faculty exchange programs with industry**.	Create more **student-industry networking opportunities, guest lectures, and company-**	Build **structured internship pipelines and research collaborations** with universities.	Provide **tax incentives and grants for businesses that partner with universities**.

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		sponsored projects.		
Sustainability Considerations in 5G	Train faculty on **energy-efficient 5G networks and green ICT applications**.	Integrate **sustainability modules into technical 5G courses**.	Encourage **sustainable network design and carbon footprint reduction strategies** in education.	Require universities to **embed sustainability into all digital transformation curricula**.
Certification and Standardization	Develop **recognized 5G certification programs in collaboration with industry**.	Offer **affordable certification pathways for students to gain industry-recognized credentials**.	Support **global 5G workforce standardization to ensure graduates meet employer expectations**.	Implement **EU-level policies for unified 5G education standards**.

Table 6 Recommendations proposed by each stakeholder group

4. Bridging the Skills Gap: Analysis of Interviews Responses

In total, 59 participants replied to the structured interview questions. More specifically, **17 educators, 18 students, 17 industry professionals, and 7 policymakers**. They all had diverse backgrounds, roles, and expertise, combining different points of view.

4.1. Educators

University educators provided valuable insights into the role of 5G networks and green industrial technologies in higher education, highlighting the need for curriculum advancements, interdisciplinary learning, and stronger industry collaboration. While some institutions have made progress in integrating 5G topics into their teaching, many educators identify significant gaps in hands-on experience, research infrastructure, and student engagement with these emerging fields. As the demand for professionals skilled in 5G and sustainability grows, universities must address these challenges to better prepare students for the evolving job market.

4.1.1. The Importance of 5G and Green Industrial Technologies in Higher Education

Educators across various disciplines acknowledge the transformative impact of 5G technology on industries such as telecommunications, logistics, healthcare, and smart cities. Faculty members in engineering and ICT-related fields are particularly well-acquainted with the technical advancements of 5G, incorporating it into their courses on wireless communication, network design, and digital transformation. However, educators in business, supply chain management,

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and environmental studies, while recognizing 5G's relevance, have had less exposure to its technical aspects.

The integration of 5G into university curricula is seen as essential for preparing students for future careers. Many educators stress that high-speed, low-latency connectivity will create opportunities in network engineering, AI-driven automation, edge computing, and energy-efficient communication systems. The demand for professionals who understand 5G's applications is expected to rise as industries increasingly rely on real-time data processing and AI-powered network management. Additionally, green industrial technologies, which focus on sustainability and energy-efficient solutions, are seen as critical to reducing the environmental impact of modern digital infrastructure. Some educators argue that exposing students to sustainability-focused 5G applications—such as smart grids, renewable energy integration, and eco-friendly network hardware—will equip them with the skills to build more sustainable technological ecosystems.

Despite widespread agreement on the importance of 5G and green industrial technologies, several educators note that these subjects are often introduced only at the postgraduate level, leaving undergraduate students with limited exposure. This creates a gap in foundational knowledge that could hinder students from developing expertise early in their academic journeys. Some faculty members also point out that many students remain unaware of career opportunities related to 5G, leading to a lack of interest compared to more popular fields such as artificial intelligence and cybersecurity.

4.1.2. Challenges in Integrating 5G and Green Technologies into University Curricula

While universities are making efforts to incorporate 5G topics into existing programs, many educators cite significant barriers to full integration. One of the primary challenges is the **lack of access to 5G infrastructure and laboratory facilities**. Unlike software-based fields, which can be taught through simulations and coding exercises, 5G requires specialized hardware, spectrum testing equipment, and network deployment tools. Many institutions do not have the financial resources to build dedicated 5G labs, making it difficult to provide students with hands-on learning experiences.

Another major obstacle is the **fast-paced nature of technological advancements**. The field of 5G is evolving rapidly, with research already progressing toward 6G networks. This makes it challenging for educators to keep up with the latest developments and update their teaching materials accordingly. Several faculty members mention that they struggle to stay informed due to limited access to professional development programs, industry conferences, and standardization bodies such as ITU and IEEE.

Additionally, **declining student interest in telecommunications and networking** poses a challenge for educators trying to promote 5G-related courses. Many students are drawn to fields such as AI, machine learning, and cybersecurity, perceiving them as more lucrative and cutting-edge. To address this, some educators advocate for a more interdisciplinary approach that connects 5G education with emerging fields like AI-driven network automation, IoT integration, and cybersecurity for 5G networks.

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The **integration of green industrial technologies** into 5G education also faces hurdles. While sustainability is a growing concern across industries, many educators note that current curricula do not sufficiently cover energy-efficient network infrastructure, low-power communication systems, and renewable energy applications in 5G networks. Some faculty members emphasize the need to develop specialized courses that focus on the environmental impact of 5G and how engineers can design sustainable networks using techniques such as energy-aware network slicing and AI-optimized resource allocation.

4.1.3. Skills and Competencies Required for 5G-Related Careers

Educators emphasize that students pursuing careers in 5G-related fields need a combination of technical, interdisciplinary, and soft skills. On the technical side, **network design, spectrum management, AI-powered network automation, and edge computing** are seen as crucial competencies. As 5G networks become more software-defined, students must also gain expertise in network softwarization, virtualization, and cloud-native architectures. Faculty members stress that cybersecurity knowledge is equally important, given the vulnerabilities associated with large-scale 5G deployments.

Beyond technical expertise, educators highlight the importance of **problem-solving, critical thinking, teamwork, and business acumen**. As 5G becomes deeply integrated into industries beyond telecommunications, students will need to work in interdisciplinary teams that combine engineering, business strategy, and regulatory compliance. Communication skills are also emphasized, as graduates will need to articulate complex technological concepts to both technical and non-technical stakeholders.

In terms of sustainability, educators argue that students should be trained in **energy-efficient network design, renewable energy integration, and environmental impact assessments** for digital infrastructure. Understanding how to optimize power consumption in base stations, data centers, and connected devices will be key to making 5G networks more sustainable.

4.1.4. Industry Collaboration and Hands-On Learning Opportunities

One of the most frequently mentioned solutions for improving 5G education is **strengthening collaboration between universities and industry**. Many educators believe that academic institutions should work more closely with telecom companies, network equipment providers, and regulatory bodies to provide students with real-world learning opportunities. Several suggest that universities should establish **internship programs, industry-led research projects, and guest lecture series** featuring professionals from the telecommunications sector.

A few educators highlight successful models where universities have partnered with companies to develop **5G testbeds**, allowing students to experiment with real network deployments. Such initiatives provide hands-on experience that is currently lacking in most programs. Some also advocate for **certification programs in 5G technologies**, developed in collaboration with industry leaders, to enhance students' employability.

Apart from infrastructure challenges, educators stress that **curricula need to be continuously updated** to reflect the latest advancements in 5G and green industrial technologies. They propose adopting **modular and interdisciplinary course structures**, where students can choose electives that align with their career interests, whether in engineering, business, or sustainability.

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Some also suggest incorporating **problem-based learning approaches**, where students tackle real-world case studies on 5G network deployment, energy efficiency, and digital transformation strategies.

4.1.5. Long-Term Strategies for 5G and Green Technology Education

Looking ahead, educators believe that universities must take a proactive approach to stay at the forefront of 5G education. A key recommendation is **investing in faculty training and continuous professional development**. Universities should facilitate access to international conferences, research collaborations, and certification programs that help educators stay updated on the latest 5G advancements.

Another long-term strategy involves **establishing dedicated research centers and innovation hubs** focused on 5G and sustainable digital technologies. These centers could serve as incubators for new ideas, bringing together students, researchers, and industry partners to work on cutting-edge projects. Universities are also encouraged to promote **lifelong learning programs**, offering micro-credentials and online courses that allow professionals to upskill as 5G technology continues to evolve.

Additionally, several educators stress the **importance of policy support and institutional investment**. Universities need funding to develop modern lab facilities, participate in global 5G standardization efforts, and attract top talent in telecommunications and sustainability research. Policymakers can play a crucial role by incentivizing academia-industry collaborations, supporting public-private research initiatives, and integrating 5G education into national digital strategies.

4.1.6. Final words

University educators widely recognize the importance of 5G and green industrial technologies in shaping the future workforce. However, challenges such as resource constraints, curriculum gaps, and limited industry engagement hinder the full realization of 5G's educational potential. To bridge these gaps, universities must adopt a more interdisciplinary, hands-on, and industry-driven approach, ensuring that students not only understand 5G's technical foundations but also its real-world applications and sustainability implications. Through strengthened collaborations, updated curricula, and investment in research infrastructure, higher education institutions can better equip students with the knowledge and skills needed to thrive in the digital economy.

The following summary table provides a structured synthesis of educators' perspectives on 5G education, based on the previous subsections. It categorizes their insights into **three key dimensions**: the **current situation and challenges**, the **improvements they propose**, and the **strategies they recommend for long-term curriculum development**. This structured overview helps align their perspectives with actionable solutions to improve 5G education in universities.

Section	Current Situation & Challenges	Proposed Improvements	Future Strategies
The Importance of 5G and Green	Educators recognize the **transformative**	Introduce **5G awareness programs**	Establish **dedicated 5G and sustainability**

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Industrial Technologies in Higher Education	**impact of 5G** in multiple industries, but **undergraduate education lacks foundational 5G courses**. Green Industrial Technologies are **not well-integrated into curricula**.	**at the undergraduate level** and integrate sustainability into existing technical courses.	**research centers** to drive interdisciplinary innovation.
Challenges in Integrating 5G and Green Technologies into University Curricula	Universities **lack the infrastructure (labs, testbeds) and faculty expertise** to keep up with rapid 5G advancements. Curriculum updates are slow, and students are more attracted to **AI and cybersecurity** than 5G.	Develop **faculty training programs** in partnership with industry and provide **financial support** for upgrading lab facilities.	Design **flexible, modular courses** combining 5G with AI, IoT, and sustainability, ensuring **continuous updates based on industry trends**.
Skills and Competencies Required for 5G-Related Careers	Students are graduating without **practical experience** in 5G technologies. The **demand for interdisciplinary skills** is increasing, but **few courses cover business and sustainability aspects** of 5G.	Introduce **project-based learning** to develop **technical (network design, AI-driven automation) and soft skills (problem-solving, business acumen)**.	Implement **industry-recognized certification programs** that validate expertise in **technical and interdisciplinary 5G applications**.
Industry Collaboration and Hands-On Learning Opportunities	University-industry collaboration is **limited**, making it difficult for students to gain real-world exposure. Many universities lack **internship agreements or company-sponsored projects**.	Expand **internship programs, joint research projects, and guest lectures** led by industry professionals.	Establish **long-term partnerships with telecom companies**, ensuring **continuous knowledge transfer and skill alignment**.

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Long-Term Strategies for 5G and Green Technology Education	Current **teaching methodologies rely too much on theory** and do not encourage **lifelong learning**. Faculty members struggle to stay updated.	Promote **problem-based learning (PBL)** and interdisciplinary teaching models. Provide **incentives for faculty upskilling** in 5G-related domains.	Develop **lifelong learning pathways**, including **micro-credentials and professional development courses** tailored to the evolving 5G ecosystem.

Table 7 Summary of educators' perspectives on 5G education

4.2. Students

The responses gathered from university students across different academic backgrounds reveal valuable insights into their awareness, learning preferences, skill expectations, and perceived gaps in their education regarding 5G networks. While students studying technical fields such as Telecommunications, Electrical Engineering, and AI tend to have a deeper understanding of 5G applications, students from business, law, and public administration backgrounds demonstrate a growing interest in its broader implications. Despite the high level of enthusiasm for learning about 5G, there are recurring concerns regarding a lack of practical exposure and industry engagement in university curricula.

4.2.1. General Awareness and Interest in 5G Technology

Most students recognize the transformative potential of 5G technology across various industries. Those in engineering-related fields have a strong grasp of the technical foundations of 5G, particularly in its role in IoT applications, AI integration, and smart city development. Some students, especially those in telecommunications and digital systems, are familiar with specific aspects of 5G networks, such as network design, security protocols, and latency optimization.

Students highlight several aspects of 5G technology that excite them, including its high-speed connectivity, ultra-low latency, and ability to support massive IoT ecosystems. Many express enthusiasm for the role of 5G in automation, particularly in manufacturing, healthcare, and real-time positioning systems. They see opportunities for integrating AI into network optimization, predicting demand, and automating network management.

However, students from non-technical disciplines, such as business, political science, and law, demonstrate a limited understanding of 5G's technical functions. They tend to view 5G in the context of broader applications, such as digital transformation, cybersecurity, and smart infrastructure. Some business students are particularly interested in how 5G can reshape industries such as logistics, retail, and finance, while law students focus on its implications for cybersecurity, data privacy, and ethical concerns surrounding digital governance.

Overall, while students from technical disciplines have a deeper technical understanding, there is universal recognition of 5G's potential impact across various industries. However, there is also a consensus that universities do not provide enough structured learning opportunities to fully prepare students for careers involving 5G technologies.

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4.2.2. Educational Gaps and Learning Needs

One of the most significant themes that emerged from the responses is the gap between theoretical education and practical application. While universities provide a basic foundation in wireless communication principles, many students feel that there is insufficient emphasis on real-world applications of 5G. This issue is particularly evident in engineering and ICT programs, where students are introduced to digital communication concepts but lack hands-on experience with 5G-specific applications.

Students from mechanical engineering and AI backgrounds stress the importance of interdisciplinary learning, noting that 5G's real impact will come from its integration with fields like AI, cybersecurity, and sustainable technology. They emphasize the need for more structured learning pathways that explore how 5G can be used in industrial automation, predictive analytics, and energy-efficient operations.

Business and law students highlight a different concern: the near absence of 5G-related topics in their courses. While digital transformation and IoT are occasionally mentioned, there are few, if any, dedicated modules exploring the economic, legal, and strategic implications of 5G. Some students suggest that universities should introduce courses on how 5G can be leveraged in business models, supply chain optimization, and digital marketing. Law students also argue that courses should delve deeper into regulatory frameworks governing 5G networks, particularly in areas such as data security, surveillance, and competition law.

A common sentiment across all fields is the need for a stronger focus on sustainability in 5G education. While some students acknowledge that 5G can contribute to greener industrial processes, they note that discussions on energy efficiency, environmental impact, and sustainable network design are largely absent from their coursework. They suggest that universities should integrate more content on energy-saving techniques, such as low-power network infrastructure and AI-driven optimization for reduced energy consumption.

4.2.3. Preferred Learning Methods and Hands-On Experience

When asked about their preferred learning methods, students overwhelmingly favor practical, hands-on experiences over purely theoretical instruction. Many express frustration with the lack of real-world exposure to 5G applications, stating that traditional lectures do not sufficiently prepare them for industry demands.

Students suggest that universities should prioritize the following approaches to enhance 5G education:

1. **Industry Collaborations:** Many students advocate for greater collaboration between universities and industry partners. They believe that guest lectures from professionals, industry-sponsored projects, and direct engagement with 5G-enabled businesses would provide valuable insights and practical exposure.
2. **Internships and Research Projects:** A significant number of students stress the importance of internships and research opportunities in 5G-related fields. They argue that real-world projects would allow them to develop critical problem-solving skills and gain hands-on experience in network deployment, cybersecurity, and AI integration.

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3. **Simulation and Prototyping Labs:** Several students suggest that universities should invest in lab environments where they can experiment with 5G-enabled technologies. For example, they propose setting up testbed environments to measure network performance in smart cities, manufacturing, or healthcare applications.

4. **Hackathons and Case Studies:** Some students recommend introducing hackathons focused on 5G-related problem-solving, where interdisciplinary teams collaborate to design and test innovative solutions. Others propose using real-world case studies to analyze how 5G is being deployed in different industries.

5. **Cross-Disciplinary Learning:** Given 5G's impact across various fields, students suggest that universities should offer interdisciplinary courses that combine technical, business, and policy perspectives. For example, an AI student could benefit from understanding network security challenges, while a business student could learn how 5G enhances supply chain visibility.

4.2.4. Expectations from Universities and Career Aspirations

Many students express concern that their universities are not adequately preparing them for careers in 5G-related fields. While they appreciate the foundational knowledge they receive, they believe that their institutions should offer more structured career support, including:

- **Certification Programs:** Students argue that universities should introduce certifications in 5G technologies, which could help bridge the gap between academic learning and industry requirements. Certifications in areas such as AI-driven 5G networks, cybersecurity in 5G, and IoT applications could provide a competitive edge in the job market.

- **Career Guidance and Mentorship:** Many students feel that career counseling services should be more aligned with emerging technology trends. They suggest that universities should facilitate mentorship programs where students can connect with industry professionals working in 5G-related roles.

- **International Collaboration:** A number of students highlight the importance of international exposure in understanding global trends in 5G development. They believe that cross-university collaborations, exchange programs, and international research partnerships would help them stay updated with cutting-edge advancements.

In terms of career aspirations, students recognize that 5G knowledge will provide a competitive advantage in various roles, particularly in telecommunications, AI automation, smart city planning, and industrial digitalization. Business students see opportunities in 5G-driven digital transformation, while law students acknowledge its growing relevance in cybersecurity and regulatory compliance.

4.2.5. Final words

The survey responses indicate a strong recognition of the importance of 5G technology among university students but also highlight significant gaps in education and hands-on training. While students from engineering and ICT backgrounds have a relatively solid foundation in wireless communication, they often lack practical exposure to 5G-specific

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applications. Students from business, law, and public policy fields, on the other hand, acknowledge 5G's importance but feel that their programs do not provide sufficient focus on its economic, regulatory, and strategic implications.

To address these gaps, universities must adopt a more interdisciplinary and hands-on approach to 5G education. Greater industry collaboration, practical training opportunities, and specialized certification programs would help students develop the skills they need to succeed in 5G-related careers. By doing so, universities can ensure that graduates are not only knowledgeable about 5G but also equipped to drive innovation and address real-world challenges in a rapidly evolving digital landscape.

The following summary table presents a structured synthesis of university students' perspectives on 5G education, derived from the insights discussed in the previous subsections.

Section	Current Situation & Challenges	Proposed Improvements	Future Strategies
General Awareness and Interest in 5G Technology	High enthusiasm for 5G and its applications, particularly among students in technical fields. However, students from business, law, and public administration backgrounds have limited technical understanding.	Introduce interdisciplinary 5G awareness programs to cater to both technical and non-technical students.	Develop cross-disciplinary courses integrating business, policy, and technical aspects of 5G.
Educational Gaps and Learning Needs	Students feel their university curricula lack hands-on training, interdisciplinary learning, and industry engagement. Business and law students report minimal exposure to 5G-related topics.	Expand course offerings to include sustainability, digital transformation, and legal aspects of 5G. Incorporate project-based learning to address practical knowledge gaps.	Encourage universities to establish flexible, modular curricula that evolve with 5G advancements and workforce demands.
Preferred Learning Methods and Hands-On Experience	Strong preference for experiential learning, but universities rely heavily on theoretical instruction. Limited access to 5G testbeds and industry-sponsored projects.	Increase industry collaborations through internships, guest lectures, and research partnerships. Provide hands-on training with real-world case	Establish dedicated 5G innovation hubs and digital twin simulations for students to experiment with 5G applications.

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		studies and lab environments.	
Expectations from Universities and Career Aspirations	Students feel unprepared for 5G careers due to a lack of structured career guidance and certification programs. Interest in 5G-related job opportunities is high but lacks institutional support.	Introduce career-oriented initiatives, such as 5G certification programs and mentorship opportunities with industry professionals.	Promote international collaboration programs and global research initiatives to expose students to cutting-edge 5G innovations.

Table 8 Summary of students' perspectives on 5G education

4.3. Industry

The perspectives of industry professionals on 5G education and green industrial technologies provide valuable insights into the evolving workforce needs, the gaps in university curricula, and the necessary steps to prepare students for careers in these fields. Representatives from telecommunications, software development, IoT, and network equipment manufacturing emphasize that while universities provide strong theoretical foundations, they often lack practical, hands-on training and interdisciplinary knowledge. This gap has a direct impact on companies' ability to find well-prepared graduates, innovate, and scale 5G-related projects.

4.3.1. The Growing Importance of 5G and Green Industrial Technologies

Industry professionals unanimously agree that 5G technology is becoming increasingly important across multiple sectors, including telecommunications, industrial automation, smart cities, healthcare, and fintech. The ability of 5G networks to support ultra-low latency, high-speed connectivity, and massive IoT deployments has created a surge in demand for skilled professionals. The representatives highlight that beyond telecommunications, expertise in 5G is now required in roles such as cloud engineering, AI development, product management, and sustainability analysis.

Alongside 5G, green industrial technologies are gaining traction as companies seek to reduce their environmental footprint. Sustainability in 5G infrastructure involves optimizing energy efficiency, reducing emissions from network operations, and developing low-power IoT systems. Industry leaders stress the importance of training future professionals to understand the relationship between 5G technology and energy efficiency. They note that skills in network performance optimization, AI-driven resource allocation, and energy-efficient hardware development will be crucial for ensuring sustainable 5G deployment.

4.3.2. Current Challenges in Workforce Readiness

Despite the growing relevance of 5G, industry professionals express concern over the lack of skilled graduates ready to enter the workforce. A major issue they identify is the **gap between theoretical knowledge and practical application**. Many graduates are well-versed in networking concepts but lack real-world experience in 5G network design,

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optimization, and security. Companies often find that new hires require extensive training before they can contribute effectively to 5G projects.

Another significant challenge is the lack of interdisciplinary expertise. Industry leaders emphasize that 5G professionals must possess a combination of technical, business, and regulatory knowledge. Many graduates struggle to navigate the business aspects of 5G, such as cost modeling, policy compliance, and market strategy. Some companies report difficulties in finding candidates who can bridge the gap between technology and business strategy, which is essential for roles in product management, technical sales, and regulatory affairs.

Industry professionals also highlight that AI and automation are becoming essential components of 5G networks. The shift toward software-defined networks, AI-driven network optimization, and predictive analytics means that professionals need programming skills and an understanding of machine learning applications in telecommunications. Graduates who lack exposure to AI-driven network management and automation tools often struggle to meet the industry's expectations.

4.3.3. The Role of Hands-On Training and Industry Collaboration

One of the most frequently cited solutions for addressing workforce readiness challenges is **increasing hands-on training opportunities in university programs**. Industry representatives stressed the importance of lab-based learning, simulations, and project-based courses that allow students to work with real 5G network components. Some companies suggest that universities should invest in 5G testbeds where students can gain experience in network deployment, configuration, and troubleshooting.

Internships and industry collaborations are also seen as critical for preparing students for real-world challenges. Many industry leaders express a willingness to partner with universities through joint research initiatives, mentorship programs, and guest lectures. However, some note that **current university-industry collaborations are not as effective as they could be**. In many cases, partnerships remain limited to theoretical discussions rather than providing students with meaningful, hands-on experiences.

Some industry professionals believe that **certification programs** could help bridge the skills gap. By offering industry-recognized certifications in areas such as 5G network security, AI-driven network automation, and green telecommunications, universities could enhance graduates' employability. These certifications could be developed in partnership with telecom companies and standards organizations to ensure alignment with industry needs.

4.3.4. Key Skills and Emerging Trends in 5G and Green Technologies

Industry representatives highlight several critical technical skills that graduates need to succeed in 5G-related roles. These include:

- **Network Architecture & Spectrum Management** – A deep understanding of how 5G networks are structured, including radio access networks, core networks, and spectrum allocation.

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- **Edge Computing & IoT Integration** – Knowledge of how 5G enables real-time data processing and IoT applications, which is crucial for industrial automation and smart cities.
- **AI & Machine Learning for Network Optimization** – AI is increasingly used to enhance network efficiency, predict failures, and automate performance tuning.
- **Cybersecurity in 5G** – Understanding the security vulnerabilities of 5G networks, including encryption, authentication, and threat detection.
- **Energy-Efficient Network Design** – Skills in designing power-efficient base stations, optimizing network energy consumption, and integrating renewable energy sources into 5G infrastructure.

Beyond technical expertise, industry leaders emphasize the **importance of soft skills** such as problem-solving, adaptability, and cross-disciplinary collaboration. Many professionals stress that working in 5G requires the ability to communicate complex technical concepts to non-technical stakeholders, making **business acumen and regulatory knowledge** valuable assets.

4.3.5. Bridging the Gap Between Academia and Industry

A recurring theme in industry interviews is the need for **closer collaboration between universities and the private sector**. While some organizations already engage in research partnerships, others note that academia needs to be more proactive in aligning curricula with industry demands. Several professionals suggest that universities should:

- **Offer multidisciplinary courses** that combine technical knowledge with business and regulatory aspects.
- **Encourage more project-based learning** and case studies based on real-world 5G deployment challenges.
- **Expand internship and apprenticeship programs** in collaboration with industry partners.
- **Regularly update curricula** to keep pace with technological advancements in 5G and sustainability.

Some industry representatives advocate for the **establishment of industry-academic innovation hubs** where students, researchers, and professionals can collaborate on cutting-edge 5G applications. These hubs could facilitate knowledge exchange and accelerate the development of new solutions for energy-efficient network management, AI-driven optimizations, and next-generation connectivity.

4.3.6. Future Outlook: The Evolution of 5G and Its Workforce Implications

Looking ahead, industry professionals predict that **5G will continue evolving toward greater automation, sustainability, and AI integration**. The transition to **6G networks** is already on the horizon, and future professionals will need to be equipped with skills in AI-powered network orchestration, quantum networking, and ultra-low-power communication technologies.

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Additionally, **private 5G networks are expected to play a larger role in industrial automation**, particularly in manufacturing, logistics, and healthcare. Universities must prepare students to work in specialized environments where 5G is integrated with robotics, IoT, and AI-driven decision-making.

As sustainability becomes a global priority, industry leaders emphasize that **future 5G professionals must be trained in green industrial technologies**. This includes expertise in carbon footprint analysis, sustainable network hardware design, and energy-efficient data transmission. Graduates who understand how to balance network performance with environmental responsibility will be in high demand.

4.3.7. Final words

Industry professionals widely recognize the importance of 5G and green industrial technologies, but they also stress that current university programs do not fully prepare students for the demands of the workforce. While universities provide strong theoretical foundations, there is a pressing need for **more hands-on training, interdisciplinary education, and stronger industry collaborations**.

To close the skills gap, universities should **expand internship opportunities, invest in 5G testbeds, introduce certification programs, and incorporate sustainability into their curricula**. By fostering closer ties with industry partners and adapting their programs to the rapidly changing technological landscape, academic institutions can ensure that graduates are well-equipped to drive innovation in 5G and beyond.

The table below summarizes industry insights on 5G education, focusing on **challenges, improvements, and future strategies**. It highlights key areas such as **workforce readiness, hands-on training, industry collaboration, and emerging skills** to align academic programs with industry needs.

Section	Current Situation & Challenges	Proposed Improvements	Future Strategies
The Growing Importance of 5G and Green Industrial Technologies	5G is expanding into **telecom, smart cities, and healthcare**, but **sustainability expertise is lacking**.	Introduce **5G + sustainability training** and promote **eco-friendly network design**.	Establish **research centers** focusing on **green 5G technologies**.
Current Challenges in Workforce Readiness	Graduates **lack practical experience** in 5G deployment, AI, and cybersecurity. **Interdisciplinary skills are underdeveloped**.	Expand **internships, hands-on labs, and interdisciplinary training**.	Implement **continuous learning programs** to keep skills updated.

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The Role of Hands-On Training and Industry Collaboration	**Few universities have access to 5G testbeds** or structured industry collaboration.	Strengthen **industry-academic partnerships, co-designed curricula, and simulation environments**.	Develop **long-term alliances** to keep curricula aligned with industry needs.
Key Skills and Emerging Trends in 5G and Green Technologies	High demand for **technical (AI, cybersecurity) and business (regulation, strategy) skills**, but **graduates are underprepared**.	Introduce **skill-based certifications** and **expand business-integrated 5G training**.	Implement **adaptive curricula** that evolve with **emerging technologies**.
Bridging the Gap Between Academia and Industry	Universities **struggle to adapt** to fast-paced 5G changes. **Industry collaboration is limited**.	Develop **co-created courses, structured apprenticeships, and joint research**.	Establish **joint innovation labs** between universities and telecom firms.
Future Outlook: The Evolution of 5G and Its Workforce Implications	The 5G workforce must prepare for **private networks, AI-driven automation, and sustainability**	Expand **lifelong learning pathways** for continuous 5G upskilling.	Position universities as **hubs for next-gen digital innovation and 6G research**.

Table 9 Summary of industry's perspectives on 5G education

4.4. Policymakers

Policymakers from various regions and institutions have provided valuable insights into the role of 5G technology in economic growth, its integration into university curricula, and the policies needed to bridge the skills gap in this field. Across different countries and agencies, there is a shared recognition that 5G is a transformative technology with applications across multiple industries, including healthcare, manufacturing, smart cities, and environmental sustainability. However, there is also a consensus that universities are not fully prepared to equip students with the necessary skills to meet the growing demand for expertise in 5G and green industrial technologies.

4.4.1. The Importance of 5G in Economic and Technological Development

Policymakers broadly agree that 5G technology is critical for economic growth and digital transformation. The European Innovation Council, for example, highlights that global economic activity is increasingly dependent on electronic infrastructures, with 5G serving as a key enabler of cross-border transactions and international business expansion. By enhancing connectivity, reducing latency, and improving network efficiency, 5G opens up new opportunities for industries ranging from telecommunications to artificial intelligence and the IoT.

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Beyond economic benefits, 5G is also seen as a driver of innovation and industrial competitiveness. The ability to process vast amounts of real-time data is particularly beneficial for healthcare, where applications like telemedicine, connected medical devices, and remote surgeries are becoming more feasible. Similarly, in smart cities, 5G is crucial for managing urban infrastructure, optimizing traffic flow, and enabling efficient energy consumption. Additionally, environmental technologies, such as smart grids and sustainable energy solutions, stand to benefit significantly from the adoption of 5G, as high-speed connectivity allows for real-time monitoring and optimization of energy consumption.

While policymakers acknowledge the transformative potential of 5G, they also stress the need for universities to align their educational programs with emerging technological trends. Without a concerted effort to develop expertise in 5G-related fields, there is a risk that industries will struggle to find qualified professionals, slowing down technological progress.

4.4.2. The Role of Green Industrial Technologies in 5G Development

The integration of green industrial technologies into university curricula is viewed as equally important as 5G itself. Several policymakers highlight the need for sustainable approaches to digital infrastructure, particularly as 5G networks require substantial energy consumption. One major area of concern is the environmental footprint of 5G base stations and network components, which policymakers argue must be optimized for energy efficiency.

Green industrial technologies can play a significant role in reducing carbon emissions and improving energy efficiency in telecommunications. One approach is the implementation of AI-driven resource allocation, which enables networks to dynamically adjust power consumption based on demand. Additionally, integrating renewable energy sources into 5G infrastructure—such as using solar-powered base stations—can contribute to sustainability goals. Some policymakers advocate for dedicated research initiatives focused on making 5G deployment more environmentally friendly, emphasizing that universities should train students to develop energy-efficient network solutions.

4.4.3. Gaps in University Education and the Need for Practical Training

A common concern among policymakers is that **universities are not adequately preparing students for careers in 5G-related fields**. While some institutions have made progress in incorporating digital skills training, many still lack **practical, hands-on experiences** that are essential for workforce readiness.

One significant gap is theoretical-heavy curricula that do not provide students with opportunities to work with real 5G infrastructure. Policymakers emphasize the need for universities to establish 5G testbeds and simulation labs where students can gain experience in deploying, troubleshooting, and optimizing networks. Without direct exposure to 5G technologies, graduates often enter the workforce without the necessary skills to meet industry demands.

Additionally, policymakers note that interdisciplinary education is crucial for the future workforce. Beyond engineering and telecommunications, 5G impacts business strategy, law, public policy, and environmental sustainability. Universities must, therefore, develop cross-disciplinary programs that equip students with both technical expertise and business acumen.

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Another critical issue is regional disparities in access to 5G education. Policymakers from rural regions stress that while urban universities may have access to advanced technological resources, students in rural areas often lack exposure to cutting-edge digital technologies. Without targeted funding and policies to bridge this gap, rural communities may struggle to keep pace with technological advancements, exacerbating economic inequalities.

Key Skills in Demand for 5G and Green Technologies

Policymakers identify several **key skill areas** that universities should prioritize in their curricula:

- **Network Architecture & Spectrum Management** – Understanding the design and optimization of 5G networks.
- **IoT Integration & Edge Computing** – Developing solutions that leverage real-time data processing at the network edge.
- **AI & Machine Learning for Network Optimization** – Using AI to enhance network efficiency and predictive maintenance.
- **Cybersecurity for 5G** – Addressing security vulnerabilities in 5G networks, particularly in IoT and cloud applications.
- **Sustainable Network Design** – Implementing energy-efficient 5G infrastructure and integrating renewable energy solutions.

Beyond technical expertise, policymakers also emphasize the need for **problem-solving, adaptability, and collaboration skills**. As 5G adoption expands across industries, professionals will need to **work in cross-functional teams**, combining engineering knowledge with insights from business, law, and public policy.

4.4.4. The Role of Public-Private Partnerships in Skills Development

One of the most frequently cited recommendations from policymakers is the need for **stronger collaboration between universities and industry**. Many policymakers argue that **public-private partnerships** can play a key role in addressing the skills gap by providing students with **real-world learning opportunities**.

Internships, research collaborations, and joint training programs with telecommunications companies are seen as essential for bridging the gap between academia and industry. Several policymakers point to successful initiatives where universities have partnered with private companies to develop applied research projects and training programs. For example, Pre-Commercial Procurement (PCP) models have been used in Europe to fund collaborative R&D efforts that align with industry needs.

Additionally, policymakers stress that government funding should prioritize university-industry partnerships. By offering financial incentives for universities to engage with businesses, governments can accelerate the development of industry-relevant curricula and ensure that graduates have access to the latest technological advancements.

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4.4.5. Long-Term Policy Strategies for Workforce Readiness

To sustain a workforce skilled in 5G and green industrial technologies, policymakers outline several long-term strategies:

1. **Investing in Digital Education Programs** – Expanding government-funded training initiatives focused on 5G, AI, and sustainable technology.
2. **Updating University Curricula** – Encouraging universities to integrate interdisciplinary courses that combine technology, business, and environmental sustainability.
3. **Promoting Lifelong Learning** – Establishing reskilling and upskilling programs to ensure that professionals remain competitive in the rapidly evolving 5G landscape.
4. **Fostering International Collaboration** – Strengthening global partnerships to facilitate knowledge exchange and joint research in 5G and sustainability.

4.4.6. Final words

Policymakers emphasize that **5G education is not just a technological issue but a broader economic and societal challenge**. The successful integration of 5G and green industrial technologies into university programs requires **a coordinated effort between academia, industry, and government**. While universities provide foundational knowledge, they must also **prioritize practical training, interdisciplinary learning, and industry collaboration** to fully prepare students for the demands of the future workforce. By implementing targeted policies, funding mechanisms, and public-private partnerships, governments can help ensure that students graduate with the skills necessary to drive innovation, economic growth, and sustainability in the 5G era.

This table summarizes policymakers' views on **5G education**, focusing on **challenges, improvements, and long-term strategies** to align policies with industry needs and digital transformation goals.

Section	Current Situation & Challenges	Proposed Improvements	Future Strategies
The Importance of 5G in Economic and Technological Development	Policymakers recognize **5G as a key driver of digital transformation and industrial competitiveness** but note **misalignment between university programs and market needs**.	Encourage **universities to integrate emerging 5G applications** (smart cities, AI-driven industries) into curricula.	Develop **national 5G workforce roadmaps** aligned with digital and economic strategies.
The Role of Green Industrial	Sustainability is **a priority**, but universities lack	Introduce **green technology modules** in engineering and	Support **research initiatives on sustainable 5G**

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Technologies in 5G Development	**courses on energy-efficient networks and digital sustainability**.	business courses. Promote **eco-friendly 5G network design**.	**solutions**, integrating **AI and renewable energy**.
Gaps in University Education and the Need for Practical Training	Many programs remain **too theoretical, lacking hands-on experience with real 5G infrastructure**. Limited industry collaboration hinders workforce readiness.	Fund **university-based 5G testbeds, simulation labs, and applied research projects**.	Standardize **practical training models** across institutions to ensure **consistent 5G skill development**.
The Role of Public-Private Partnerships in Skills Development	**Collaboration between academia and industry is fragmented**, reducing access to **internships, industry projects, and mentorship programs**.	Expand **government incentives** for industry-academic partnerships, including **joint research, co-designed curricula, and work-based learning programs**.	Establish **national centers of excellence in 5G education**, fostering long-term **university-industry-government cooperation**.
Long-Term Policy Strategies for Workforce Readiness	A **lack of policy coordination and funding for lifelong learning** limits workforce adaptability to **5G advancements**.	Invest in **lifelong learning programs, micro-credentials, and global certification frameworks**	Promote **international cooperation** for 5G education and workforce mobility across Europe and beyond.

Table 10 Summary of policymakers' perspectives on 5G education

5. Conclusions and future steps

In the context of task T2.1, 5G-DiGITs has conducted an extensive needs assessment to evaluate the preparedness of universities in delivering education on Beyond 5G (B5G) and green industrial technologies. By gathering insights from educators, students, industry professionals, and policymakers, this report highlights the existing gaps in skills development, interdisciplinary education, and industry collaboration while also providing a roadmap for addressing these challenges.

Across all stakeholder groups, one of the most prominent findings is the gap between theoretical knowledge and practical application. Educators recognize the need to integrate 5G, AI, IoT, and sustainability into curricula, yet many universities lack sufficient laboratory facilities, testbeds, and industry partnerships to provide students with hands-on experience. Many faculty members also struggle to keep pace with the rapid evolution of 5G

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technologies, citing limited access to updated teaching resources and professional development opportunities. Without these, integrating cutting-edge advancements into coursework remains difficult.

Students, on the other hand, express strong enthusiasm for learning about 5G and its applications but highlight a lack of practical exposure and industry-driven learning opportunities. Many report that their universities offer only basic overviews of 5G concepts, with few chances to engage in real-world projects, case studies, or internships. A key concern among students is the limited interdisciplinary approach to 5G education, with most learning focused solely on telecommunications. However, many students recognize that 5G plays a crucial role across various industries, including smart cities, logistics, healthcare, and finance, and that cross-disciplinary knowledge is essential for future job prospects.

Industry professionals reinforce the idea that university graduates often lack the hands-on experience and technical competencies required in the job market. Employers seek professionals who understand not only the technical aspects of 5G—such as network automation, cybersecurity, and AI-driven optimization—but also how these technologies impact business models, regulatory frameworks, and sustainability efforts. However, many industry representatives note that universities are slow to adapt to these evolving demands, resulting in a skills gap that forces companies to invest in additional training for new hires. Industry leaders emphasize that closer collaboration with academia through internship programs, industry-designed curricula, and joint research projects could help bridge this gap.

Policymakers also recognize that universities need greater support to modernize their programs and align them with workforce needs. One key concern is the lack of funding and infrastructure to support state-of-the-art training environments, such as 5G testbeds and cross-disciplinary innovation hubs. They advocate for stronger public-private partnerships to ensure that universities have the resources to offer high-quality, up-to-date education. Additionally, policymakers stressed the need for regulatory and policy frameworks that promote the integration of sustainability into 5G education, helping to create a workforce that is not only technically proficient but also capable of addressing environmental challenges in the digital economy.

Building on these insights, suggested steps forward include:

- Developing a modular curriculum, incorporating problem-based learning (PBL), industry case studies, and hands-on training opportunities.
- Strengthening university-industry collaborations through joint research, internship programs, and co-designed learning materials.
- Enhancing interdisciplinary education by integrating 5G with AI, IoT, sustainability, and policy frameworks.
- Investing in faculty training to ensure educators are equipped with the latest technological advancements and pedagogical tools.
- Advocating for policy and funding support to improve infrastructure, access to testbeds, and long-term educational sustainability.

These strategies can bridge the gap between academia and industry, equip students with future-proof skills, and contribute to Europe's digital and green transformation.

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To consolidate the key insights from this study, the following table summarizes the **main challenges identified**, the **findings from different stakeholders**, and the **recommended actions** to address these issues. This structured overview helps align educational strategies with industry needs, ensuring a more effective and future-ready 5G workforce.

Key Challenges	Main Findings from Stakeholders	Recommended Actions
Lack of Hands-On Experience	Students and industry highlight a **gap between theory and practice**. Universities lack **testbeds and real-world 5G training environments**.	Establish **5G labs, digital twins, and university-industry internships**. Fund **applied learning projects**.
Interdisciplinary Skill Gaps	Educators and industry stress the need for **AI, IoT, business, and regulatory knowledge** alongside technical skills.	Develop **modular, interdisciplinary curricula** combining **tech, business, and policy**. Offer **cross-disciplinary training programs**.
Weak Industry-Academia Collaboration	Industry finds university programs **too theoretical**, while educators struggle to **access industry input for curricula**.	Promote **joint research, co-designed courses, guest lectures, and structured internships**. Provide **policy incentives for partnerships**.
Limited Focus on Sustainability	Policymakers emphasize **the need for sustainability in 5G**, but **few universities offer related training**.	Integrate **green technologies, energy-efficient networks, and environmental impact studies** into 5G education.
Lack of Standardized Certifications	Industry prefers candidates with **recognized, standardized credentials**, but students struggle to access them	Develop **EU-wide certification frameworks** aligned with global 5G workforce needs.
Funding and Policy Barriers	Universities lack resources to **modernize curricula and facilities**. Policymakers see **funding constraints as a challenge**.	Increase **funding for 5G education infrastructure, upskilling, and workforce readiness programs**. Implement **policy frameworks that promote digital education**.

Table 11 Main challenges, findings and recommendations

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6. Annexes

Appendix A – Questionnaires and Interviews material

A.1. Questionnaires

A.1.1. Educators

Needs Assessment Questionnaire for Advanced 5G Technology Skills Requirements in Universities (Educator version)

Purpose: This questionnaire is designed to gather insights from educators to identify specific skills and knowledge gaps in advanced 5G technologies about the skills required to teach and implementing advanced 5G technologies in university programs. Your responses will help shape the curriculum and training opportunities for both students and faculty in preparing for the evolving 5G landscape.

Section 1: Demographics

1. **Institution Name:** _____
2. **Department/Faculty:** _____
3. **Your Role:**
    - Faculty member
    - Researcher
    - Department Chair
    - Other Academic Teaching Staff
4. **What is the level of education in which you lecture?**
    - Undergraduate
    - Master´s
    - PhD
    - Professional/technical trainings

Section 2: Current Knowledge and Engagement with 5G

5. **How familiar are you with the concepts and applications of 5G technologies?**
    - Not familiar
    - Basic understanding

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- Moderate understanding
- Advanced understanding
- Expert level

6. **What aspects of 5G technology do you currently teach or research? (Select all that apply)**
   - 5G Network Architecture
   - Radio Frequency (RF) Engineering
   - Internet of Things (IoT) in 5G
   - 5G Security
   - 5G Applications (e.g., autonomous vehicles, smart cities, healthcare)
   - Software and Network Slicing
   - Edge Computing & Cloud Integration
   - Energy efficiency and sustainability in/with 5G
   - Other: _____
7. **Do you currently incorporate any 5G-related content into your teaching or research, especially related to Green Industrial solutions (energy efficiency, sustainability, etc.)?**
   - 5g only
   - Green industrial only
   - Both
   - None

Section 3: Identifying Skill Requirements

8. **What key technical skills do you think students will need to master to be effective in the field of 5G technology?** (Please rate each skill from 1 to 5, where 1 = Not important at all, and 5 = Extremely important)
   - Wireless Communications
   - Network Planning and Optimization
   - Radio Frequency (RF) Design
   - Software Development for 5G Networks
   - Machine Learning & AI for 5G Applications
   - Network Security and Privacy

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- IoT Integration
- Green skills in 5G technologies (energy efficiency, sustainability)
- Data Analysis and Management
- Cloud Computing & Edge Networks
- Other: _____

9. **How important are the following technical skills / knowledge for students in order to be effective in the field of 5G technology?** (Please rate each skill from 1 to 5, where 1 = Not important at all, and 5 = Extremely important)
    - Business/Management (e.g., project management, entrepreneurship)
    - Ethics and Social Implications
    - Policy & Regulatory Knowledge
    - Data Science/Analytics
    - Sustainability
    - Cybersecurity and Digital Trust
    - Communication & Collaboration
    - Legal Issues in Technology
    - Other: _____
10. **What are the key challenges you foresee in teaching 5G technology at the university level?** (Select all that apply)

- Lack of faculty expertise
- Insufficient resources (labs, equipment, software)
- Limited student interest or awareness
- Keeping pace with the rapid evolution of technology
- Lack of industry partnerships
- Lack of standardized curriculum
- High costs associated with 5G-related programs
- Other: _____

11. **Drawing on your personal teaching experience, which of the following challenges do you foresee when teaching 5G technology?** (Select all that apply)

- Limited personal expertise or training opportunities in 5G technology
- Insufficient course materials or hands-on resources (e.g., labs, equipment, software)

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- Difficulty generating student interest or engagement in 5G-related topics
- Keeping course content updated with the rapid evolution of 5G technology
- Difficulty establishing connections with industry partners to enhance course relevance
- Lack of clear curriculum guidelines or standardization in 5G education
- High costs involved in developing or delivering 5G-related coursework
- Other: _____

Section 4: Training and Resources for Educators

12. **How helpful would each of the following professional development or training opportunities be in improving your ability to teach 5G-related topics? (Please rate each option on a scale from 1 to 5, where 1 = Not helpful at all and 5 = Extremely helpful**)

- Online courses/webinars on 5G technology
- Hands-on workshops (e.g., network simulation, equipment use)
- Research conferences and symposiums on 5G
- Collaborative partnerships with industry leaders
- Development of teaching materials (e.g., textbooks, case studies)
- Mentoring from experts in 5G technology
- Access to advanced 5G lab equipment
- Other: _____

13. **Would you be interested in participating in a 5G-focused curriculum development group or task force?**

- Yes
- No
- Maybe

Section 5: University Infrastructure and Collaboration

14. **Does your university currently offer any courses or programs specifically focused on 5G technologies?**

- Yes
- No

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- Planning to offer soon

15. **What resources or partnerships would be most helpful to support the integration of advanced 5G technologies in the curriculum?** (Select all that apply, up to three most important)

- Access to 5G testbeds or simulation platforms
- Collaboration with industry experts (e.g., telecom companies, startups)
- Research grants and funding for 5G initiatives
- Industry-sponsored projects for students
- Guest lectures from 5G professionals
- Internship opportunities with 5G-related companies
- Other: _____

16. **Are there any specific topics or emerging trends in 5G technology that you believe should be prioritized in the university curriculum?**

- _____

Section 6: Final Thoughts

17. **What are the most important outcomes you hope to achieve by incorporating 5G technology into university programs? (Select all that apply)**

- Prepare students for careers in 5G-related industries
- Foster innovation and research in 5G applications
- Create industry partnerships for real-world learning
- Contribute to the development of 5G technology standards
- Enhance global competitiveness in advanced telecommunications
- Other: _____

18. **Please provide any additional comments or suggestions on how to effectively integrate 5G technologies into university curricula and research:**

- _____

Thank you for participating! Your input is invaluable in helping us align university programs with the growing demand for expertise in advanced 5G technologies.

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A.1.2. Students

Needs Assessment Questionnaire for Advanced 5G Technology Skills Requirements in Universities (Student Version)

Purpose: This questionnaire is designed to gather insights from students about the skills and knowledge they believe are necessary to succeed in advanced 5G technologies. Your responses will help universities design better courses, training programs, and research opportunities in the growing field of 5G.

Section 1: Demographics

1. **University Name:** _____
2. **Department/Faculty:** _____
3. **Year of Study:**
    - First Year
    - Second Year
    - Third Year
    - Fourth Year
    - Graduate
    - Other: _____
4. **Major/Program of Study:** _____

Section 2: Current Knowledge of 5G Technology

5. **How familiar are you with 5G technology?**
    - Not familiar at all
    - Heard of it, but don't know much
    - Basic understanding (e.g., know it's about faster mobile networks)
    - Moderate understanding (e.g., understand some applications and technical details)
    - Advanced understanding (e.g., have studied it in-depth, including technical aspects)
6. **Which of the following aspects of 5G technology have you learned in your university studies about? (Select all that apply)**
    - 5G Network Architecture

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- Radio Frequency (RF) Engineering
- Internet of Things (IoT) in 5G
- 5G Security
- Edge Computing & Cloud Integration
- 5G Applications (e.g., smart cities, autonomous vehicles, healthcare)
- Network Slicing & Virtualization
- Energy efficiency and sustainability in/with 5G
- Other: _____

7. **Have you had any formal exposure to 5G technology in your coursework or projects, especially related to Green Industrial solutions (energy efficiency, sustainability, etc.)?**
   - 5g only
   - Green industrial only
   - Both
   - None

Section 3: Skills and Knowledge Requirements for 5G

8. **Which of the following skills / knowledge do you believe are important for you to develop in order to work effectively with 5G technologies? (Select all that apply)**
   - Wireless Communications & Networking
   - Radio Frequency (RF) Design and Engineering
   - Software Development (e.g., for 5G applications, network management)
   - Cybersecurity and Network Security for 5G
   - Machine Learning & AI for 5G Applications
   - Data Analysis & Big Data Management
   - IoT Systems Design and Implementation
   - Green skills in 5G technologies (energy efficiency, sustainability)
   - Cloud Computing & Edge Computing
   - Business and Management skills related to 5G projects
   - Other: _____

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9. **Which of the following interdisciplinary areas do you think are necessary to support 5G technologies? (Select all that apply)**

- Business/Entrepreneurship (e.g., project management, startups)
- Ethics and Social Implications of Technology
- Policy & Regulatory Knowledge
- Sustainability
- Legal & Privacy Concerns in Telecommunications
- Collaboration & Communication Skills
- Other: _____

Section 4: Interest and Readiness for 5G-related Courses

10. **How interested are you in pursuing further education or training on 5G technologies?**

- Not interested
- Somewhat interested
- Interested
- Very interested

11. **What topics would you be most interested in for learning about 5G technologies?** (Please rate from 1 to 5, where 1 = Not important at all, and 5 = Extremely important)

- 5G Network Architecture and Design
- Wireless Communication Systems
- Security in 5G Networks
- Applications of 5G (e.g., autonomous vehicles, smart cities, healthcare)
- Cloud Computing and Edge Computing for 5G
- Software Development for 5G and IoT
- Hands-on Labs and Projects for 5G Technology
- Energy efficiency and sustainability with 5G
- Other: _____

Section 5: Hands-on Learning and Industry Collaboration

12. **Would you be interested in participating in internships, projects, or research focused on 5G technologies?**

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- Yes
- No
- Maybe

13. **What kind of hands-on learning experiences would be most valuable for you in understanding 5G technology? (Select all that apply)**

- Access to 5G testbeds and simulation platforms
- Industry-sponsored projects or case studies
- Internship programs with telecom companies or tech firms
- Hackathons or innovation challenges focused on 5G
- Workshops on 5G-related hardware and software
- Other: _____

14. **Do you think university-industry partnerships (with companies in telecommunications, tech, or IoT) would enhance your learning experience about 5G?**

- Yes
- No
- Not sure

Section 6: Resources and Support

15. **What resources would help you learn more about 5G technologies? (Select all that apply)**

- Online courses and webinars
- Books and textbooks on 5G
- Access to software or hardware for 5G simulations and experiments
- Expert lectures or seminars from industry professionals
- Peer-to-peer learning or study groups
- Other: _____

16. **Would you be interested in joining a student club or network focused on 5G technology and innovation?**

- Yes
- No
- Maybe

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Section 7: Final Thoughts

17. **What do you think are the biggest challenges or barriers to learning and working with 5G technologies?**

- Lack of available courses or programs
- Insufficient hands-on learning opportunities
- Lack of access to industry resources (e.g., equipment, labs)
- High cost of learning materials or equipment
- Complexity of the technology
- Other: _____

18. **Do you have any additional comments or suggestions on how universities can better prepare students for the 5G technology landscape?**

- _____

Thank you for participating! Your input is crucial in helping us understand the skills, knowledge, and resources required to prepare students for the future of 5G technologies.

A.1.3. Industry

Needs Assessment Questionnaire for Advanced 5G Technology Skills Requirements in Universities (Industry Professional Version)

Purpose: This questionnaire aims to gather insights from industry professionals about the essential skills and knowledge required for university students to effectively contribute to the evolving field of advanced 5G technologies. Your feedback will help universities better align their curriculum, training programs, and research initiatives with industry needs and trends.

Section 1: Demographics

1. **Industry Sector:**
    - Telecommunications
    - Wireless Technology
    - Software/IT Solutions
    - IoT (Internet of Things)
    - Network Equipment Manufacturing
    - Consulting/Advisory Services

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- Other: _____

2. **Your Role/Title:** _____
3. **How many years of experience do you have working in the 5G technology space?**
   - Less than 1 year
   - 1-3 years
   - 3-5 years
   - 5+ years

Section 2: Current Industry Needs for 5G Skills

4. **Which areas of 5G technology do you believe are most critical for university graduates to understand and be skilled in?** (Please rate each area from 1 to 5, where 1 = Not important at all, and 5 = Extremely important)
   - 5G Network Architecture (e.g., RAN, core network, transport)
   - Radio Frequency (RF) Engineering and Design
   - Internet of Things (IoT) and 5G Integration
   - Network Security and Privacy for 5G
   - Software Development (e.g., for 5G apps, network management)
   - Machine Learning & AI in 5G Networks
   - Energy efficiency and sustainability in/with 5G
   - Edge Computing and Cloud Integration
   - Data Management and Analytics
   - Business and Commercialization of 5G Solutions
   - Other: _____
5. **What skills are most needed for professionals working with 5G in your industry?** (Please select all that apply, up to three most important)
   - Network Planning and Optimization
   - Software Engineering and Development for 5G
   - Cloud Computing & Edge Network Design
   - Wireless Communications Theory and Practical Application
   - 5G Security and Privacy Management
   - Data Science and Analytics for 5G

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- IoT Systems Integration
- Project Management and Business Development
- Green skills in 5G technologies (energy efficiency, sustainability)
- Other: _____

6. **Are there any emerging trends in 5G that universities should focus on to better prepare students for the workforce?**
   - _____

Section 3: Industry Expectations for University Graduates

7. **Which of the following competencies do you expect university graduates working in 5G to have?** (Please rate each competence from 1 to 5, where 1 = Not important at all, and 5 = Extremely important)
   - Strong foundational knowledge in wireless communications
   - Practical hands-on experience with 5G hardware and software
   - Ability to design and optimize 5G networks
   - Familiarity with the integration of IoT devices and services in 5G
   - Ability to develop software applications for 5G networks
   - Understanding of the regulatory and policy landscape for 5G technology
   - Expertise in machine learning and AI applications for 5G
   - Problem-solving and troubleshooting skills for network-related issues
   - Ability to work in interdisciplinary teams
   - Other: _____
8. **What soft skills do you believe are necessary for university graduates to succeed in 5G-related roles in your industry?** (Please rate each skill from 1 to 5, where 1 = Not important at all, and 5 = Extremely important)

- Communication and Collaboration
- Critical Thinking and Problem Solving
- Adaptability and Continuous Learning
- Project Management and Organizational Skills
- Innovation and Creativity
- Leadership and Teamwork
- Other: _____

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Section 4: Curriculum and Training Needs

9. **What specific technical training or certifications would you recommend for university students entering the 5G technology space? (Select all that apply)**

- Certifications in 5G wireless technologies (e.g., vendor-specific certifications)
- Network Design and Planning
- Cloud and Edge Computing Certifications
- Security Certifications for 5G security
- Programming and Software Development for Telecom Networks
- Data Science and Analytics Training for 5G Applications
- Project Management Certifications
- Other: _____

10. **Would you recommend universities to develop specialized 5G-related courses and/or programs?**

- Courses
- Programs
- Both
- Not sure

11. **What role do you think university-industry partnerships (e.g., internships, co-op programs, joint research) can play in developing the next generation of 5G professionals?**

- Essential to providing practical experience
- Helpful, but not necessary
- Not very important

12. **Would your company be open to collaborating with universities to offer internships, co-op programs, or real-world projects for students in 5G-related fields?**

- Yes
- No
- Maybe

Section 5: University Resources and Support

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13. **What types of resources do you believe universities should invest in to help students develop 5G-related skills?** (Select all that apply, up to three most important)

- Access to 5G testbeds and simulation environments
- Industry-standard hardware and software for 5G network design
- Guest lectures and workshops from industry experts
- Research funding for 5G innovation projects
- Collaboration with telecom providers and tech companies
- Access to real-world case studies and projects
- Other: _____

14. **What additional support could universities provide to make their 5G-related courses and programs more industry-relevant?**

- _____

Section 6: Final Thoughts

15. **What do you see as the most important factor in ensuring that university graduates are prepared for careers in 5G technologies?**

- _____

16. **Do you have any other suggestions for how universities can better align their programs with the evolving needs of the 5G industry?**

- _____

Thank you for your time and insights. Your feedback will help universities better prepare students for success in the fast-evolving field of 5G technology.

A.1.4. Policymakers

Needs Assessment Questionnaire for Advanced 5G Technology Skills Requirements in Universities (Policy Maker Version)

Purpose: This questionnaire is designed to gather insights from policymakers regarding the essential skills and knowledge that universities should prioritize to prepare students for the challenges and opportunities of advanced 5G technologies. Your input will help shape policy decisions related to higher education, workforce development, and the integration of 5G technologies in university curricula.

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Section 1: Demographics

1. **Organization/Agency Name:** _____
2. **Position/Role:** _____
3. **Country/Region:** _____
4. **Years of Experience in Policy Development for Technology/Education:**
    - Less than 1 year
    - 1-3 years
    - 3-5 years
    - 5+ years

Section 2: Current Understanding of 5G Technology and Its Impact

5. **How familiar are you with 5G technology and its implications for society, the economy, and the workforce?**
    - Not familiar
    - Basic understanding
    - Moderate understanding
    - Advanced understanding
6. **Which of the following areas do you believe are most crucial for policy development in the context of 5G?** (Please rate each area from 1 to 5, where 1 = Not important at all, and 5 = Extremely important)
    - Infrastructure development and investment
    - Regulatory frameworks for 5G deployment
    - Cybersecurity and data privacy
    - Workforce development and skills training
    - Public-private partnerships and collaborations
    - Social and ethical implications (e.g., equity, access)
    - Environmental and sustainability considerations
    - Economic impact and innovation facilitation
    - Energy efficiency and sustainability in/with 5G
    - Other: _____

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Section 3: Skills and Competencies for the 5G Workforce

7. **In your opinion, in which of the following areas, effort is needed by policy-makers to enhance competitiveness in the emerging 5G job market?** (Please rate each area from 1 to 5, where 1 = Not important at all, and 5 = Extremely important)
    - Wireless communications and network architecture
    - Network security and data privacy
    - Software development for 5G applications
    - IoT systems integration with 5G networks
    - Artificial intelligence and machine learning in 5G
    - Cloud computing and edge computing
    - Network optimization and planning
    - 5G business and commercialization strategies
    - Green skills in 5G technologies (energy efficiency, sustainability)
    - Regulatory and policy knowledge for 5G
    - Other: _____
8. **What are the most critical soft skills / knowledge that you believe will support successful careers in 5G technology?** (Please rate each skill from 1 to 5, where 1 = Not important at all, and 5 = Extremely important)
    - Problem-solving and critical thinking
    - Communication and collaboration
    - Project management and leadership
    - Adaptability and continuous learning
    - Ethical decision-making
    - Innovation and entrepreneurship
    - Other: _____

Section 4: Role of Universities in Preparing the 5G Workforce

9. **What role do you believe universities should play in preparing students for careers in 5G technologies?**

- Deliver specialized degree programs in 5G technology
- Offer certificate programs or short courses focused on 5G skills

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- Integrate 5G-related content into existing curricula (e.g., engineering, business, policy)
- Foster research and innovation in 5G technologies
- Provide hands-on learning opportunities through labs, projects, or internships
- Collaborate with industry to ensure curriculum relevance
- Other: _____

10. **How important is it for universities to integrate interdisciplinary training (e.g., combining technical skills with policy, business, or social sciences) to address the challenges of 5G deployment?**

- Extremely important
- Important
- Somewhat important
- Not important

11. **In your opinion, to what extent do current university curricula prepare students for careers in 5G technologies?**

- Very well
- Somewhat well
- Neither well nor poorly
- Not very well
- Not at all well
- Not sure

Section 5: Policy and Funding Support for 5G Education

12. **What kind of policy initiatives or funding support do you think are needed to help universities develop the necessary programs for 5G workforce preparation? (Select all that apply)**

- Government funding for 5G-related research and curriculum development
- Industry partnerships to provide resources, internships, and real-world case studies
- Establishment of national or regional centers of excellence for 5G education and training
- Scholarships or grants for students pursuing 5G-related studies
- Public-private partnerships to ensure alignment between education and industry needs

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- Development of certification and accreditation programs for 5G skills
- Other: _____

13. **To what extent, if at all, should government policies be involved in the development of 5G talent and expertise in higher education?**

- They should have a major role
- They should have a moderate role
- They should have a minor role
- They should not be involved at all
- Not sure

14. **To what extent do you perceive a gap in government policies designed to support the development of 5G talent and expertise in higher education?**

- No gap at all
- A slight gap
- A moderate gap
- A significant gap
- Not sure

15. **What are the biggest challenges you foresee in developing a skilled 5G workforce through higher education? (Select all that apply, up to three most important)**

- Lack of funding or resources for educational programs
- Rapid technological advancements that outpace curriculum development
- Difficulty in attracting students to 5G-related fields
- Lack of qualified faculty to teach advanced 5G topics
- Disparities in access to technology and training between universities
- Other: _____

Section 6: Collaboration and Industry Engagement

16. **How can universities and the government collaborate to ensure the workforce is prepared for the demands of 5G technology? (Select all that apply, up to three most important)**

- Encourage joint research initiatives between universities and industry partners
- Develop internships or apprenticeship programs with 5G-focused companies

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- Create policy frameworks that incentivize industry involvement in education
- Foster innovation hubs or tech incubators for 5G startups
- Provide funding for universities to develop industry-relevant 5G curricula
- Other: _____

17. **Would you be open to supporting or participating in initiatives that aim to align university education with the needs of the 5G industry (e.g., advisory boards, curriculum design, research projects)?**

- Yes
- No
- Maybe

Section 7: Final Thoughts

18. **What are the top three priorities that policymakers should focus on to ensure the effective development of 5G-related skills in universities?**

- _____
- _____
- _____

19. **What additional comments or recommendations do you have for aligning university programs with the needs of the 5G workforce?**

- _____

Thank you for your time and insights. Your input is crucial in shaping policies that will ensure universities are preparing students with the right skills for the rapidly evolving field of 5G technology.

A.2. Interviews

A.2.1. Educators

Interview questions for educators on a needs assessment to identify the skills requirements for advanced 5G technologies in universities

---

Demographics

1. **Institution Name:** _____

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2. **Department/Faculty:** _____
3. **Your Role:**
    - Faculty member
    - Researcher
    - Department Chair
    - Other Academic Teaching Staff
4. **What is the level of education in which you lecture?**
    - Undergraduate
    - Master´s
    - PhD
    - Professional/technical trainings

General Perspective on 5G in Education

5. **Awareness and Importance**
    - How familiar are you with the advancements and applications of 5G and Green Industrial technologies in various industries?
    - From your perspective, why is it important to incorporate advanced 5G and green technologies into university education?
    - What opportunities do you see for students who are skilled in 5G and green industrial technologies?
6. **Current Integration**
    - To what extent (how much and what kind of topics) are 5G and Green Industrial topics currently included in your curriculum or teaching materials?
    - What are the key challenges you face in integrating 5G and Green Industrial technologies into your teaching or offering courses in this domain?

Skills and Competencies

7. **Core Skills Requirements**
    - What specific technical skills (e.g., network design, spectrum management, edge computing, AI for 5G) do you think students need to excel in 5G-related careers? What about sustainability in/with 5G?

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- What interdisciplinary / soft skills (e.g., problem-solving, critical thinking, teamwork, business skills) are essential for success in fields influenced by 5G?

8. **Emerging Trends**
    - Are there any emerging trends or technologies in 5G that you believe students need to learn about how to remain relevant in the future job market? Is it easy to identify these relevant trends?
    - How do you see the integration of technologies like IoT, AI, or machine learning influencing the skills required for 5G?

Challenges and Gaps

9. **Curriculum Gaps**
    - Where do you see the biggest gaps / underrepresented topics in the current university curriculum when it comes to preparing students for careers in advanced 5G technologies?
    - What kind of hands-on experience or practical training do you think is currently lacking?
10. **Barriers to Implementation**
    - What challenges do educators, in our opinion, face in staying updated with the latest advancements in 5G technologies?
    - Are there any resource limitations (e.g., access to lab equipment, funding, industry collaborations) that hinder effective teaching of 5G-related topics?

Teaching Strategies and Resources

11. **Educational Methods**
    - What teaching methods do you believe are most effective for helping students develop the technical skills required for 5G technologies?
    - How do you incorporate real-world applications of 5G into your teaching to make the concepts more relevant?
12. **Resource Needs**
    - What kind of resources (e.g., training materials, lab facilities, partnerships) would help you teach advanced 5G technologies more effectively?
    - Are there specific professional development opportunities or training programs you would like to access to enhance your knowledge of 5G?

Collaboration and Support

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13. **Industry Collaboration**
    - How can universities better collaborate with industry to ensure students are job-ready in fields requiring advanced 5G skills?
    - Are there any existing partnerships or programs you have participated in that have been particularly helpful in preparing students for 5G-related roles?
14. **Policy and Institutional Support**
    - Are there currently gaps in institutional and policy support for integrating 5G technologies into higher education, and if so, what are they?
    - What role should university administration and policymakers play in supporting the development of a 5G-ready curriculum?
    - What policies or initiatives do you think are necessary to better integrate 5G technologies into higher education?

Future Vision

15. **Evolving Role of Educators**
    - How do you see your role evolving as universities adopt more advanced 5G technologies in their programs?
    - What steps do you think universities should take to ensure their graduates remain competitive in a 5G-enabled workforce?
16. **Long-Term Goals**
    - What long-term strategies would you recommend for universities to stay ahead in teaching skills relevant to 5G and related technologies?
    - How can universities balance foundational knowledge with specialized 5G training to prepare students for future advancements?
17. Any other comments
    - Any other comments regarding the topic?

A.2.2. Students

Interview questions for students to assess their perspectives on the skills requirements for advanced 5G technologies in universities

---

Demographics

1. **University Name:** _____
2. **Department/Faculty:** _____

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3. **Year of Study:**
    - First Year
    - Second Year
    - Third Year
    - Fourth Year
    - Graduate
    - Other: _____
4. **Major/Program of Study:** _____

General Understanding of 5G

5. **Awareness and Interest**
    - Identify your study level (field, year of study, specialty, etc.).
    - How familiar are you with 5G and Green Industrial technologies and their applications in various industries?
    - What excites you the most about learning 5G technologies and their potential impact on your field of study or career?
    - Do you think 5G-related skills are important for your future career? Why or why not?
6. **Perceptions of Relevance**
    - How do you see 5G technologies influencing the industry or field you wish to work in?
    - Do you feel your current university program addresses the importance of 5G and Green Industrial technologies adequately? What are the key topics that have been included in the current courses?
    - Do you feel adequately prepared for a career in 5G technologies based on your current education?

Skills and Learning Needs

7. **Skills Identification**
    - What specific skills or knowledge areas related to 5G (e.g., network design, cybersecurity, IoT, AI integration) do you think are important to learn? What about sustainability in/with 5G?

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- Are there any interdisciplinary skills / soft skills (e.g., teamwork, critical thinking, problem-solving, business skills) that you think are essential for applying 5G technologies effectively?

8. **Preferred Learning Areas**
    - Are you more interested in the theoretical foundations of 5G, its practical applications, or a mix of both?
    - What areas of 5G (e.g., smart cities, autonomous vehicles, augmented reality) interest you the most and why?

Current Education Experience

9. **Curriculum and Opportunities**
    - Have you encountered any courses, projects, or extracurricular opportunities at your university related to 5G technologies? If yes, what kind of courses? If not, what kind of courses would you prefer to have?
    - Do you feel there are enough opportunities for hands-on experience or practical learning hands-on experience or practical learning opportunities in this area? If not, what's missing?
10. **Resource Gaps**
    - What kind of resources (e.g., labs, mentorship, industry exposure) do you think your university needs to better support learning about 5G technologies?
    - Have you faced any challenges accessing information or training on 5G and green industries related topics?

Preferred Learning Methods

11. **Teaching and Engagement**
    - How do you prefer to learn about advanced technologies like 5G and green industries? (e.g., lectures, practical labs, industry projects, online resources)
    - What type of projects or assignments would help you better understand and apply 5G technologies?
12. **Hands-On Experience**
    - Do you think internships, research projects, or collaborations with industry would help you develop 5G-related skills? Why?
    - What kind of practical experiences would you like to see integrated into your education regarding 5G?

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Future Aspirations

13. **Career Relevance**
    - How do you see 5G-related skills benefiting your career in the future?
    - Are there specific job roles or industries where you think 5G knowledge will give you a competitive advantage?
14. **Expectations from Universities**
    - What role do you think universities should play in preparing students for careers involving 5G and green industrial technologies?
    - What specific initiatives or programs would you like your university to implement to help students gain 5G-related skills, especially for green industries (sustainability, energy efficiency)?

Feedback on Support

15. **University Support**
    - Do you feel your faculty is doing enough to prepare students for the technological changes brought by 5G? Why or why not?
    - What additional support (e.g., career guidance, access to experts, certifications offered) would help you feel more prepared to work with 5G technologies?
16. **Collaboration Opportunities**
    - Would you be interested in collaborating with industry professionals or researchers to learn more about 5G technologies? If so, in what capacity? If no, why not?
    - How important do you think international exposure or cross-university collaborations are for learning about 5G advancements?
17. Any other comments
    - Any other comments regarding the topic?

A.2.3. Industry

Interview questions for industry professionals to identify the skills requirements for advanced 5G technologies in universities

---

Demographics

1. **Industry Sector:**

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- Telecommunications
- Wireless Technology
- Software/IT Solutions
- IoT (Internet of Things)
- Network Equipment Manufacturing
- Consulting/Advisory Services
- Other: _____

2. **Your Role/Title:** _____
3. **How many years of experience do you have working in the 5G technology space?**
    - Less than 1 year
    - 1-3 years
    - 3-5 years
    - 5+ years

Understanding Industry Needs

4. **Workforce Demand**
    - What is your specific industry sector?
    - What specific roles or job functions in your organization and/or industry require expertise in advanced 5G and Green Industrial technologies?
    - Which technical skills (e.g., network architecture, edge computing, IoT, AI integration) do you find most critical for professionals working with 5G? What about sustainability in/with 5G?
    - Are there any emerging skills or knowledge areas related to 5G that you foresee becoming essential in the near future?
    - Where do you currently find the relevant talent?
5. **Soft Skills and Interdisciplinary Expertise**
    - Besides technical skills, what soft skills (e.g., problem-solving, collaboration, adaptability, business skills) are crucial for success in 5G-related roles?
    - How important is an interdisciplinary understanding of 5G, combining technical expertise with knowledge in areas like business, policy, or ethics?

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Current Skills Gap

6. **Workforce Readiness**
    - Are you currently facing challenges in finding qualified professionals with the necessary skills in 5G technologies?
    - What do you see as the biggest skills gap in graduates entering 5G-related roles in your industry?
    - Do you think current university programs adequately prepare students for the technical and practical demands of working with 5G?
7. **Specific Challenges**
    - What areas of 5G-related expertise do you find particularly lacking among recent graduates?
    - How do these skill gaps impact your organization's ability to innovate or scale 5G-related projects?

Collaboration with Academia

8. **University Partnerships**
    - Does your organization collaborate with universities to address the skills requirements for 5G technologies? If so, how? If not, how would you like to collaborate?
    - What types of partnerships or programs (e.g., internships, joint research, guest lectures) do you believe are less and most effective for bridging the gap between academia and industry?
9. **Feedback on Curriculum**
    - What specific topics or skills would you like to see incorporated into university curricula related to 5G?
    - How important is hands-on experience, such as lab work or industry projects, in preparing students for 5G-related roles?

Training and Development

10. **Skill Development Practices**
    - Does your organization offer training or upskilling programs for 5G technologies? If so, what do they focus on? If not, what do you think your organization should focus on?

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- Do you think universities should collaborate with industry to provide continuous learning opportunities for professionals already in the workforce? If yes, how?

11. **Preferred Learning Approaches**
    - What kind of learning methods do you think are most effective for teaching 5G technologies, such as project-based learning, simulations, or certification programs? Do you also consider collaborative methods (apprenticeships / workshops with industry experts, etc.).
    - Would you be willing to participate in or sponsor programs where industry experts train or mentor university students in 5G-related skills?

Future Trends and Long-Term Vision

12. **Anticipated Industry Changes**
    - How do you see 5G technologies evolving in the next 5–10 years, and what new skills do you think will become important as a result?
    - Are there any specific sectors or applications of 5G (e.g., healthcare, autonomous vehicles, smart cities) that you think universities should prioritize in their training programs?
13. **Shaping the Workforce**
    - What medium-term strategies should universities adopt to ensure they are producing graduates equipped to work in a 5G-enabled economy?
    - How can industry and academia work together to stay ahead of technological advancements in 5G?

Closing and Feedback

14. **Insights on Education**
    - In your experience, what separates a well-prepared graduate from one who struggles to adapt to the demands of 5G-related roles?
    - What advice would you give universities to better align their programs with industry needs in 5G?
15. **Your Contribution**
    - Would your organization be open to contributing resources, expertise, or funding, or collaborative projects to university initiatives focused on 5G education? If yes, what opportunities you see? If not, why not?

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- Are there any additional recommendations you would like to share on how universities can better prepare students for careers in 5G technologies?

16. **Any other comments**
    - Any further comments about the topic?

A.2.4. Policymakers

Interview questions for policy makers to assess the skills requirements for advanced 5G technologies in universities

---

Demographics

1. **Organization/Agency Name (optional): _____**
2. **Position/Role (optional): _____**
3. **Country/Region: _____**
4. **Years of Experience in Policy Development for Technology/Education:**
    - Less than 1 year
    - 1-3 years
    - 3-5 years
    - 5+ years

General Understanding of 5G in Education and Industry

5. **Awareness and Priorities**
    - What is your understanding of the role of 5G technologies in driving technological and economic growth?
    - From a policy perspective, how critical is the integration of 5G and Green Industrial skills development in university curricula?
    - What key industries or sectors do you think will benefit the most from graduates trained in advanced 5G technologies?
    - How are you currently prioritizing 5G and Green Industries technologies in your policies or in your work?
6. **Current Status**
    - How would you evaluate the current readiness of universities to address the skills gap in advanced 5G technologies? How do you assess it (based on data, reports, etc)?

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- Are there any specific national or regional policies currently in place to support 5G-related skills development in higher education?

Identifying Skills Gaps

7. **Demand-Supply Dynamics**
    - What specific skills or knowledge areas related to 5G (e.g., network architecture, IoT integration, AI applications in 5G, cybersecurity) are most in demand across industries? What about sustainability in/with 5G?
    - Where do you see the biggest skills gap in the current workforce that universities should address?
    - Are there any emerging 5G technologies or applications that require immediate attention in terms of skills development?
8. **Challenges**
    - What challenges do you perceive in equipping university graduates with the skills needed for advanced 5G and Green Industrial technologies?
    - Are there any disparities in the availability of these skills across different regions or demographics?

Policy and Funding

9. **Policy Support**
    - How can government policies better support the integration of advanced 5G technologies (focusing on in university programs?
    - What role do you see for public-private partnerships in bridging the skills gap for 5G technologies?
    - Any need for new or more tailored policies and/or collaboration?
10. **Funding and Resources**
    - Are there adequate funding mechanisms to help universities invest in 5G-related research and training infrastructure?
    - What incentives could encourage universities to prioritize 5G skills development?

Curriculum Development and Partnerships

11. **Academic-Industry Collaboration**

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- How do you think universities can better collaborate with industry to ensure graduates are job-ready for 5G-related roles?
- Can you share examples of successful collaborations or programs that have effectively bridged the skills gap in other advanced technologies?

12. **Curriculum Updates**
    - What core topics or modules do you believe should be included in a university curriculum to address 5G skills needs effectively?
    - How should universities balance foundational knowledge with practical, hands-on training in 5G technologies?

Future Outlook

13. **Long-Term Strategy**
    - What long-term strategies should policymakers adopt to sustain a workforce skilled in advanced 5G technologies?
    - How can universities stay ahead of technological advancements to remain relevant in the 5G era and beyond?
14. **Global Competitiveness**
    - How can national universities position themselves globally in producing a workforce skilled in 5G technologies?
    - What role do you see international collaboration playing in addressing 5G-related skills shortages?
15. **Any other comments**
    - Any other comments regarding the topic?

Appendix B – Results from the Questionnaires

B.1. Educators

The project managed to attract responses from 28 educators with different profiles in terms of country, university, expertise, role and background. Below we present the results of their questionnaires.

Section 1: Demographics

1. **Institution Name:**

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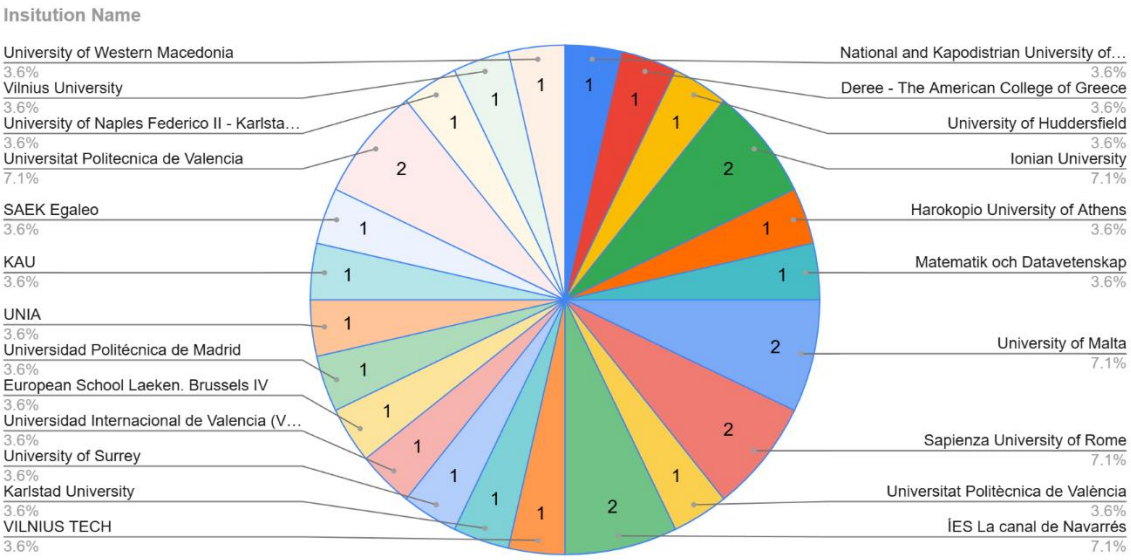

Figure 1 Institution name

2. **Department/Faculty:**

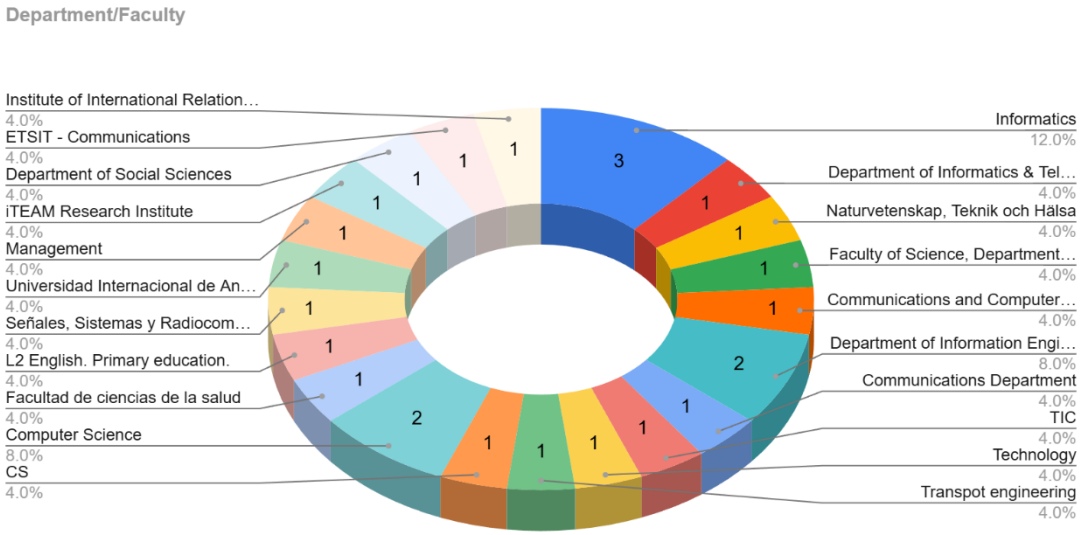

Figure 2 Department/Faculty

3. **Your Role:**

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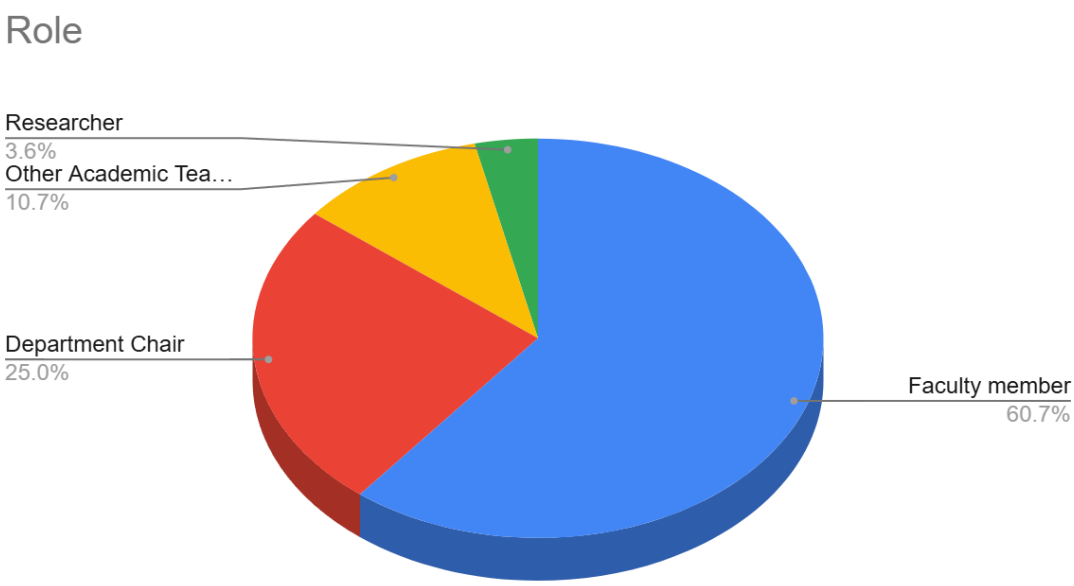

Figure 3 Role

4. **What is the level of education in which you lecture?**

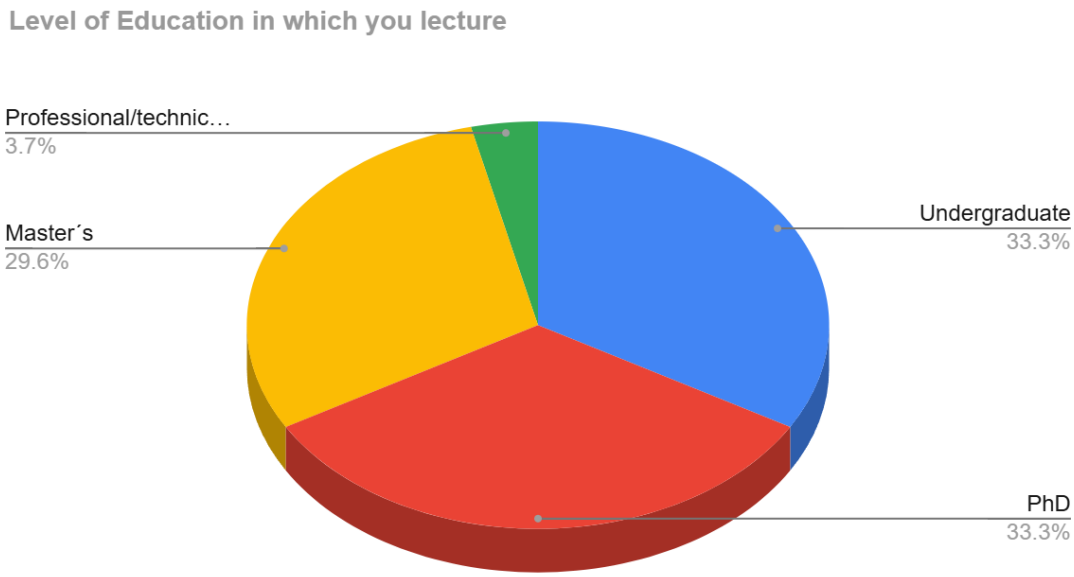

Figure 4 Level of education

Section 2: Current Knowledge and Engagement with 5G

5. **How familiar are you with the concepts and applications of 5G technologies?**

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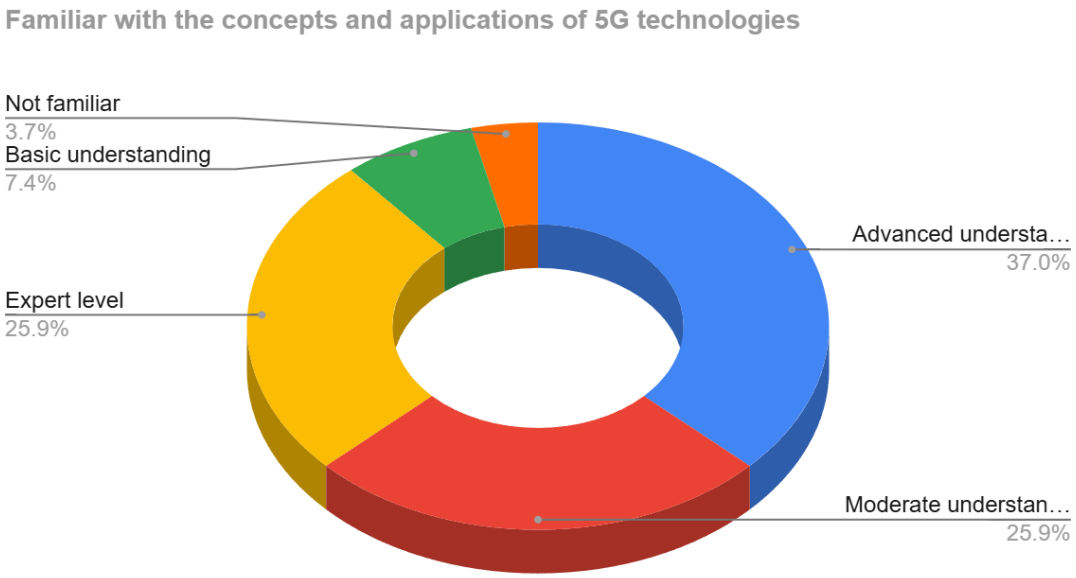

Figure 5 Familiarity with 5G

6. **What aspects of 5G technology do you currently teach or research? (Select all that apply)**

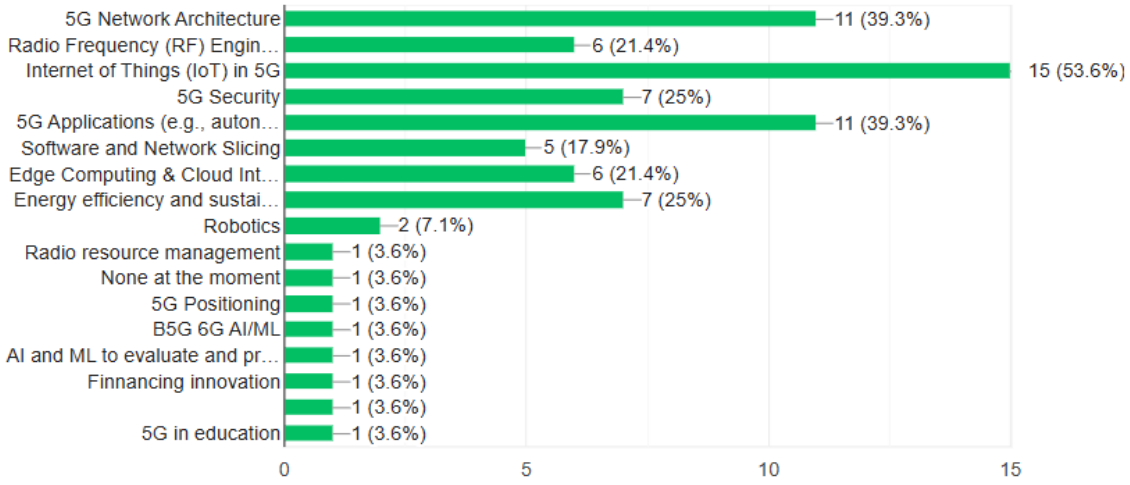

Figure 6 Aspects of 5G

7. **Do you currently incorporate any 5G-related content into your teaching or research, especially related to Green Industrial solutions (energy efficiency, sustainability, etc.)?**

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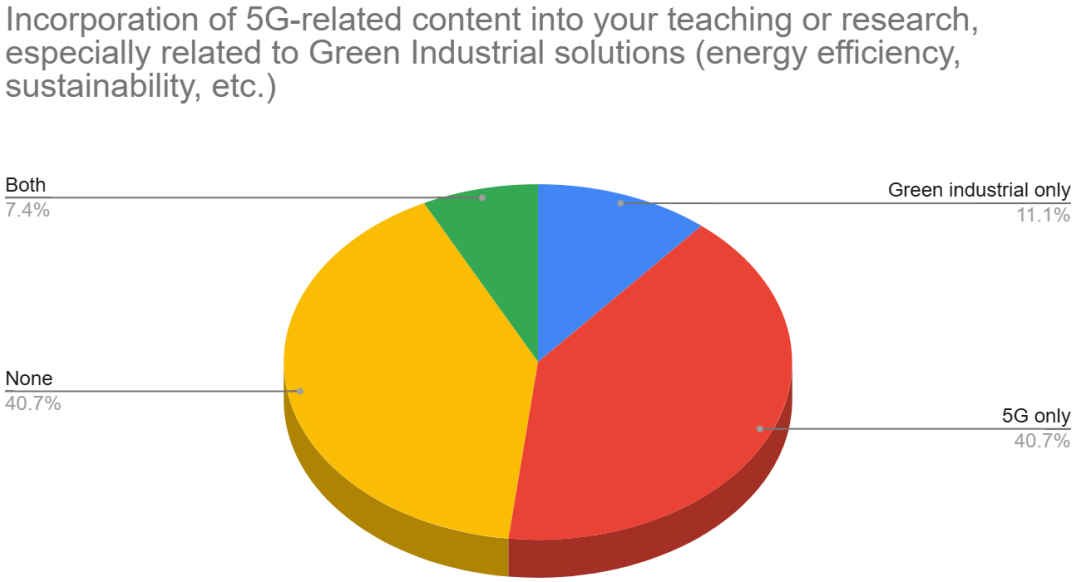

Figure 7 Related content

Section 3: Identifying Skill Requirements

8. **What key technical skills do you think students will need to master to be effective in the field of 5G technology?** (Please rate each skill from 1 to 5, where 1 = Not important at all, and 5 = Extremely important)

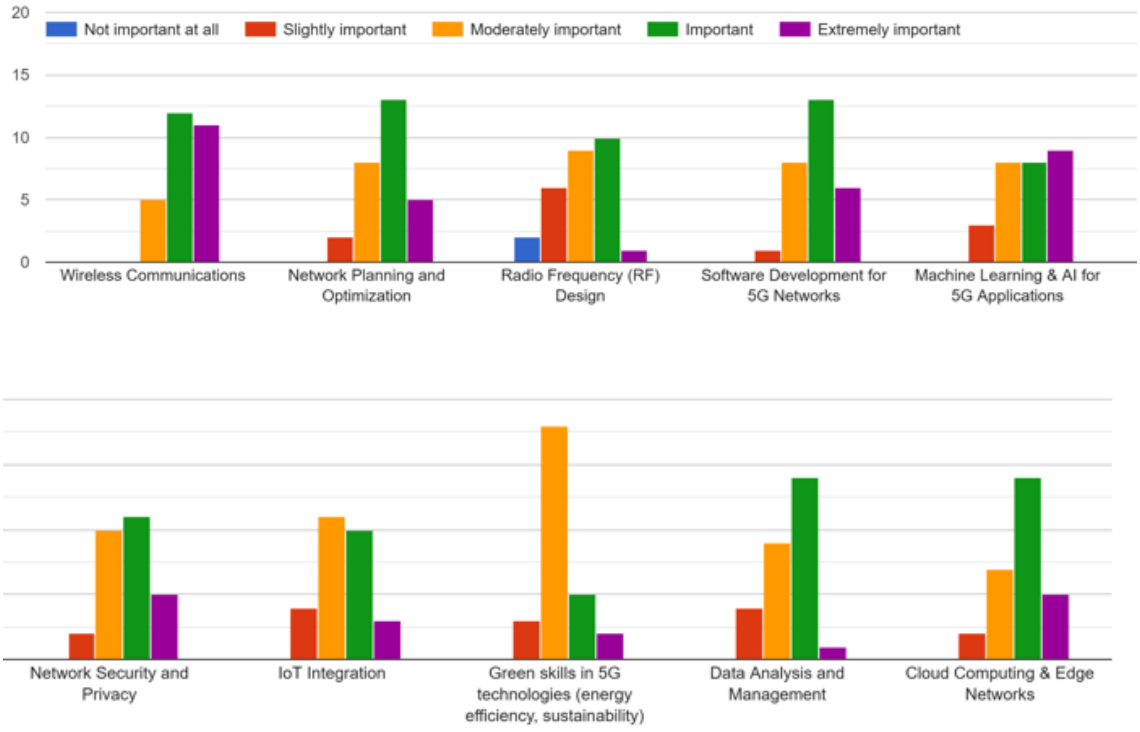

Figure 8 Skills requirements

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9. **How important are the following technical skills / knowledge for students in order to be effective in the field of 5G technology?** (Please rate each skill from 1 to 5, where 1 = Not important at all, and 5 = Extremely important)

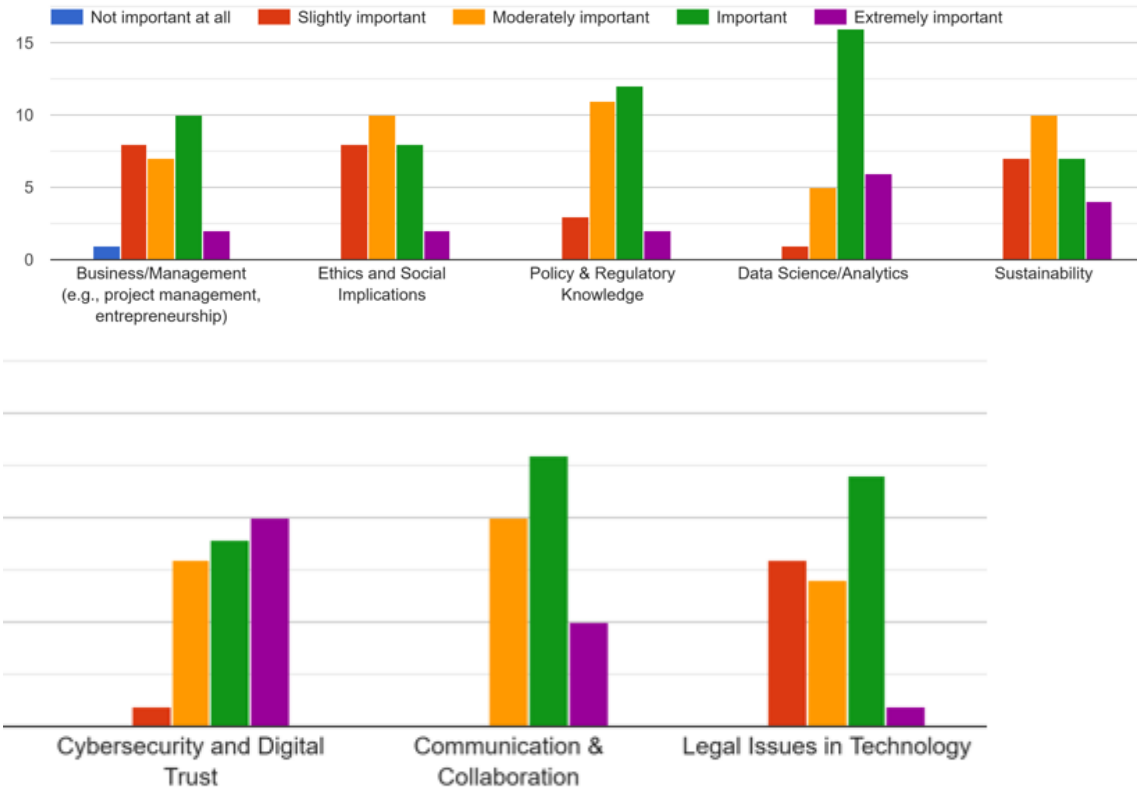

Figure 9 Technical skills/knowledge

10. **What are the key challenges you foresee in teaching 5G technology at the university level?** (Select all that apply)

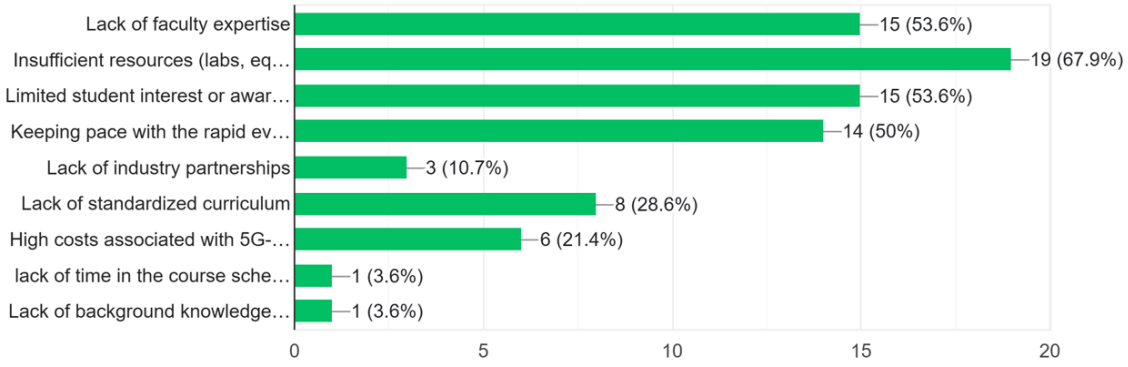

Figure 10 Key challenges

11. **Drawing on your personal teaching experience, which of the following challenges do you foresee when teaching 5G technology?** (Select all that apply)

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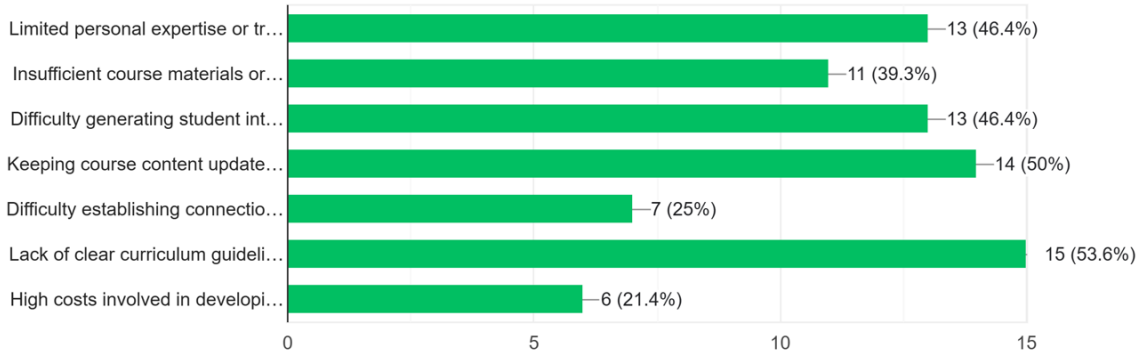

Figure 11 Personal challenges

Section 4: Training and Resources for Educators

12. **How helpful would each of the following professional development or training opportunities be in improving your ability to teach 5G-related topics? (Please rate each option on a scale from 1 to 5, where 1 = Not helpful at all and 5 = Extremely helpful)**

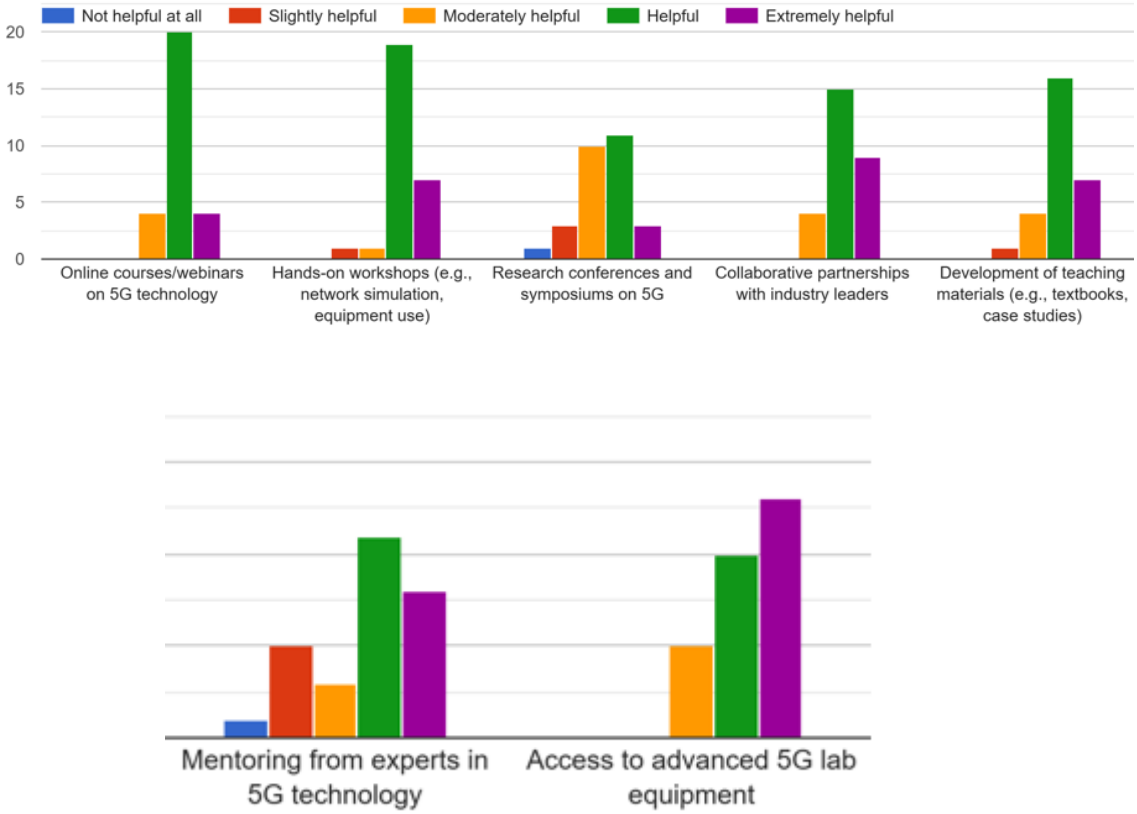

Figure 12 Professional development

13. **Would you be interested in participating in a 5G-focused curriculum development group or task force?**

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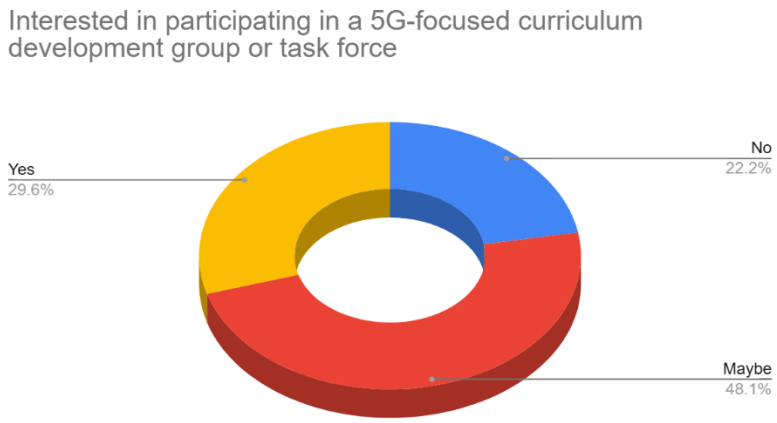

Figure 13 Interest in participating

Section 5: University Infrastructure and Collaboration

14. **Does your university currently offer any courses or programs specifically focused on 5G technologies?**

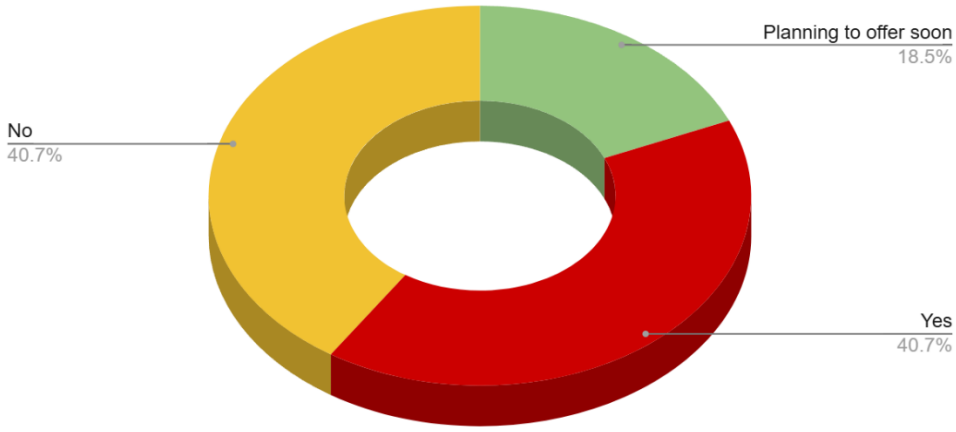

Figure 14 Related 5G courses

15. **What resources or partnerships would be most helpful to support the integration of advanced 5G technologies in the curriculum?** (Select all that apply, up to three most important)

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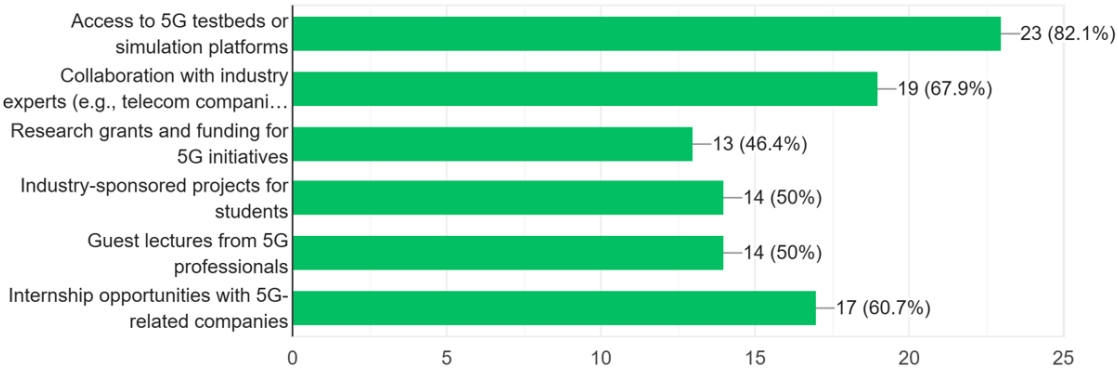

Figure 15 Helpful resources

16. **Are there any specific topics or emerging trends in 5G technology that you believe should be prioritized in the university curriculum?**

    - Data management and analysis with latest techniques (AI ML)
    - Security in the face of the emerging quantum threat
    - Network architecture, Softwarization
    - Network management
    - Edge computing, IoT, network planning, SDN
    - Its evolution to 6G
    - Block chain
    - Role of AI/ML in 5G
    - Entrepreneurship in the 5G area
    - Big data and internet of the things

Section 6: Final Thoughts

17. **What are the most important outcomes you hope to achieve by incorporating 5G technology into university programs? (Select all that apply)**

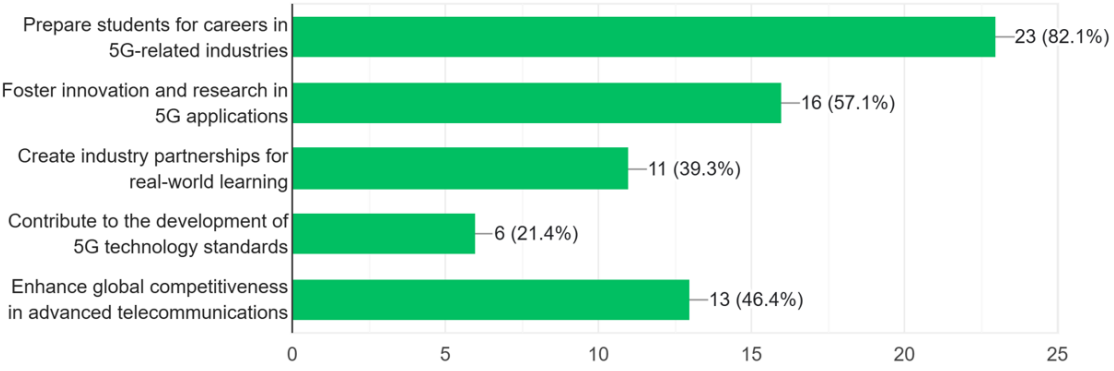

Figure 16 Important outcomes

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18. **Please provide any additional comments or suggestions on how to effectively integrate 5G technologies into university curricula and research:**

- The first step would be to give talks about what we can achieve with 5G in the classroom to spark students' curiosity. That curiosity might eventually lead the institution to explore the possibility of introducing this technology.
- Create events such as competitions and hackathons to create awareness and participation. The adoption of interactive methodologies in teaching to reach more students.
- Support for hands-on experience and laboratory activities
- Set up a simulated environment of a 5G network in a server using open-source tools to provide hands-on lab experience in a relatively easy and cost-effective manner.
- Provide clear unique selling points / use-cases for 5G not possible by other technologies. Also, 5G is commercialized, but development is ongoing with 6G. Do not get stuck on 5G. It will be replaced in coming years and eventually be shut down like 2G and 3G. Make students learn and understand the basic challenges trying to be solved, coverage, capacity, latency, system component dependencies to handle subscriptions, lookup, data-plane tunnel/transport etc. and how this has evolved in pre-5G, 5G and beyond 5G systems.
- Introduce them not only in Telecommunications and electrical engineering, do it more traversal.
- Design complete MSc programs exclusively on 5G and beyond (not only courses as part of a more general program on mobile communications).

B.2. Students

The project managed to attract responses from 44 students with different profiles in terms of country, university, specialty, maturity and background. Below we present the results of their questionnaires.

Section 1: Demographics

1. **University Name:**

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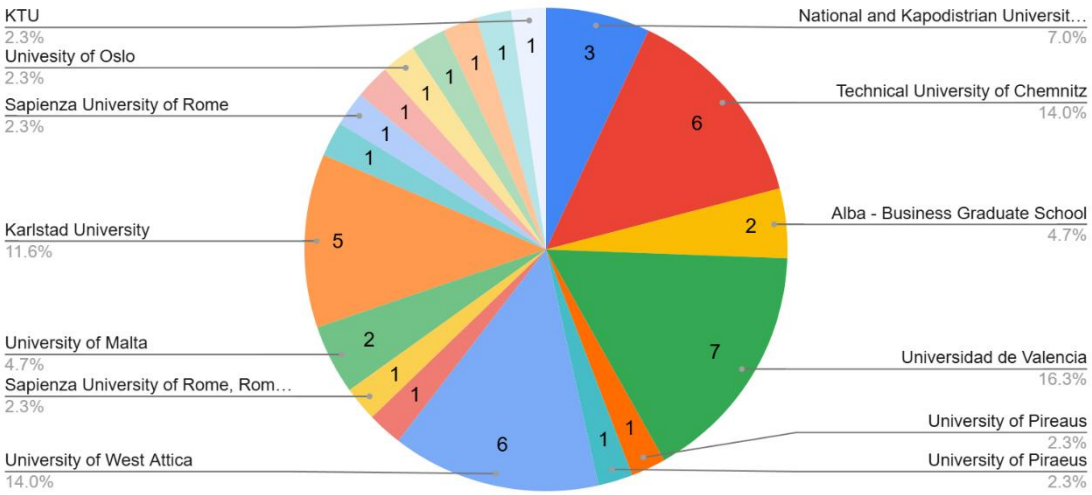


Figure 17 University name

2. **Department/Faculty:**

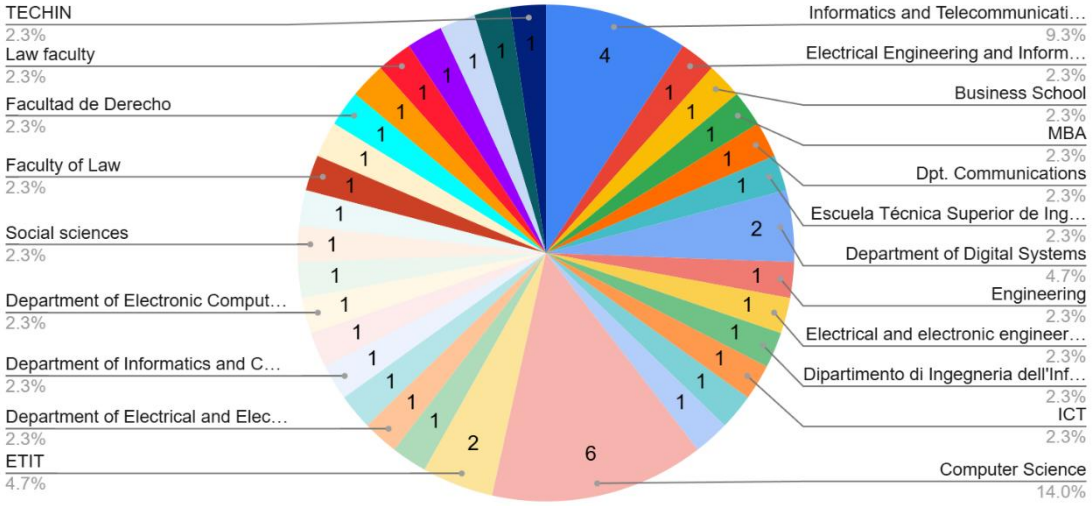
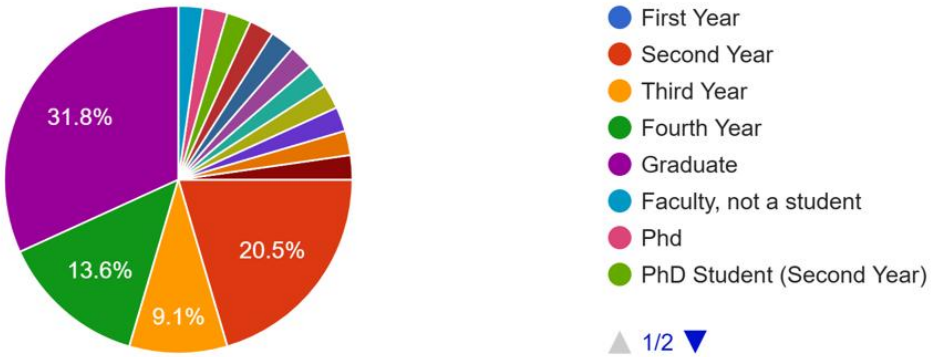


Figure 18 Department

3. **Year of Study:**



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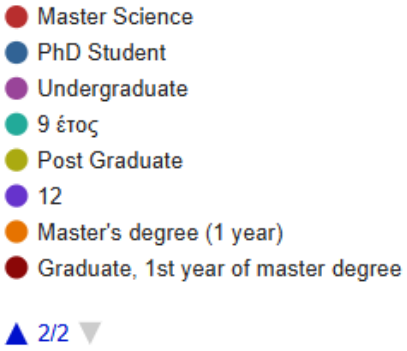

Figure 19 Year of study

4. **Major/Program of Study:**

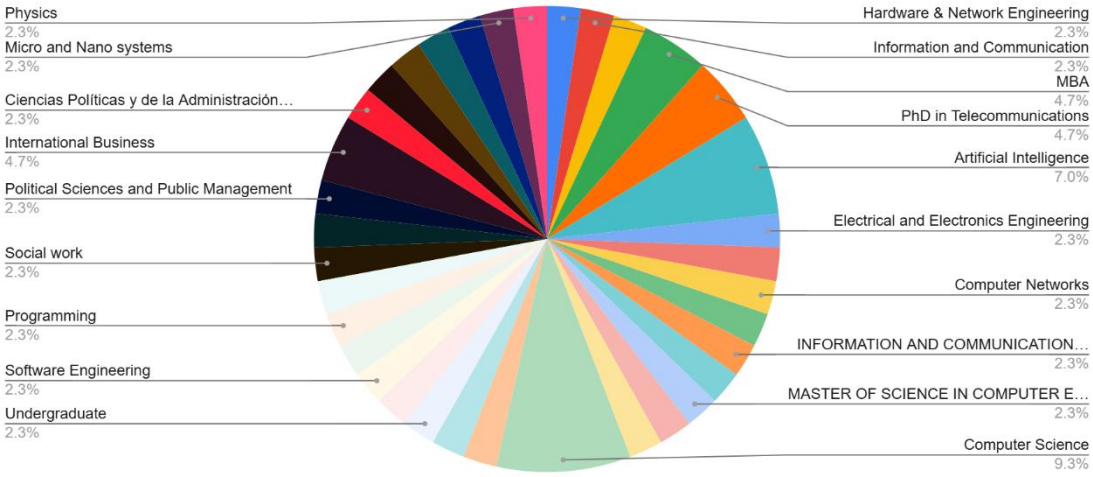

Figure 20 Program of study

Section 2: Current Knowledge of 5G Technology

5. **How familiar are you with 5G technology?**

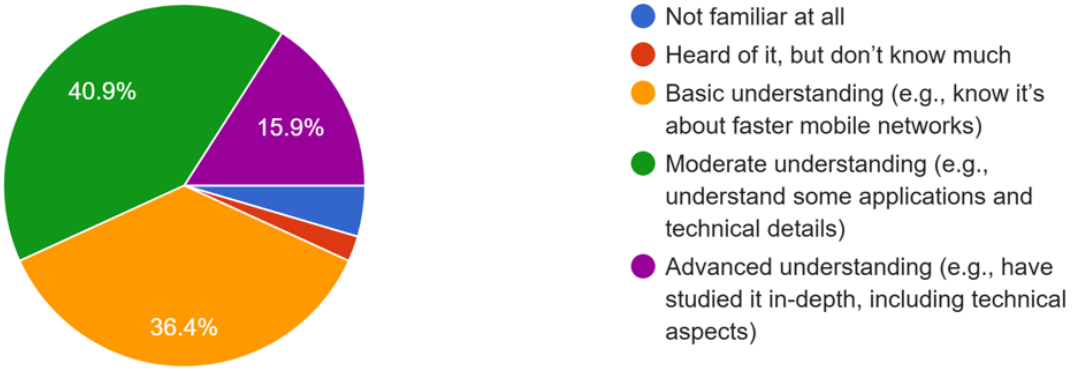

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Figure 21 Familiarity with 5G technology

6. **Which of the following aspects of 5G technology have you learned in your university studies about? (Select all that apply)**

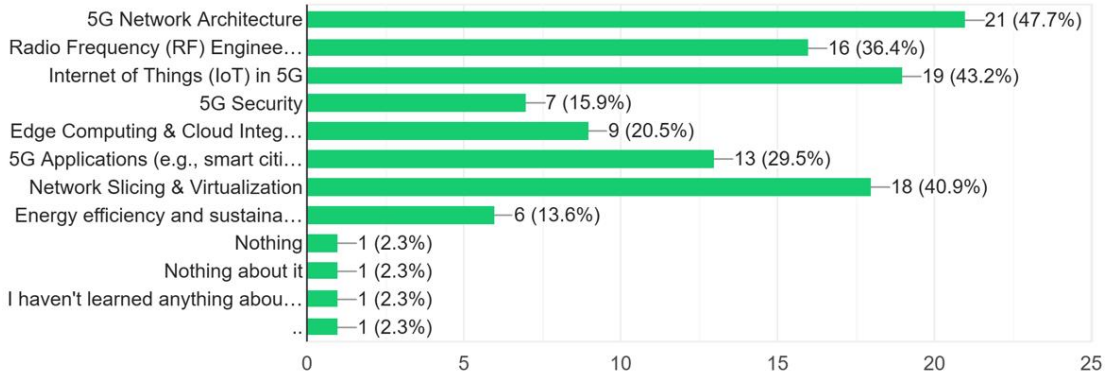

Figure 22 Aspects of 5G learnt

7. **Have you had any formal exposure to 5G technology in your coursework or projects, especially related to Green Industrial solutions (energy efficiency, sustainability, etc.)?**

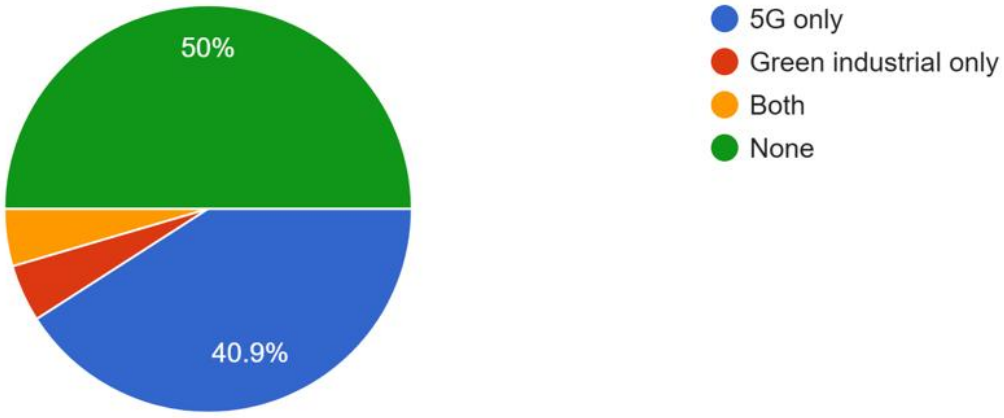

Figure 23 Formal exposure

Section 3: Skills and Knowledge Requirements for 5G

8. **Which of the following skills / knowledge do you believe are important for you to develop in order to work effectively with 5G technologies? (Select all that apply)**

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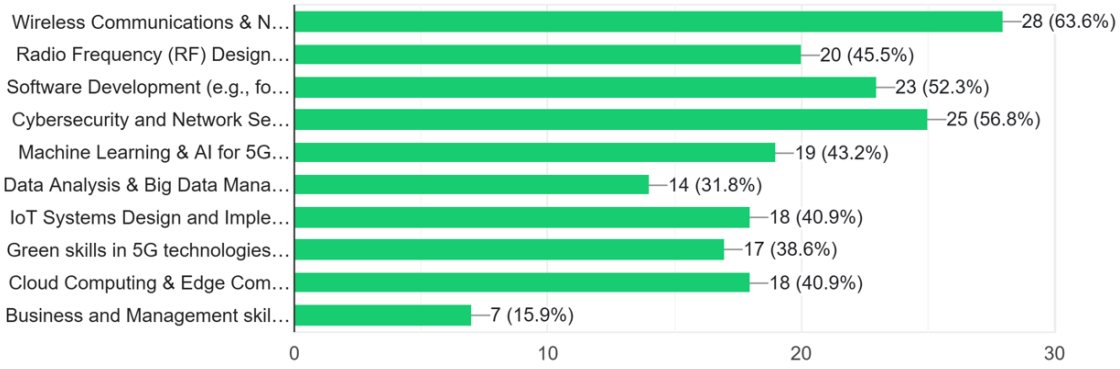

Figure 24 Skills and knowledge requirements

9. **Which of the following interdisciplinary areas do you think are necessary to support 5G technologies? (Select all that apply)**

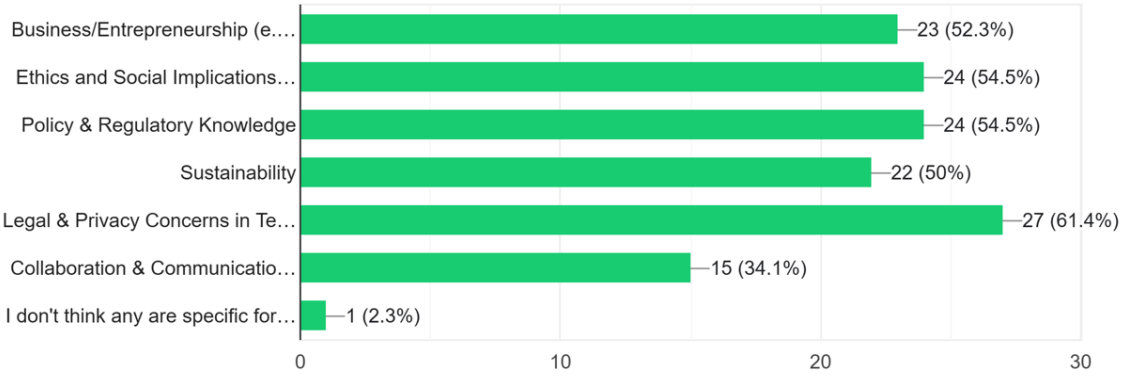

Figure 25 Necessary interdisciplinary areas

Section 4: Interest and Readiness for 5G-related Courses

10. **How interested are you in pursuing further education or training on 5G technologies?**

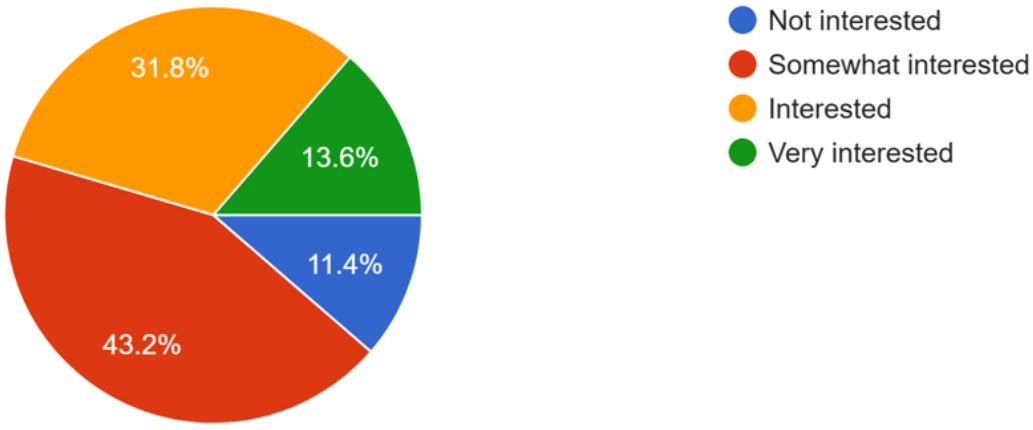

Figure 26 Interest and readiness

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11. **What topics would you be most interested in for learning about 5G technologies?** (Please rate from 1 to 5, where 1 = Not important at all, and 5 = Extremely important)

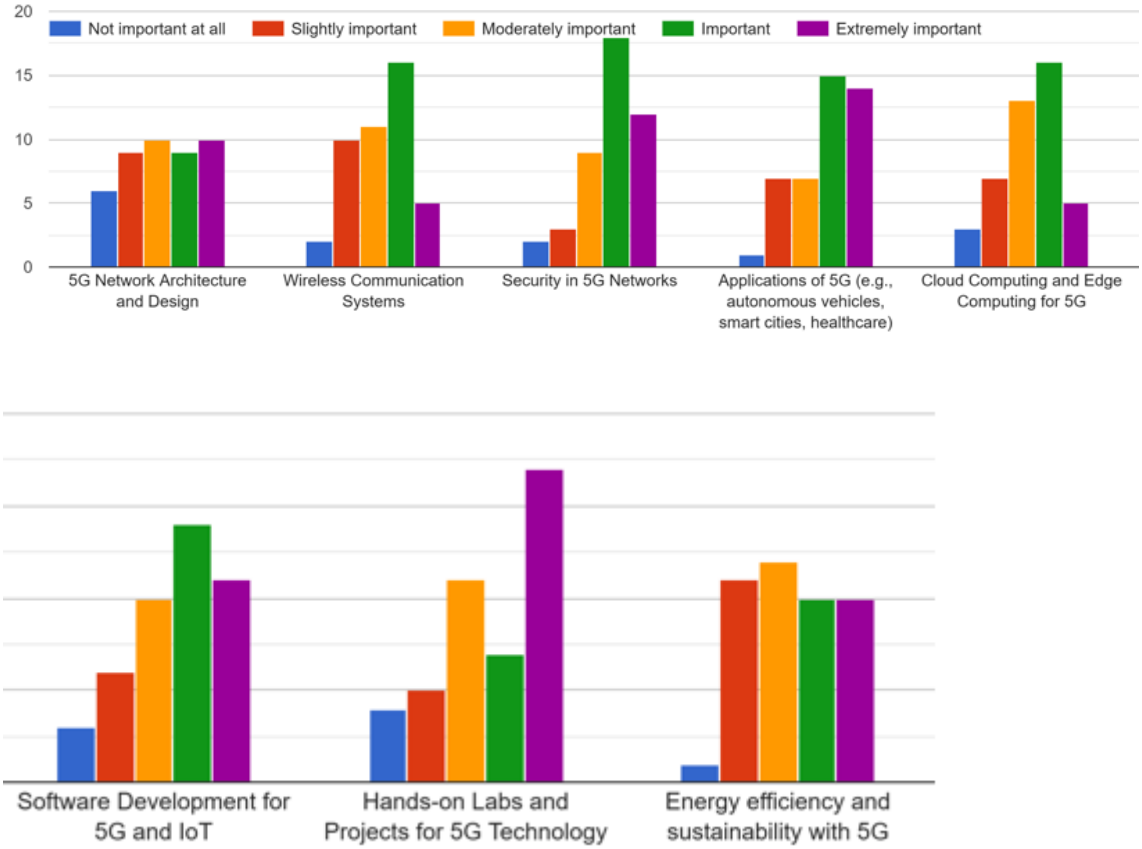

Figure 27 Most interested topics

Section 5: Hands-on Learning and Industry Collaboration

12. **Would you be interested in participating in internships, projects, or research focused on 5G technologies?**

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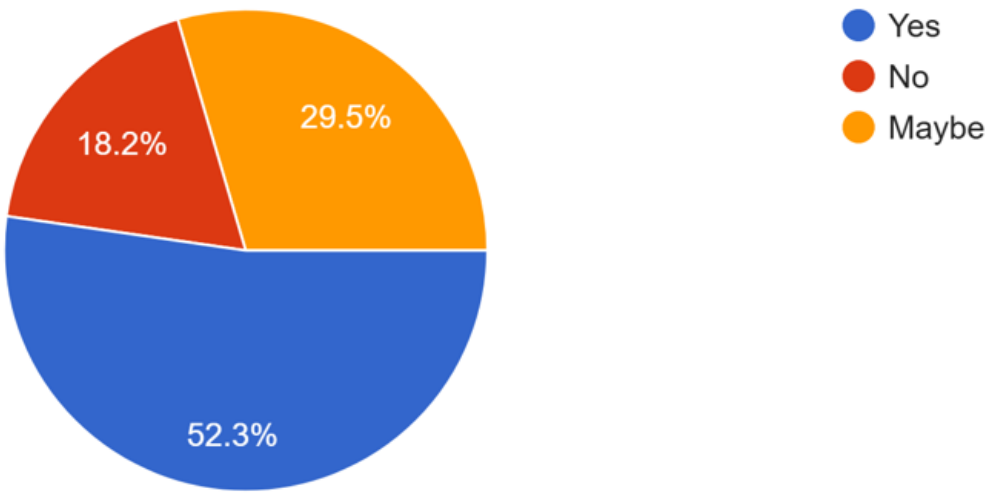

Figure 28 Future interest

13. **What kind of hands-on learning experiences would be most valuable for you in understanding 5G technology? (Select all that apply)**

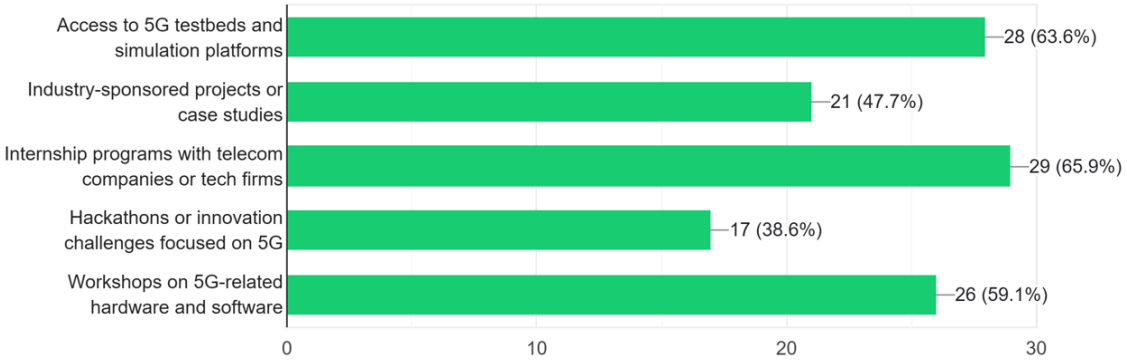

Figure 29 Hands on learning

14. **Do you think university-industry partnerships (with companies in telecommunications, tech, or IoT) would enhance your learning experience about 5G?**

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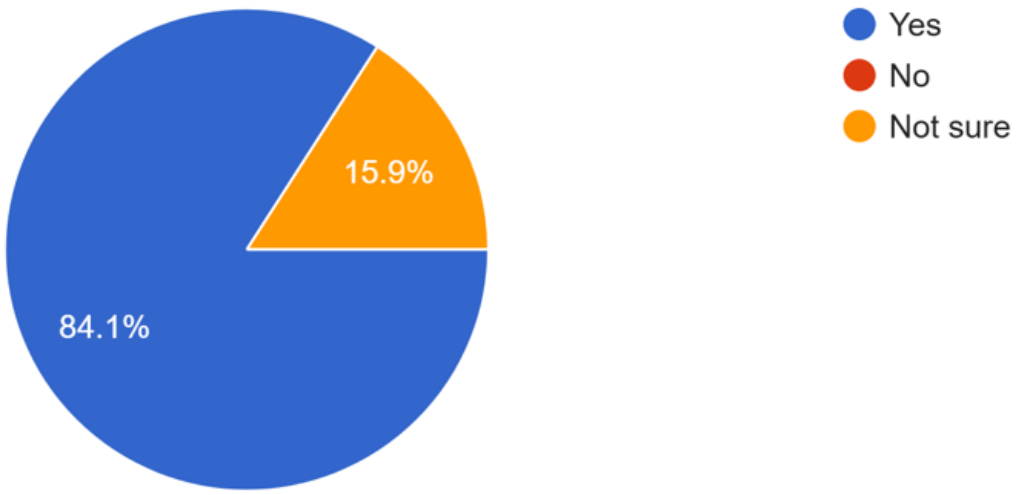

Figure 30 University-industry partnerships

Section 6: Resources and Support

15. **What resources would help you learn more about 5G technologies? (Select all that apply)**

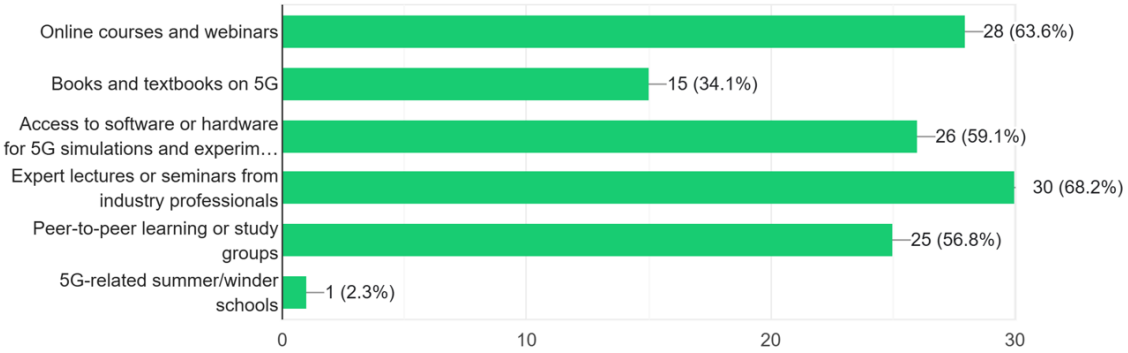

Figure 31 Interesting resources

16. **Would you be interested in joining a student club or network focused on 5G technology and innovation?**

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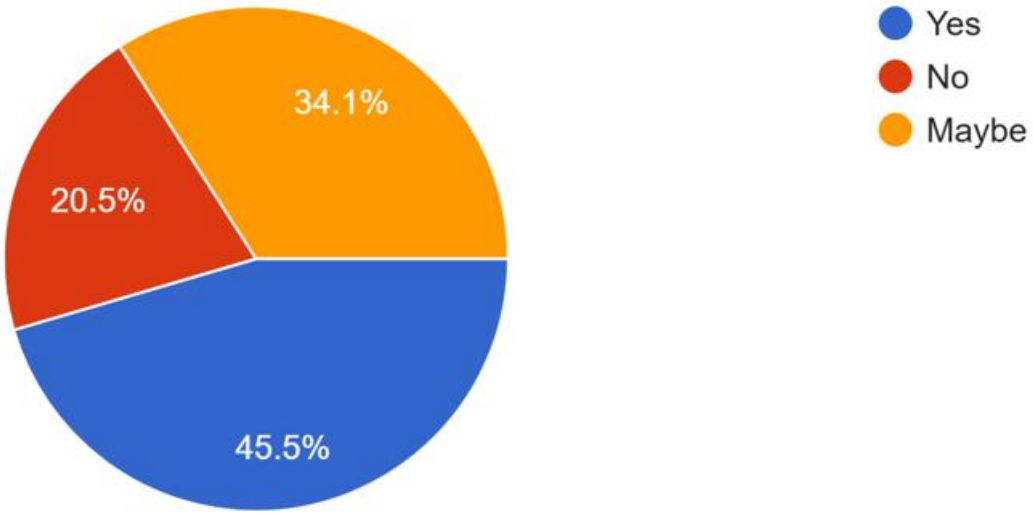

Figure 32 Joining students club

Section 7: Final Thoughts

17. **What do you think are the biggest challenges or barriers to learning and working with 5G technologies?**

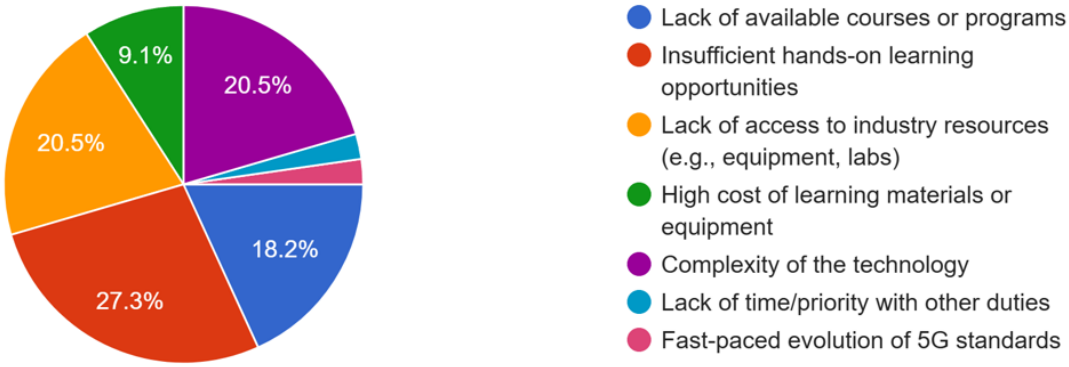

Figure 33 Biggest challenges

18. **Do you have any additional comments or suggestions on how universities can better prepare students for the 5G technology landscape?**

    - In addition to introductory courses on 5G, the universities in collaboration with industry partners can run specialized programs of various types focusing on different aspects of the technology to provide more in-depth understanding.
    - Connect to specific student interests and specific use-cases that are only possible to address with 5G.
    - If students lack basic tech knowledge, jumping into 5G can be overwhelming. Universities should first build a strong foundation

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in essential digital and networking skills before introducing advanced topics like 5G.

- More hands-on workshops, Industry partnerships, Courses focused on 5G applications (like IoT and AI).
- Big gap lab implementation and real-world implementations.

B.3. Industry

The project managed to attract responses from 39 industry representatives with different profiles in terms of country, sector, role, maturity and background. Below we present the results of their questionnaires.

Section 1: Demographics

1. **Industry Sector:**

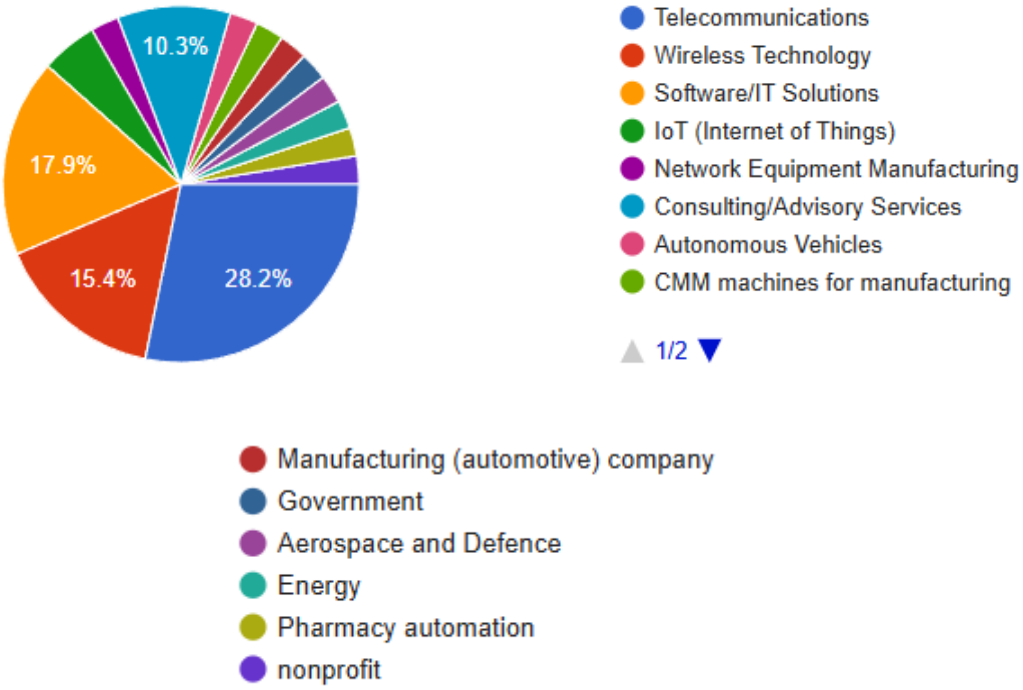

Figure 34 Industry sector

2. **Your Role/Title:**

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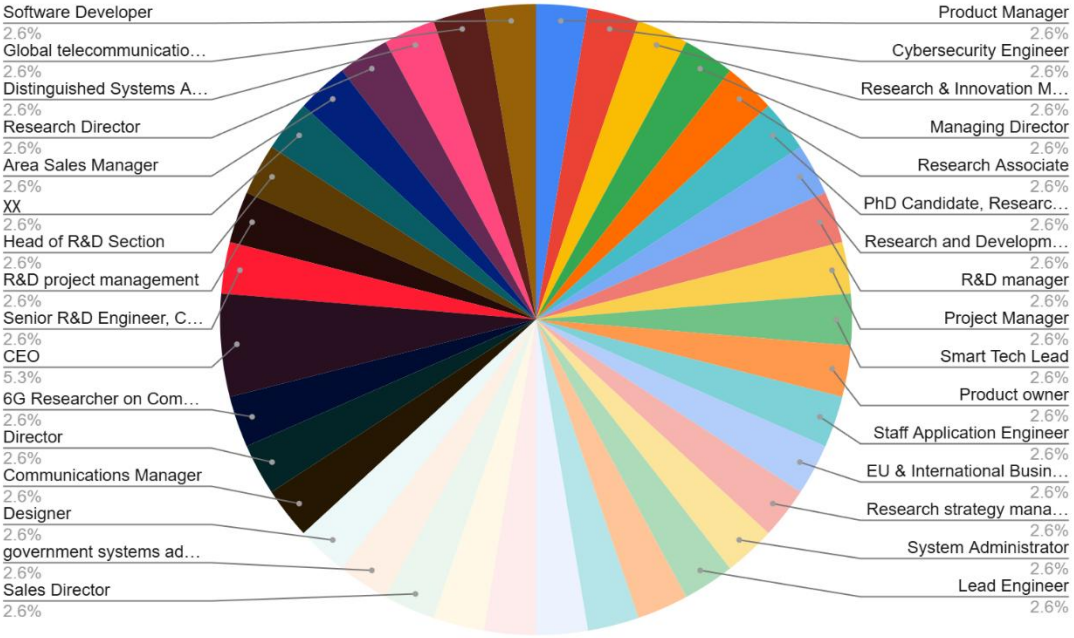

Figure 35 Role

3. **How many years of experience do you have working in the 5G technology space?**

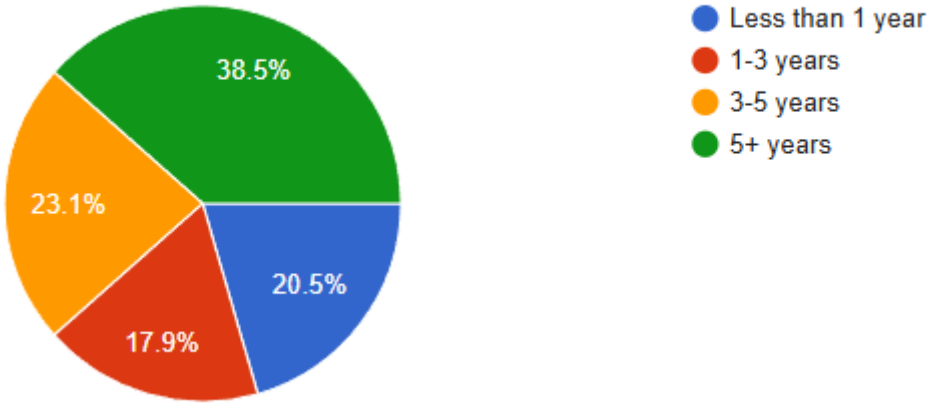

Figure 36 Years of experience

Section 2: Current Industry Needs for 5G Skills

4. **Which areas of 5G technology do you believe are most critical for university graduates to understand and be skilled in?** (Please rate each area from 1 to 5, where 1 = Not important at all, and 5 = Extremely important)

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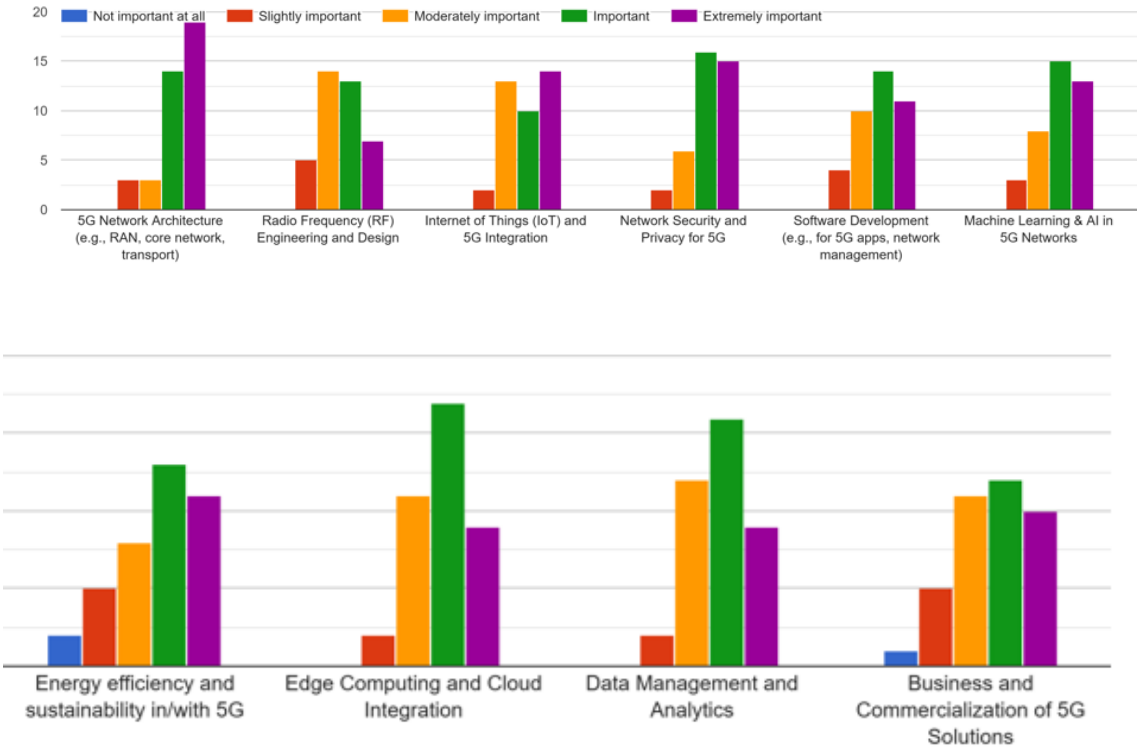

Figure 37 Critical areas

5. **What skills are most needed for professionals working with 5G in your industry?** (Please select all that apply, up to three most important)

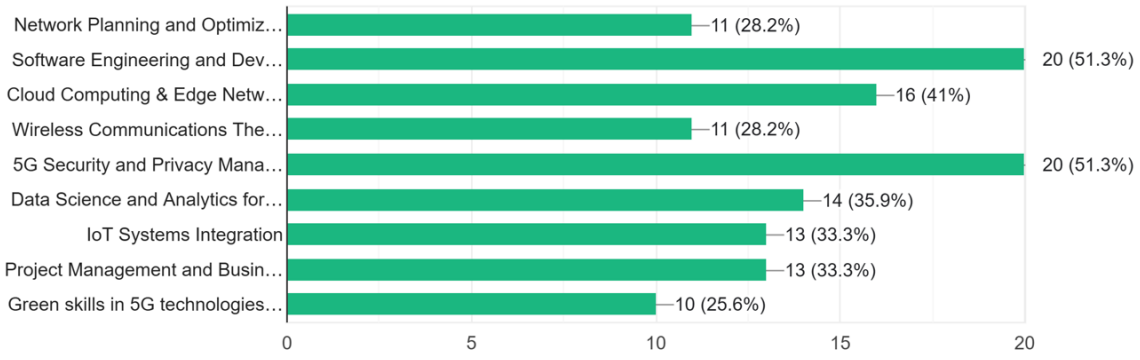

Figure 38 Needed skills

6. **Are there any emerging trends in 5G that universities should focus on to better prepare students for the workforce?**

- Machine Learning & AI in 5G Networks.
- Edge computing and IoT, Private 5G Networks, Advanced applications like AR/VR and autonomous vehicles.
- Cyber security.
- Quantum Machine Learning (QML).

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- Social impact of 5G,understanding the benefits of 5G in the society.
- Sustainability in 5BG communications, Energy efficiency and business adoption.
- ZTNA; Campus networks.
- Physical Layer.
- Network slicing.

Section 3: Industry Expectations for University Graduates

7. **Which of the following competencies do you expect university graduates working in 5G to have?** (Please rate each competence from 1 to 5, where 1 = Not important at all, and 5 = Extremely important)

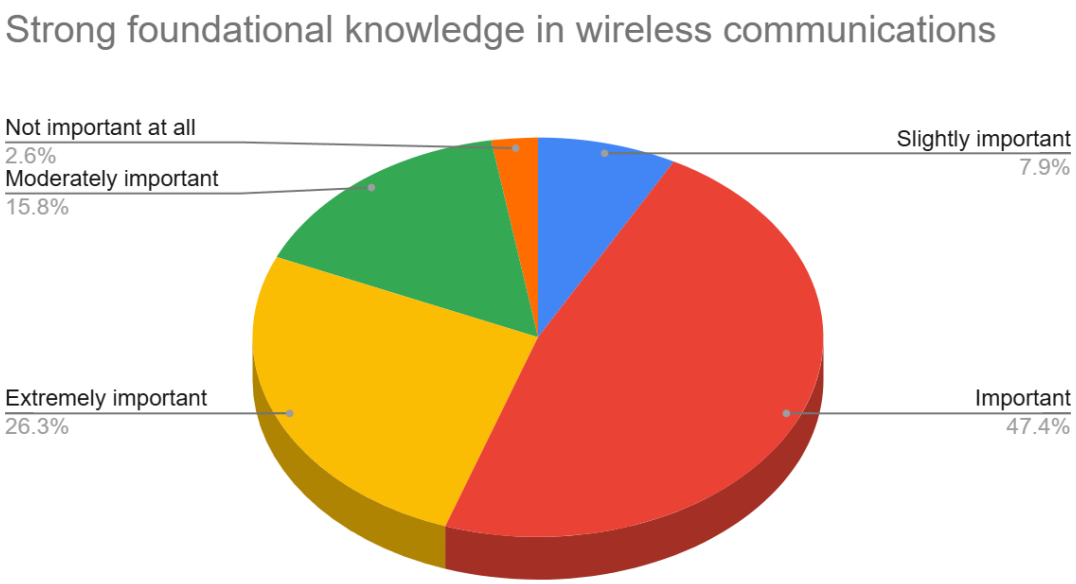

Figure 39 Expected competencies

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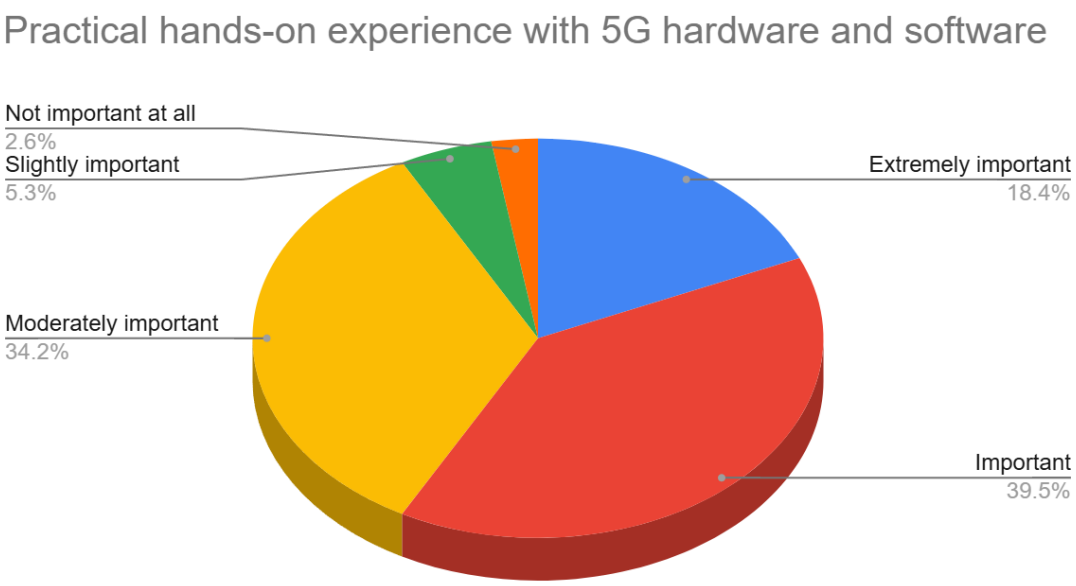

Figure 40 Hands on experience

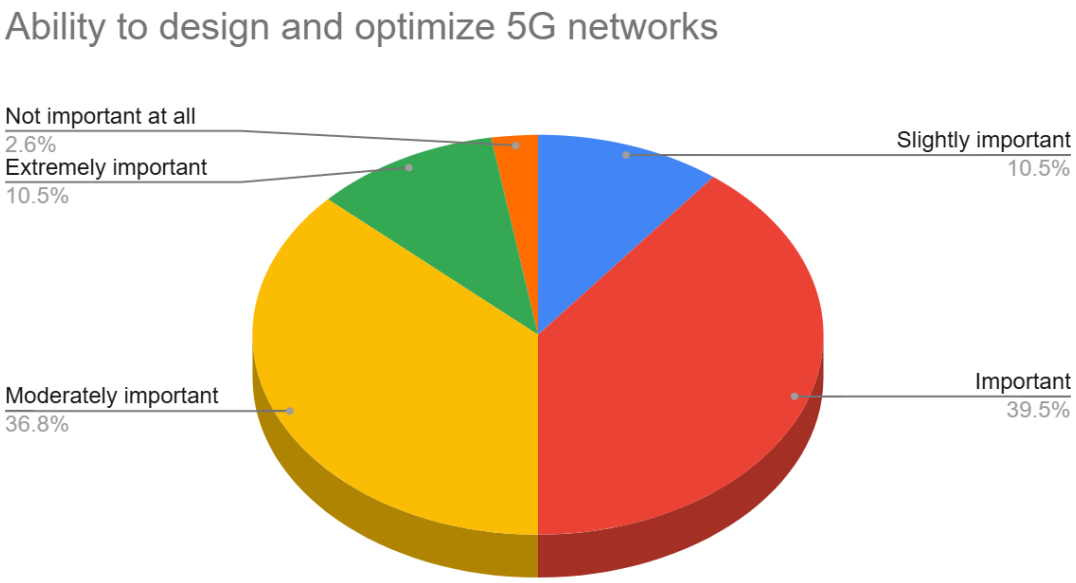

Figure 41 Ability to design

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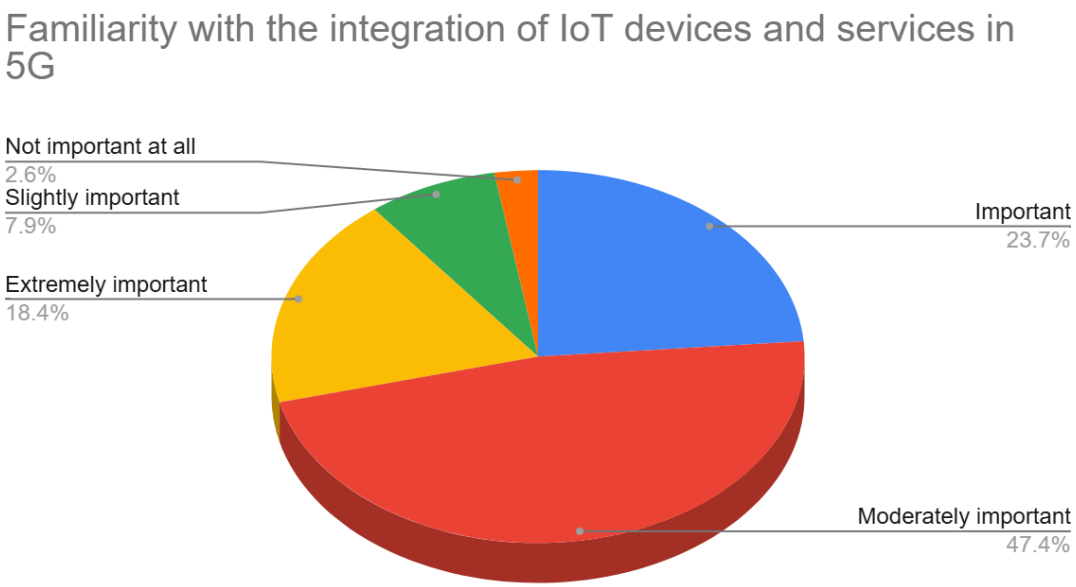

Figure 42 Familiarity with IoT

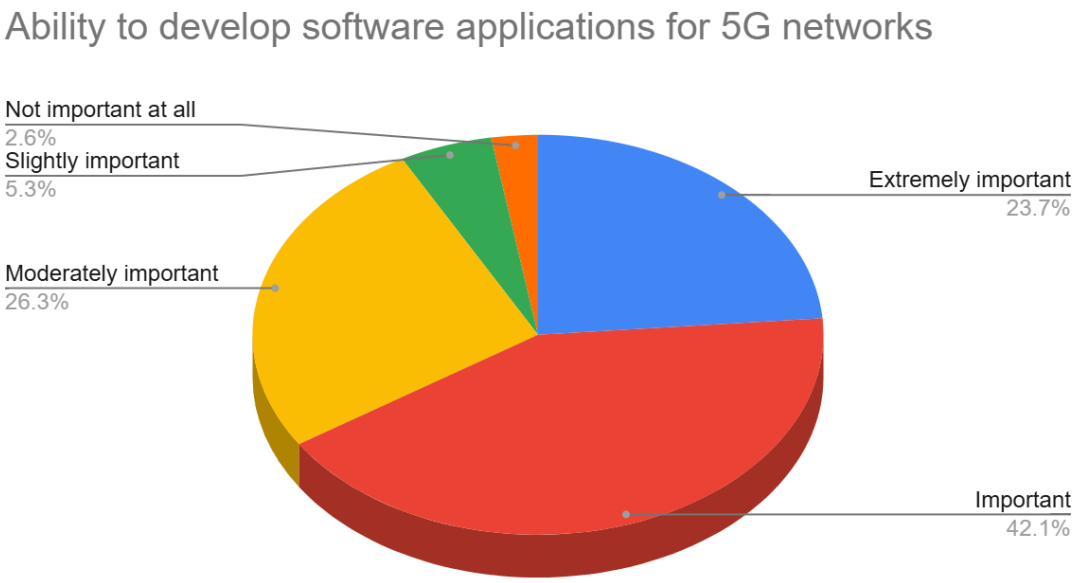

Figure 43 Software applications

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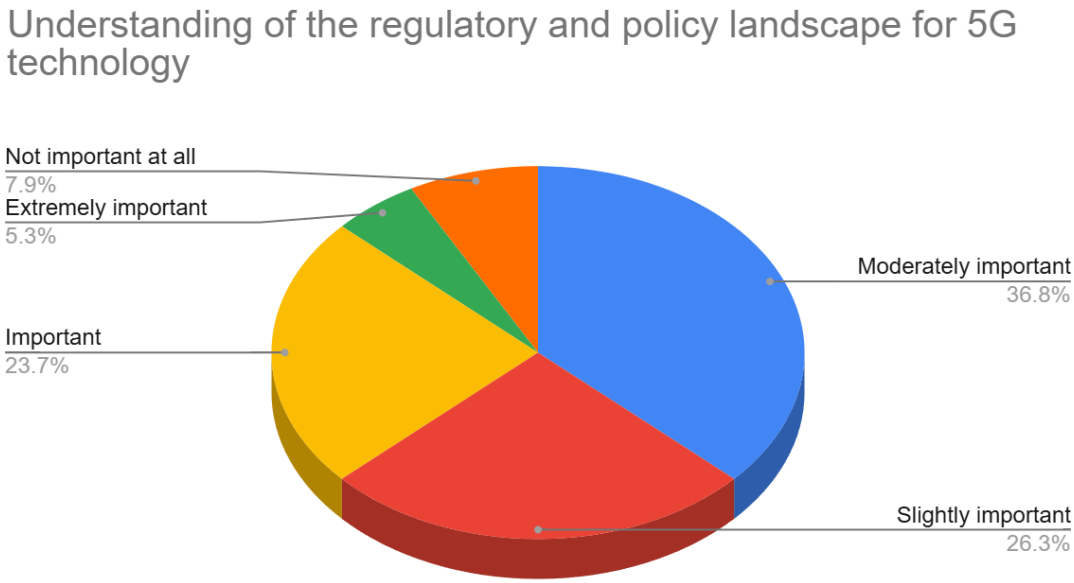

Figure 44 Policy landscape

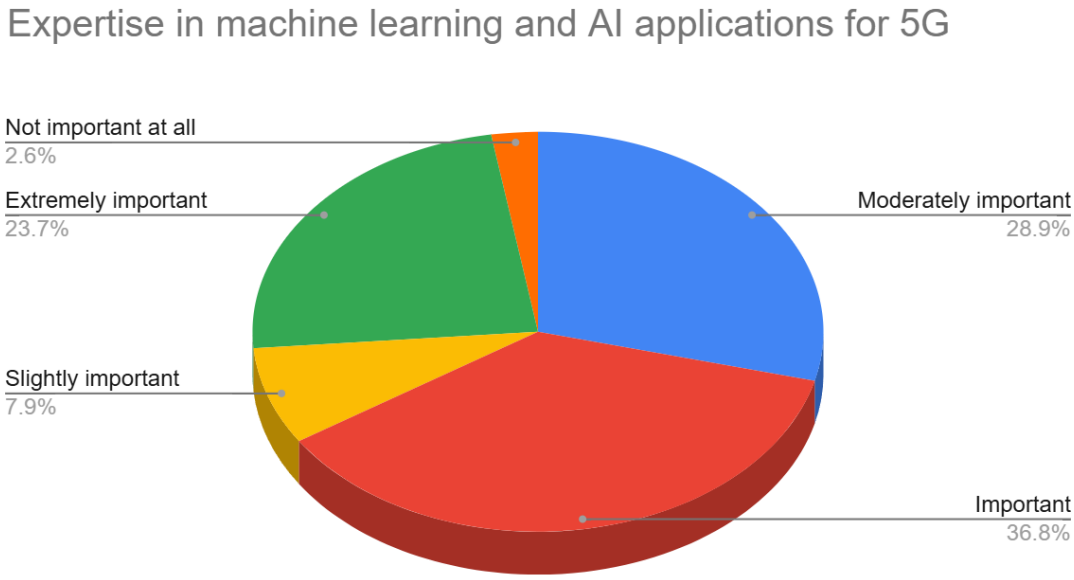

Figure 45 Machine learning and AI

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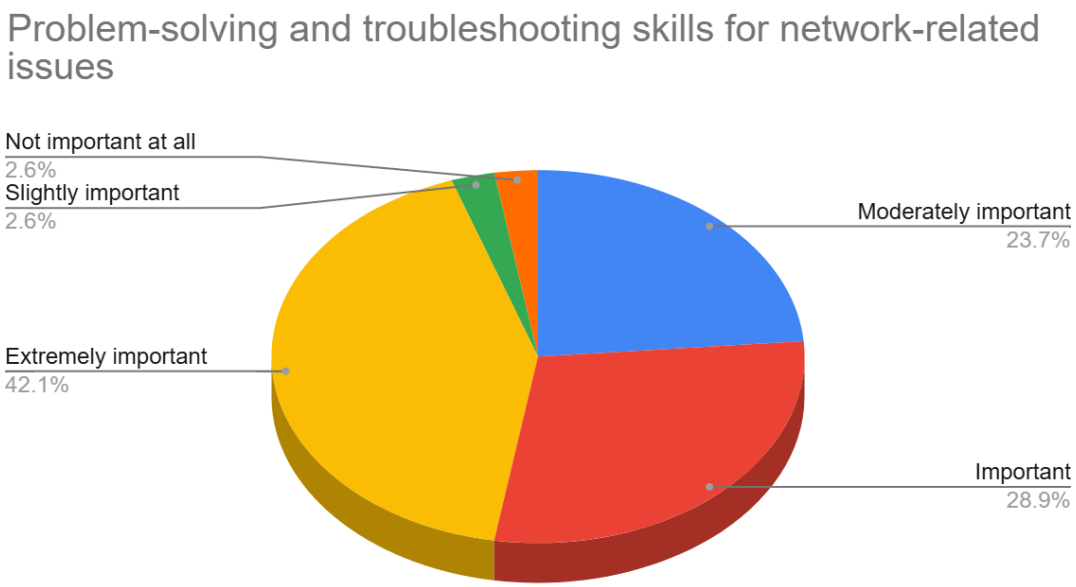

Figure 46 Problem-solving

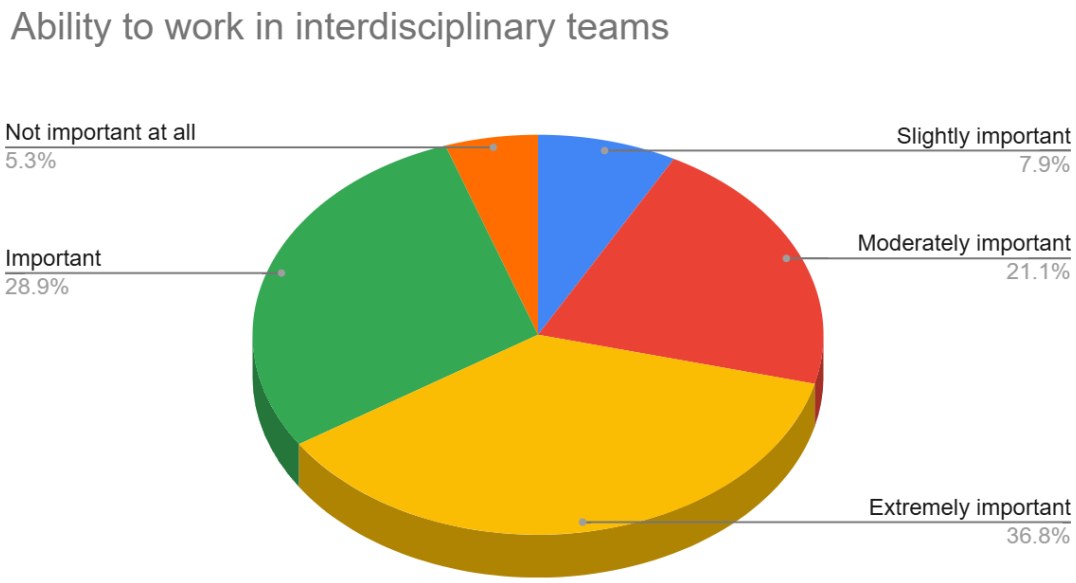

Figure 47 Interdisciplinary

8. **What soft skills do you believe are necessary for university graduates to succeed in 5G-related roles in your industry?** (Please rate each skill from 1 to 5, where 1 = Not important at all, and 5 = Extremely important)

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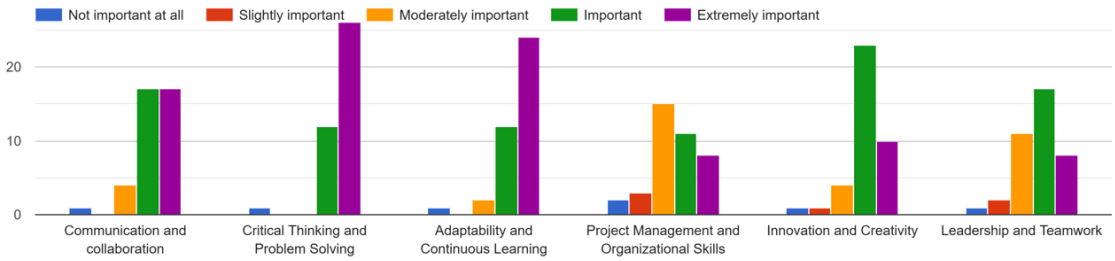

Figure 48 Soft skills

Section 4: Curriculum and Training Needs

9. **What specific technical training or certifications would you recommend for university students entering the 5G technology space? (Select all that apply)**

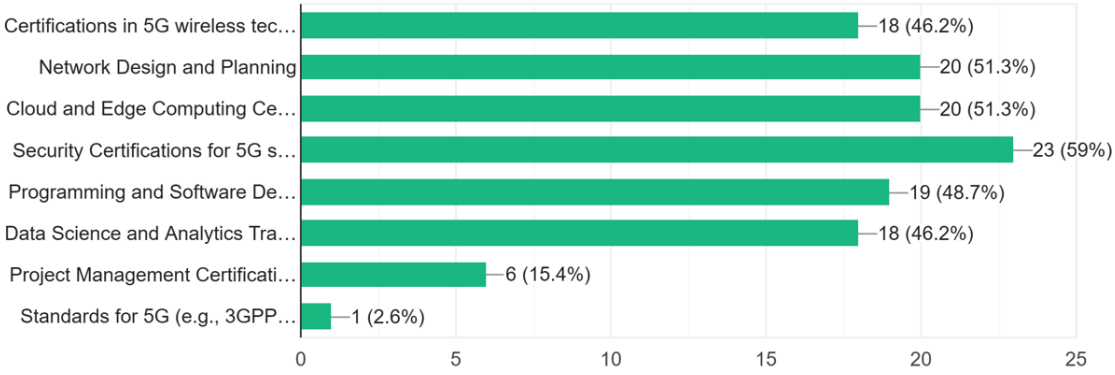

Figure 49 Technical training

10. **Would you recommend universities to develop specialized 5G-related courses and/or programs?**

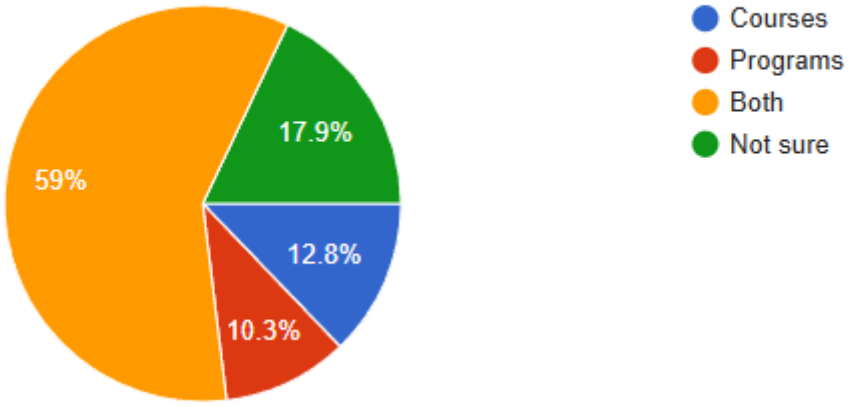

Figure 50 Recommendations

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11. **What role do you think university-industry partnerships (e.g., internships, co-op programs, joint research) can play in developing the next generation of 5G professionals?**

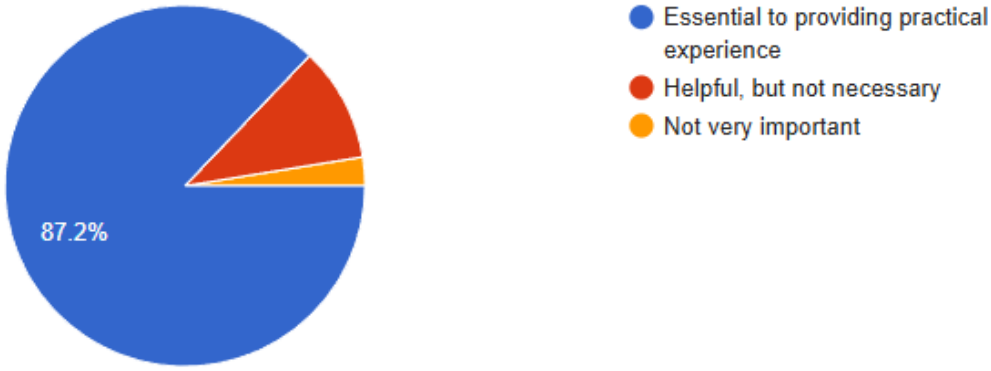

Figure 51 University-industry partnerships

12. **Would your company be open to collaborating with universities to offer internships, co-op programs, or real-world projects for students in 5G-related fields?**

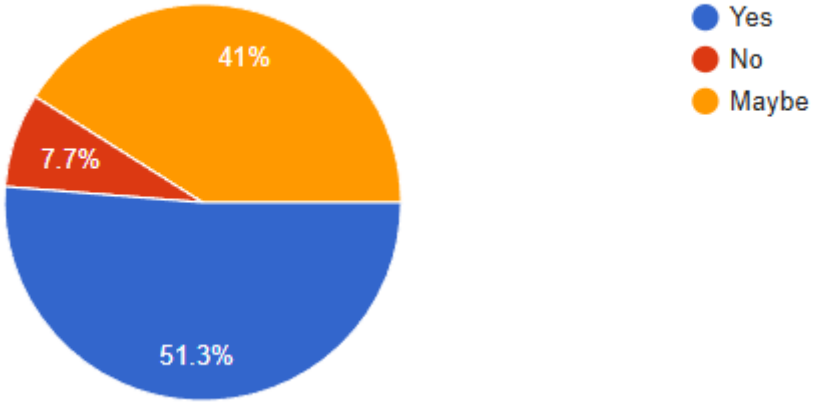

Figure 52 Open for collaboration

Section 5: University Resources and Support

13. **What types of resources do you believe universities should invest in to help students develop 5G-related skills?** (Select all that apply, up to three most important)

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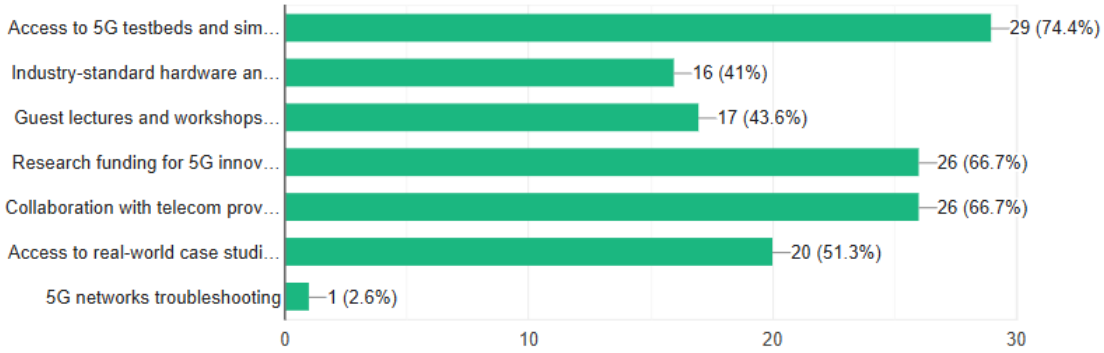

Figure 53 Types of resources

16. **What additional support could universities provide to make their 5G-related courses and programs more industry-relevant?**

- Access to real-world case studies and projects.
- Targeted funding and well-defined collaboration schemes with industry.
- Own labs based on commercial testbeds and good relations with vendors/providers (e.g. cooperation in research/degrees).
- Guest lectures from industry experts.
- Connect 5G graduate students with SW engineering and AI/ML institutions or departments if exist in the same university to create internal collaboration momentum.

Section 6: Final Thoughts

15. **What do you see as the most important factor in ensuring that university graduates are prepared for careers in 5G technologies?**

- Technical skills and adaptability.
- Good preparation to 5G technologies during studies and internship in 5G industry companies.
- Study the real-world challenges of the industry.
- A clear career plan in 5G ecosystem. The different roles (from engineering to project management and S/W development). Need to make 5G roles more attractive.
- The development of a collaborative spirit and flawless teamwork among different disciplines.
- Fundamental background on mobile communication networks (architecture, processes, operation principles). It is also beneficial for the graduate to have a specification in one/two of the many technologies that are related to the 5G and beyond networks and systems.
- Open minded, critical thinking and problem solving attitude, open to learn and adapt

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16. **Do you have any other suggestions for how universities can better align their programs with the evolving needs of the 5G industry?**

- Adapt to constant change.
- Focus on Interdisciplinary Learning.
- Combine 5G with fields like AI, cybersecurity, and IoT to prepare students for cross-functional roles. Offer Certification Programs.
- Provide industry-recognized 5G certifications to boost student employability and technical credibility.
- Unis should be present in ITU, ETSi, 6G-SNS etc.
- Continuous improvement and adaptation of the program based on feedback from former students and industry. Universities should work with the government to develop a strategy for tech independence.
- Work closer with industry to understand their needs, such as the evolution of the market needs. Now S/W programmability and skills for network developers is needed as much as engineers that lay fiber for FTTx deployments.
- Necessity to create cooperative schemes with industry partners so that present applied use cases and real market scenarios (e.g. from on going (EU-funded or other) projects).

B.4. Policymakers

The project managed to attract responses from 8 policymakers with different profiles in terms of country, position, specialty, maturity and background. Below we present the results of their questionnaires.

Section 1: Demographics

1. **Organization/Agency Name:**

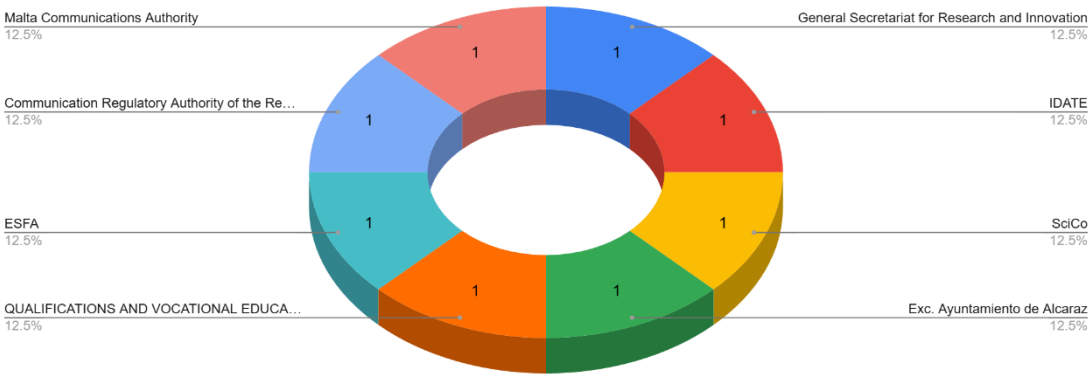

Figure 54 Organization

2. **Position/Role:**

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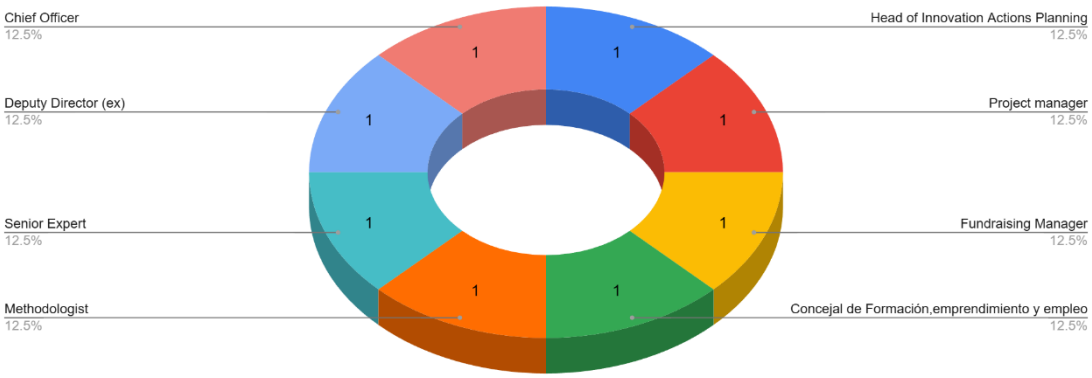

Figure 55 Role

3. **Country/Region:**

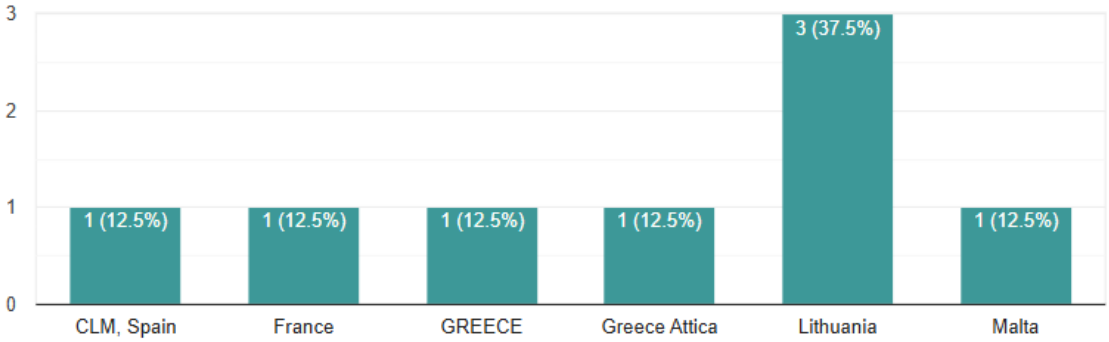

Figure 56 Country

4. **Years of Experience in Policy Development for Technology/Education:**

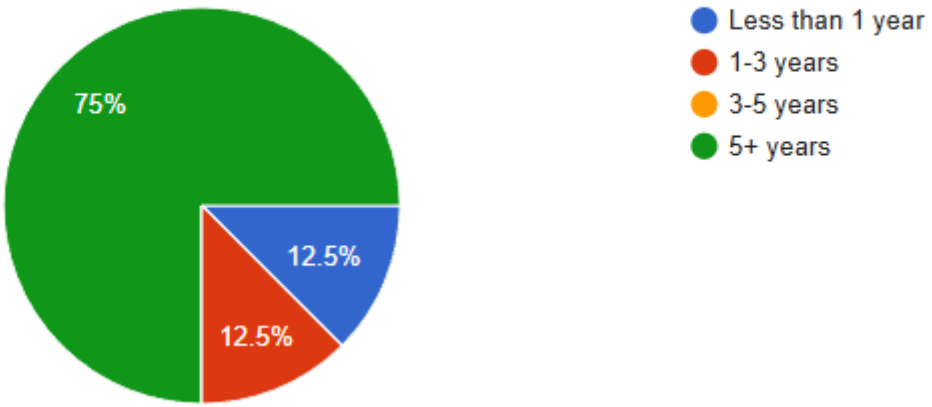

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Figure 57 Years of expertise

Section 2: Current Understanding of 5G Technology and Its Impact

5. **How familiar are you with 5G technology and its implications for society, the economy, and the workforce?**

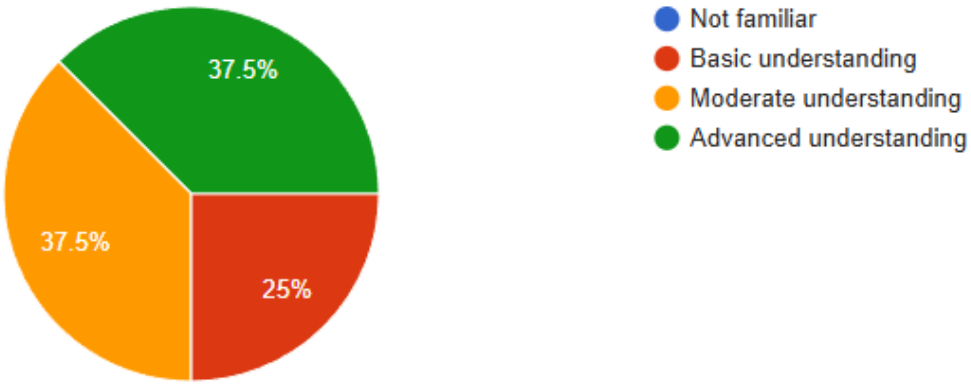
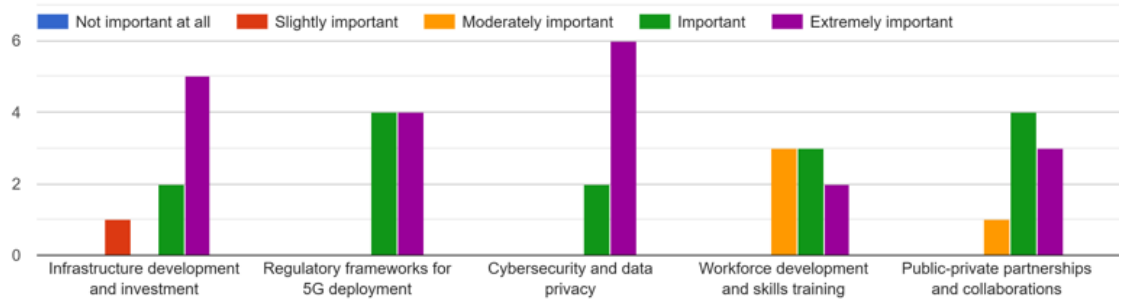


Figure 58 Familiarity

6. **Which of the following areas do you believe are most crucial for policy development in the context of 5G?** (Please rate each area from 1 to 5, where 1 = Not important at all, and 5 = Extremely important)



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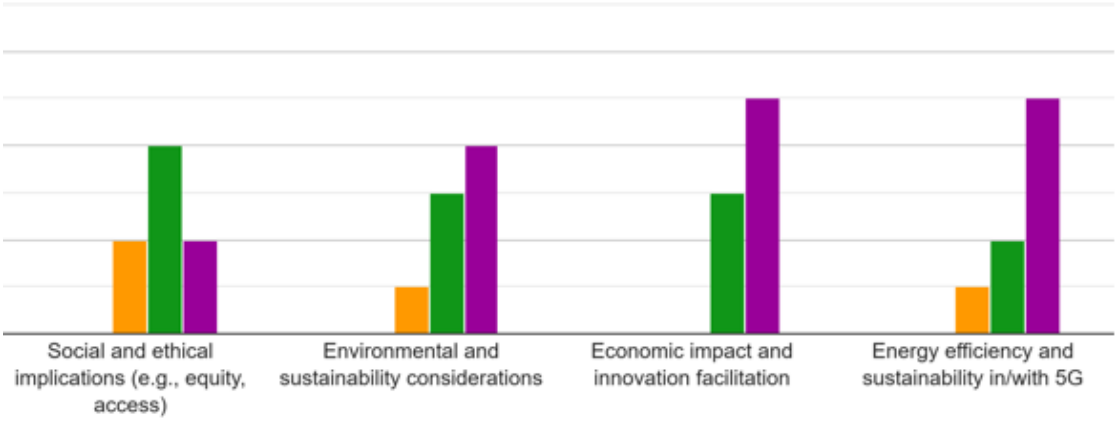

Figure 59 Crucial areas

Section 3: Skills and Competencies for the 5G Workforce

7. **In your opinion, in which of the following areas, effort is needed by policy-makers to enhance competitiveness in the emerging 5G job market?** (Please rate each area from 1 to 5, where 1 = Not important at all, and 5 = Extremely important)

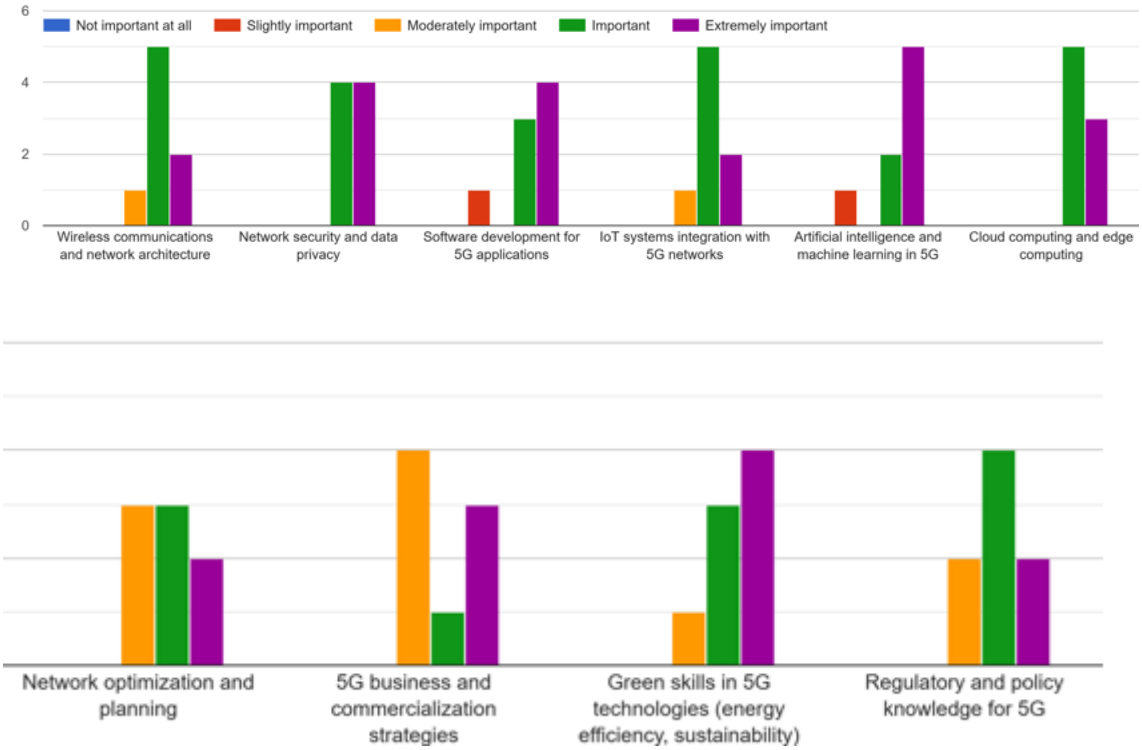

Figure 60 Policy-making areas

8. **What are the most critical soft skills / knowledge that you believe will support successful careers in 5G technology?** (Please rate each skill from 1 to 5, where 1 = Not important at all, and 5 = Extremely important)

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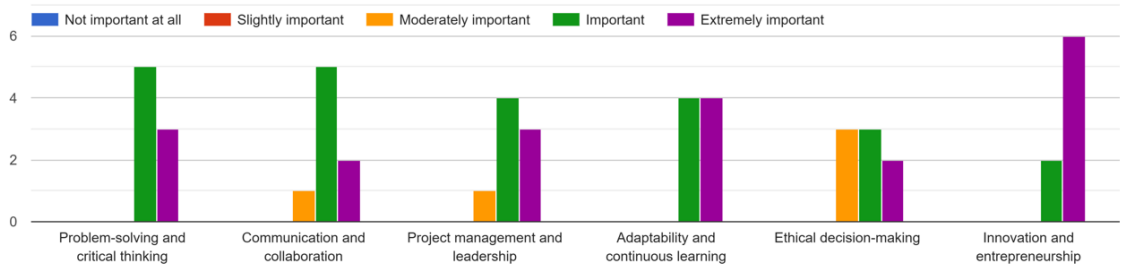

Figure 61 Critical soft skills

Section 4: Role of Universities in Preparing the 5G Workforce

9. **What role do you believe universities should play in preparing students for careers in 5G technologies?**

Figure 62 Role of universities

10. **How important is it for universities to integrate interdisciplinary training (e.g., combining technical skills with policy, business, or social sciences) to address the challenges of 5G deployment?**

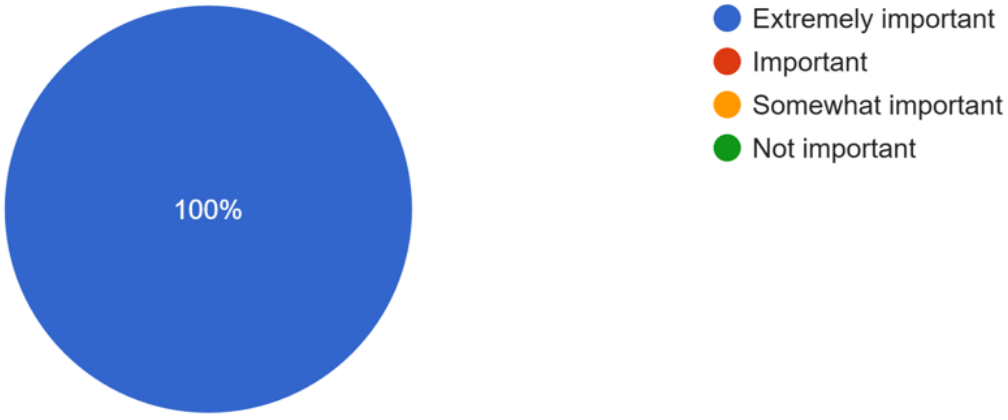

Figure 63 Interdisciplinary training

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Section 5: Policy and Funding Support for 5G Education

12. **What kind of policy initiatives or funding support do you think are needed to help universities develop the necessary programs for 5G workforce preparation? (Select all that apply)**

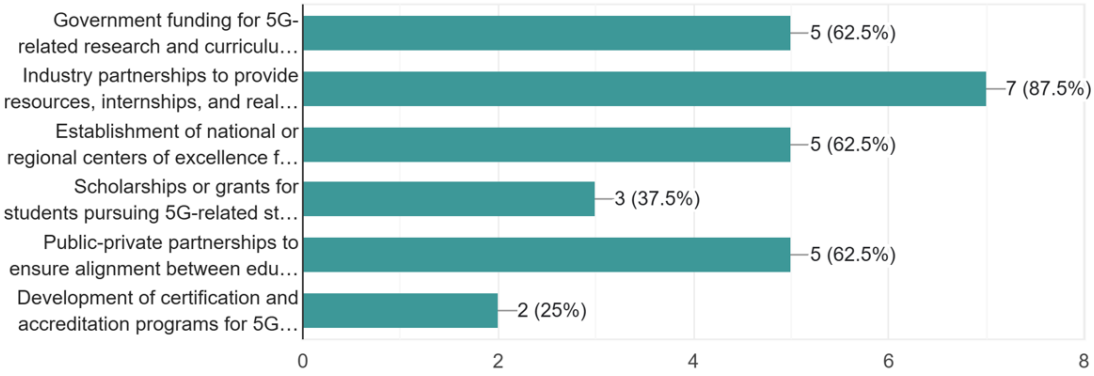

Figure 64 Policy initiatives

13. **To what extent, if at all, should government policies be involved in the development of 5G talent and expertise in higher education?**

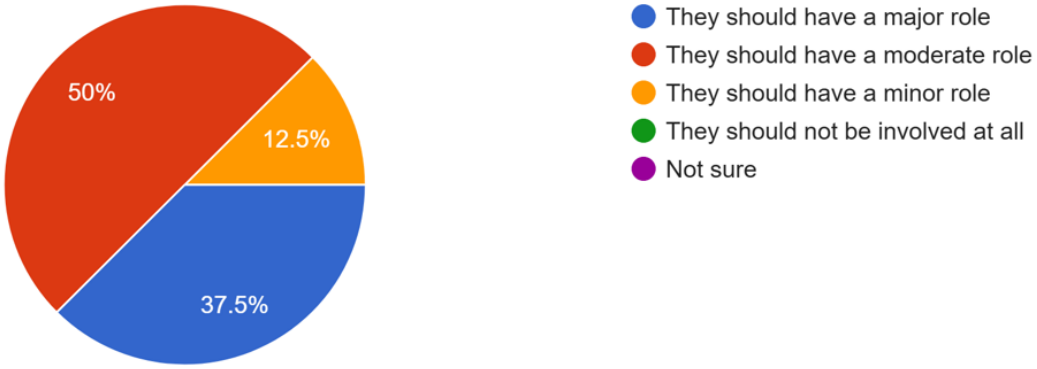

Figure 65 Involvement of policies

14. **To what extent do you perceive a gap in government policies designed to support the development of 5G talent and expertise in higher education?**

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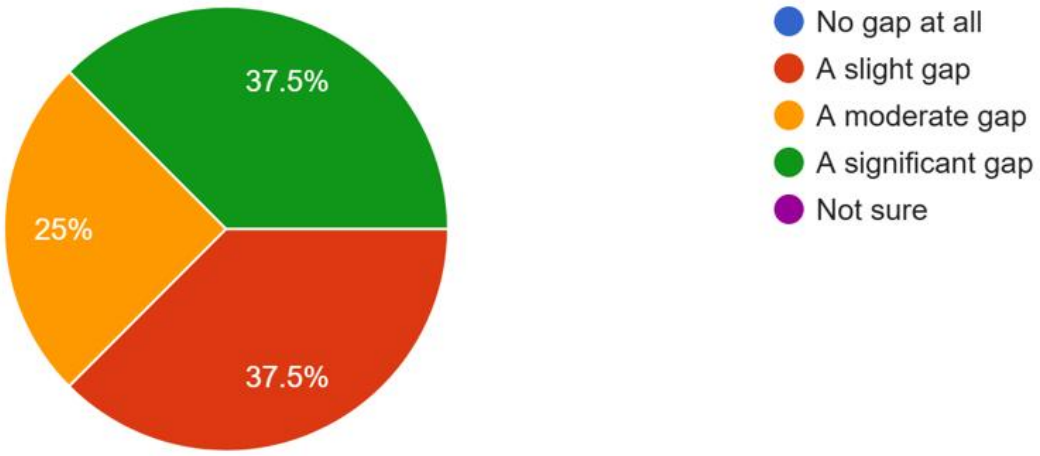

Figure 66 Gap in policies

15. **What are the biggest challenges you foresee in developing a skilled 5G workforce through higher education? (Select all that apply, up to three most important)**

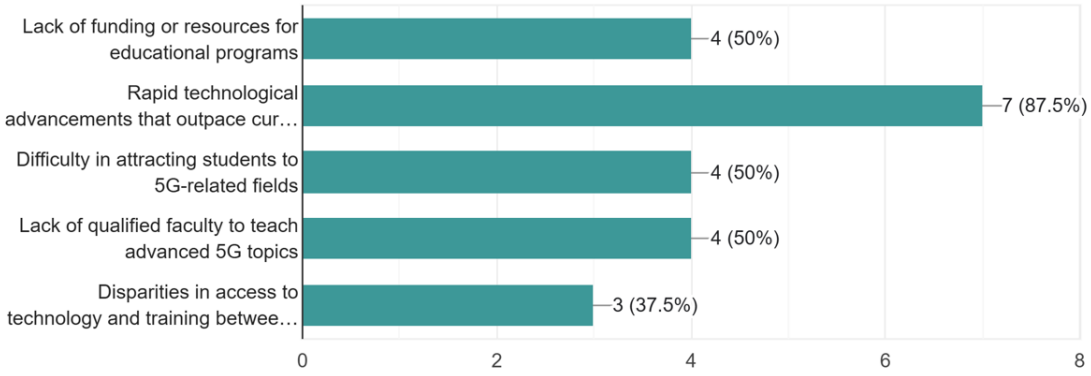

Figure 67 Biggest challenges

16. **How can universities and the government collaborate to ensure the workforce is prepared for the demands of 5G technology? (Select all that apply, up to three most important)**

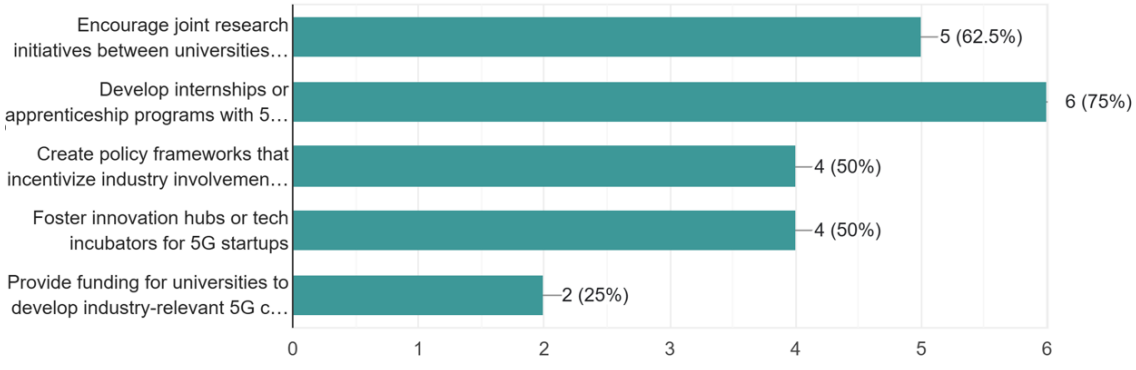

Figure 68 Collaboration with universities

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Section 6: Collaboration and Industry Engagement

17. **Would you be open to supporting or participating in initiatives that aim to align university education with the needs of the 5G industry (e.g., advisory boards, curriculum design, research projects)?**

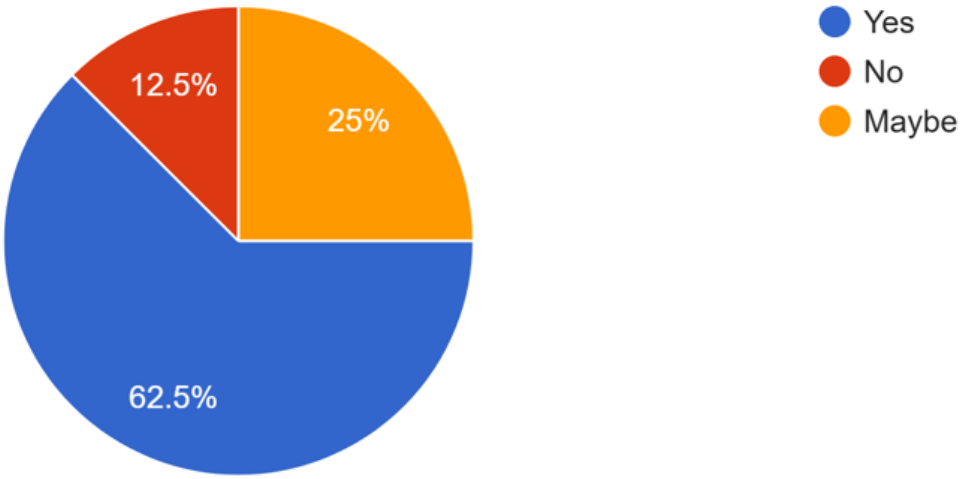

Figure 69 Open to support

Section 7: Final Thoughts

18. **What are the top three priorities that policymakers should focus on to ensure the effective development of 5G-related skills in universities?**

- Let businesses do the business by providing supporting regulation and reducing bureaucracy.
- Facilitating industry collaboration; seeding relevant use cases; supporting TRL 5+ research.
- Ethics, data privacy and 5G-enviromental projects.
- Training educators and supporting students with scholarships and specialized programs.
- Promotion and investment into related RDI (public and private), providing sound standards and investing in cybersecurity curricular and establishing ecosystemic collaboration platforms between policy makers, educators and businesses in the field.
- Accuracy, homogeneity, innovation.
- Curriculum Modernization & Industry Alignment; Investment in Infrastructure & Research; Faculty Development & Industry Collaboration.
- Promote collaboration between enterprises and academia/research centers, mobility of researchers between public and private sector.

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19. **What additional comments or recommendations do you have for aligning university programs with the needs of the 5G workforce?**

    - Any approach should look beyond 5G, pursuing advanced communications infrastructure and their use-cases, ideally with a technology-neutral approach.
    - The importance of stuff excellence cannot be overstated, especially at the launch of new teaching modules or programs.
    - Universities should offer hands-on training like internships.
    - To talk with industry more.

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