Report about the analysis of educational gaps identified in the different regional contexts and action fields

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Content

1. Introduction and objective

The European Commission (EC), in its report "Bio-based economy in Europe: state of play and FUTURE potential" (2011)[1], identified as proposed action the need to support the development of a bio-based economy, the enhancement of the creation of jobs and ensuring availability of required skills through dedicated training programmes (e.g. the Marie Curie Actions or national equivalent), facilitating researchers' mobility between academia, industry and policy, regulatory and media environments, and defining appropriate education targets. Four years later, in the report "A roadmap to a thriving industrial biotechnology sector in Europe" (2015)[2], the availability of skills and high-qualification staff was still an issue to be addressed, as one of the barriers affecting industrial biotechnology opportunities in Europe identified was the lack of skills to drive the sector forward. By then, again the action related to the development of a workforce that can maintain Europe's competitiveness in industrial biotechnology was pointed out, highlighting that "There is a crucial need to identify skills gaps and how these can be filled".

In order to address this issue, the UrBIOfuture project proposes the following main objectives:

1. To map completed and ongoing programmes addressing curricula that involve bio-based activities
2. To foster the interaction and alignment among educational and research institutions and industry.
3. To identify current education and professional gaps and skills mismatch in the bio-based field

Objectives 1 and 2 have been achieved after completion of the following activities:

D.2.2. Mapping and evaluation of existing needs and lacks in professional profiles and skills in the bio-based industry

- D3.2. Comprehensive map of completed and ongoing programmes addressing curricula in the bio-based sector
- D4.1. Results from the dynamic workshop fostering dialogue organization

The report that is now presented is intended to respond to the third objective, and to this end, this document will synthesise, compare and contrast the results obtained with the previous activities. All of the reports are available at: https://www.urbiofuture.eu/.

In order to facilitate the reading of the main results, every section is completed with a summarizing guidelines box with recommendations about where certain competences need to be reinforced according to the information gathered in this study.

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[1] Bio-based economy in Europe: state of play and future potential - Part 2, Summary of the position papers received in response of the European Commission's Public on-line consultation; 2011; Directorate-General for Research and Innovation Food, Agriculture & Fisheries, & Biotechnology; Luxembourg: Publications Office of the European Union

[2] A roadmap to a thriving industrial biotechnology sector in Europe; 2015; BIO-TIC Team; www.industrialbiotech-europe.eu

2. Methodology and sample

Four different instruments have been used for the development of this report, each of them designed to obtain specific information that allows to progress in the development of this study: focus groups. The different instruments used and the sample of participants are presented in the following sections.

2.1. Focus group

The **main objective of the Focus Group** was to get qualitative data directly from the stakeholders in order to know how they see the current needs of their companies and also the expected needs in 2030. It is important to involve stakeholders during this process since the information we get from this process will be the basis to develop the survey that it's going to be answer by all our contacts.

The development of the focus groups and the interviews have been guided considering, on the one hand, the current scenario of the bio-economic sector and, on the other hand, the desired scenario for the year 2030.

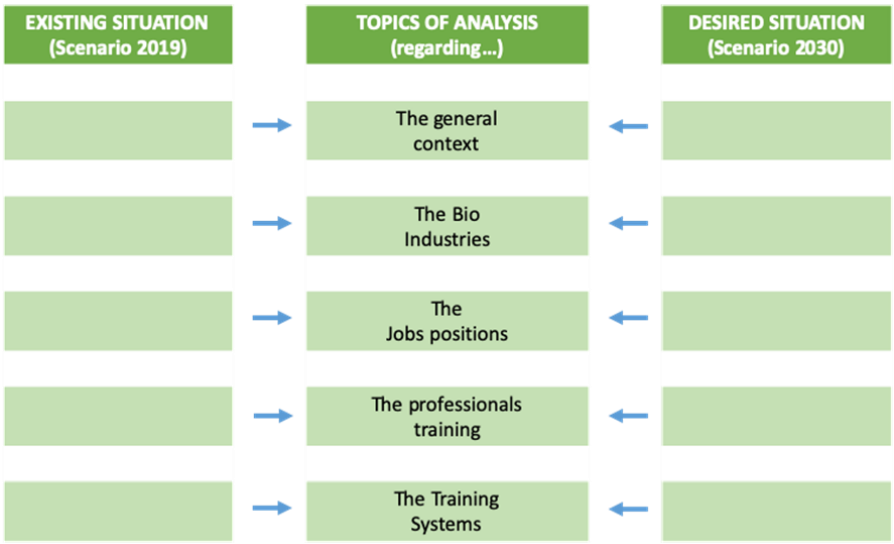


Figure 1: Scheme that guided the focus groups.

Within the UrBIOfuture project 5 focus groups (27 participants in total) and 11 interviews were carried out, following the same structure of content, with relevant agents of the Bio Industry sector during the first week of May 2019 in Belgium, Denmark, Finland, Italy, Poland, Spain and The Netherlands.

The participants were mostly women (approximately 65%), ranging between 30 and 65 years old, with the age group between 40 and 50 being the most represented, followed by the group between 50 and 60 years old. The under 40s group was the least

represented in this phase. They were all higher education graduates, most of them with PhD or Master's degrees in the scientific and technological fields: chemistry, biology, chemical engineering, computer science and materials science. Some participants had social sciences backgrounds: business administration, marketing or finance. It is worth highlighting that some profiles have more than one degree. Regarding the number of years of professional experience in the Bio-industrial sector, we observe a concentration in the extremes, with professionals with over 15 years of experience in the sector (over 25 years of experience in some cases), and another important group with less than 10 years of experience in the sector. The main positions held by the interviewed profiles are management positions in the following specific areas of the bio industry: bioplastic, packaging, eco-compatible polymers, agro-pellets, polymer technology, Education ICT, petrochemical, textile technology, food technology, chemistry, RDI Strategy, biomedicine, public administration, genomics, medical diagnosis, pharmaceutical, agro-food, animal nutrition, microbiology, cosmetics and plant genetics.

2.2. Dynamic workshop

The **main objective of the Dynamic Workshop** was to get contrast the data obtained in the focus groups using the methodology of "World Café Dialogue". This is a method for creating a living network of structured collaborative dialogue around questions that matter, in which small groups of people discuss a topic at several tables (Figure 2), with switching tables periodically and getting introduced to the previous discussion at their new table by a "table host".

This structured conversational process for knowledge sharing was used in the UrBIOfuture Dynamic Workshop in order to gather some feedback about bio-industry skills needs, at present and in 2030, at different educational levels (university, VET programmes, high school education, etc.), as well as some successful cases and lessons learnt the attendants may know and be already implementing.

Soft skills, Innovation and Entrepreneurship capacities for the Bio-based sector.
Competences needed for Bio-based sector Digitization
Competences in Circular Bio-economy and Sustainability challenges addressing the specific technical, legal and research profiles needed
New professional competences and skills for Circular Bio-based business development, marketing and communication

Figure 2: The debate tables themes.

The event was attended by 29 people representing 21 different entities, most of them members of the UrBIOfuture's working group and industrial expert group. These entities were from different type or organizations (educational and non-educational): university (2), VET institution (3), high schools (2), industry and clusters (5), Public Administration (3) and Research and Technological Organization (6).

2.3. Questionnaire to analyse industry needs

The **questionnaire to analyse industry needs** aim was to understand the future educational needs of the BIO industrial sector by 2030, and assess whether current educational systems are addressing those needs. By completing the survey the respondents were asked to rank some competences related to the sector's key competences. We ask them to complete these questions with the most relevant competences for their company. In addition, for each of the prioritized competences, they were asked to indicate at which educational level hey should be developed (VET, Undergraduate, Master or PhD).

It is important to note that the nature of the study required a process of ranking of the responses in order to meet the stated objectives: it was necessary to identify the prevalence of some elements over others. To avoid this accommodative and unselective behaviour, a response model was chosen that forced selection and ranking. Thus, each of the questions, as they are posed in this investigation, forces a positioning and, therefore, a reflection on the part of the informants that prevents them from responding to all options equally. This way the true perceptions about the phenomenon investigated can be grasped. Therefore, by forcing informants to choose among different options and rank them, a bias was avoided and the accurate reflection on the subject matter was ensured.

The questionnaire consisted of the following sections: (1) a section with information on the respondents and their companies, (2) a section with questions on general competences, (3) a section with questions on specific competences, and (4) finally a section with questions about the most important competences and some open fields for further comments. It should be possible to fill in all the questions in the questionnaire in around 45 minutes.

The following tables show the competences analysed (general specific) that were considered to construct the questionnaire, as well as the template to analyse educational programmes (section 2.4).

Competence (general competences)	Sub-competence (specific skills)
Management	Purchasing Quality Product / Logistics Resources Industrial linkers Development of business models Life Cycle Assessment (LCA) of Bio-based industry processes Project Management.
Data management	Data sensing technologies Data processing (carry out, retrieve, transform) Data transmission technologies & standards Data Analytics & Advanced Analytics Data Exploitation Technologies Information security and cybersecurity Data architecture
Personal initiative and entrepreneurship	Critical thinking Problem solving Engagement capacity to involve different types of Stakeholders (clustering) Creativity Empathy

	Persuasion Proactivity
Soft skills	Communication (public speaking) Communication (writing) Relationship building Teamwork and conflict resolution Adaptability Personal branding Collaboration Foreign Languages Competence
Sustainability and industry	Ecological perspective Circular economy / Zero waste industry Sustainable competitiveness / Economy Secure bio-based materials and residues stability, availability, transport and storage Monitoring contaminants in the products Recyclability concepts for bio-based materials
Technology	Digital skills Information and Communication Technology Cybersecurity Data mining tools/strategies Key Enabling Technologies for the Bio-Based Industry Traceability and logistics DLT (Distributed ledger technology) & Blockchain technologies Artificial Intelligence technologies
Research and innovation	Innovation and change Management and development of research Knowledge Transfer: From LAB to Industry Fundamental research Analytical capacity
Basic scientific knowledge	Maths Information and Communication Technologies. Physics Chemistry Biotechnology Biology Chemical Engineering Nanotechnology
Rules and regulation	Local legal regulations Patent regulations IPR - Intellectual Property Rights Common EU regulations Quality, safety and security regulations Waste regulations Bio-based products legal framework Digital Compliance
Social responsibility	Economic responsibilities Legal responsibilities Ethical responsibilities Philanthropic responsibilities Environmental responsibility Green engineering awareness Health Responsibilities Self-consumption energies
Sales and marketing.	Market globalization Adapting the products to new targets Openness of the industrial processes and products Marketing online and Social Media Increasing consumer/society awareness on bio-based products Packaging solutions derived from bio-based materials.

Figure 3: *Detail of general competences and its sub-competences.*

Competence (specific competences)	Sub-competence (specific skills)
Specialists in bio-based sector business/market development.	Bio-based-market knowledge & techno-economic expertise To raise society's awareness on circular bio-based economy Identify and create market applications for new bio-based products New Blue-Bio-based Business models and Value chains New Bio-based Business Models based on technological surveillance, competitive intelligence and funding attraction
Technical expertise in sustainable biomass production	Advanced pre-treatments at harvest-storage stage Precision farming Feedstock-specific & market driven cascade valorisation Precision equipment for biomass harvest/collection Advance ICT applications to logistic/storage (IoT, industry 4.0 ...) Techno-economic assessment of processes, bio-refineries and bio-based value chains Life Cycle assessment of processes, bio-refineries and bio-based value chains New varieties of macro- micro- organisms for cost-effective bio-products.
Technical expertise in primary conversion processes	Methods for efficient and cost-effective biomass' production Advanced technologies to mildly extract or separate functional components Market flexible and feedstock adaptable multiproduct integrated bio-refineries New processes to improve bio-products yield from bio-waste Implementation of cascade biomass valorisation approach in integrated bio-refineries New Industrial symbiosis designs and implementation in integrated bio-refineries Biotechnologies to convert C02 effluents to bio-chemicals.
Technical expertise in secondary conversion processes	Chemo-catalysis & Thermo-chemical processes to obtain functionalised chemicals and products Hybridization of processes for different feedstock valorisation New more efficient methods to recover/convert bio-based chemicals including cascade valorisation and circular economy approaches Design of control systems for robust, stable and sustainable production, quality and contaminants monitoring Advanced methods to preserve and generate functional natural macromolecular polymers' Biopolymer processing to obtain different materials (films, fibres, structural composites) for automotive, agriculture, building, etc... Polymerisation processes based on new bio-based monomers Oleo-chemistry (fatty acids conversion technologies) including chemistry and biotechnology.
Technical expertise in materials, products and functionalization	Materials based on lignin (and bio-aromatic) chemistry Materials based on oils and fats from plants and animals (bio-based lubricants, surfactants, solvents Bio-based alternatives for existing polymers and innovative polymers from new bio-based monomers. Extraction techniques to obtain High added-value biomolecules from marine, agri-food or forest biomass for pharmaceutical, nutraceutical and cosmetic sectors New (chemical) building blocks from renewable resources. New functional bio-based materials and products: plastics, composites, based on lignin, starch, (nano-) cellulose or carbon fibres. New packaging solutions derived from bio-based materials New products design from bio-waste.

Figure 4: *Detail of specific competences and its sub-competences.*

The answers were collected in an online survey tool (LimeSurvey) and was self-administered, meaning that informants can complete it independently, i.e. without requiring the assistance of any member of the research team. The questionnaire in English, German and Spanish was sent to more than 2,000 stakeholders in European bio-based industries identified in an earlier task. Approximately one quarter responded by filling in the questionnaire, and 152 filled in the part with general information and competences, and were included in the analyses. Two-fifths of the respondents were from Spain. Biotechnology was the most represented sector. Most of the respondents

were in managerial or professional positions. Almost nine-tenths had Masters or PhD's degrees and three-quarters had more than 5 years' experiences in the bio-based industries. The distribution company sizes represented by the respondents was as follows: almost two fifths were large companies, one quarter micro companies (less than 10 employees), one fifth small companies and almost one sixth for middle-sized.

Further information about questionnaire respondents is available in UrBIOfuture's deliverable D2.2 and in Annex 5.1 of this report.

2.4. Template to map educational programmes

The aim of the **template to map educational programmes** was to compile information on the educational programmes implemented at the different educational levels in order to draw a general map that will allow for the identification of the training offer linked to the bio industrial sector which is being offered in the European context. The sections of the template include the general competences and specific competences presented in section 2.3 (figures 3 and 4). In addition to the study of competences, other 3 key relevant variables have been observed in the different programmes analysed: type of programme, didactical methodologies and involvement of in-company training activities.

The template was an instrument to be used internally by the project members. Thus, partners completed the data from the analysis of the information from the educational programmes available on the different institutional websites of universities, VET centres or educational administrations. During the development of this study, industrial, research and academic stakeholders have been involved to guide and provide expert support along the development of the relevant competences for the bio-economy sector in 2030.

The original database of educational programmes developed during UrBIOfuture's project includes the selected information for the mapping of 1228 educational programmes, which information is available through the bio-based educational programmes search tool on the UrBIOfuture's web page. The final sample of programmes analysed is 912 bio-economy related educational programmes at four different educational levels (PhD, Master, Undergraduate and VET) across 26 European countries.

The educational programmes were analysed according to the educational level at which they are taught. In total, 912 programmes have been analysed, distributed as follows: Master's (46%); Undergraduate (35%); PhD (12%); and VET (7%). Most programmes (75%) are taught in-class and only 12% of the total are identified as blended-learning. More than half (55%) of the analysed programmes involve in-company training; at VET level it is even higher (75%). Only 10% on average do not include in-company training activities and for 35% of the programmes analysed no information is given.

Further information of the sample of programmes analysed is available in UrBIOfuture's deliverable D3.2 and in Annex 5.2 of this report.

3. Results

This section summarizes the results achieved by applying the instruments described in the "Methodology and sample" section. To facilitate the reading and contrast of the information, a first section is presented with the general vision of the stakeholders in relation to the general environment in which the Bio-industry is currently placed in Europe, followed by the assessment they have performed of the general and specific competences identified, together with their associated sub-competences, as keys for the development of the bio-industry in 2030. These, in turn, are contrasted with the results obtained in the analysis of the educational programmes linked to this sector. Finally, each section is completed with a summarizing guidelines box with recommendations about where certain competences need to be reinforced according to the results of this study.

In order to get information on the competences the respondents regarded as the most important, they were asked to choose between the listed competences (Figure 3 and 4). They had to select the most important competence for their company, then the second most important competence etc. up to the fifth most important competence among the 16 available.

It is noticeable that almost a third of the respondents score the competence category Research & Innovation highest (Figure 5). Almost two-thirds of the respondents rank Research & Innovation among the first three priorities. Second and third most important competence categories were Personal initiative and entrepreneurship, and Management.

Competences like basic scientific knowledge, data management, expertise in biomass production, technical expertise in sustainable biomass production expertise in primary and secondary biomass conversion, and social responsibility are also prioritised by some respondents but much fewer than Research & Innovation, Personal initiative and entrepreneurship, and Management.

In the following sections 3.2 and 3.3 the competence categories above are analysed more into detail. For each competence category the importance of the sub-competences are shown. To put everything in perspective it is recommended to keep the ranking of the competence categories themselves in mind when considering the scoring of their sub-competences in relation to each other.

Competence	**Priority and weighting**					**Sum**	**Score***
	1 (100)	2 (80)	3 (60)	4 (40)	5 (20)		
Research & Innovation	32	16	14	13	10	85	100
Personal initiative and entrepreneurship	15	15	10	10	8	58	64
Management	13	10	8	5	8	44	49
Sustainability and Industry	8	6	13	11	12	50	45
Specialists in bio-based sector business/market development	11	8	11	5	4	39	44

Technology / STEM (Science, Technology, Engineering and Maths)	9	14	5	6	4	38	44
Sales and Marketing	7	7	6	14	13	47	40
Basic Scientific Knowledge	4	3	10	6	5	28	26
Rules and Regulations	0	8	7	8	10	33	26
Soft Skills	3	6	4	5	10	28	23
Technical expertise in primary conversion processes	5	6	2	6	2	21	23
Technical expertise in materials, products and functionalization	2	3	7	8	5	25	21
Technical expertise in secondary conversion processes	1	3	7	4	5	20	17
Technical expertise in sustainable biomass production	3	4	3	2	2	14	15
Data Management	0	1	4	4	5	14	10
Social Responsibility - CSR	0	1	0	2	3	6	4

Figure 5: The ranking of the five most important competences by the respondents.

*A score was based on a weighted sum for each competence by multiplying the number of respondents giving to priority 1 with 100, the number giving to priority 2 with 80 etc. The weighted sum was then divided with the sum of all weighted sums and multiplied with the total number of priorities (550) given by the respondents.

3.1. Analysis of the context from stakeholders point of view

The stakeholders consulted agree that the decentralization tendency towards other countries in the future will continue, so that the exact type of industry to be developed at European level must be defined. In this regard, the introduction of robotics in production, the creation of more personalized products adapted to the needs of the final user (food, health, technology), a more efficient use of energy (increasingly more expensive), improving logistics processes to make them more efficient, preserving the environment and working in environments without regulatory pressure are all important evolutions to take into account.

Additionally, they consider it necessary to generate a joint strategy to link different sectors (new technologies, natural resources, waste management, environment, sustainable energies, health and agro-food production) that are strategic for the society. Collaboration between industries will be key in the near future, being increasingly important to find strategies that allow the exchange of knowledge and to preserve intellectual and industrial property in order to create a culture of collaboration. The creation of consortiums, clusters and other collaborative ecosystems is a present reality, which will be expanded in the future.

Among the main challenges that stand out at the socio-economic level, there is a need to find new forms of production that will provide society with the products it requires, incorporating technology that allows for the development of more efficient vertical economy processes. I will be also important to collect data in order to be able to monitor

the processes that are being developed. This implies that tools must be articulated in order to allow for working with large amounts of data to obtain information that is relevant and make it accessible to decision makers, thus helping the industry advance.

A greater integration between the research, development, innovation and production processes is necessary in order to be able to address the needs of a society increasingly demanding and competitive. It is necessary to reduce the time between each of these processes by creating new productive and business models as well.

The need to work on consumer awareness is also highlighted. At the social level, the following aspects were emphasised by consulted stakeholders:

- Decrease of the working-age population (labour force);
- Increase in elderly;
- Greater access of the population to specialized training, which is not always related to the specific needs of the industry (distance between the education sector and the industrial sector);
- Population increasingly informed, and with greater access to communication channels;
- Interest groups that advocate for more personalized products and to preserve the environment;
- Technological facilities bring together more aware people who can lobby to introduce changes in the industrial sector and push it towards more sustainable processes;
- Need to promote entrepreneurship as a way to employ the active population.
- Population not always willing to pay for the price premium of industrializing some sectors, or to get products through a sustainable industry.

New and more sustainable products will appear in the market, contributing to making progress in circular economy processes and allowing for drastic waste reduction, based on efficient, sustainable and environmentally-friendly management systems.

3.1.1. Specific analysis of the Bio-based industry

In general terms, stakeholders agree that the sector will increase its weight in the European economy in the coming years, mainly as a consequence of the need to create new products as well as to manage waste and search for more efficient and environmentally friendly processes. From this point of view, none of the current sectors are considered to disappear from the European context, although it is agreed that all of them must evolve and grow to be more efficient. In this line, it is noted that progress must be made in the treatment of raw materials to achieve products with more added value.

In the coming years the sector will be driven mainly towards the incorporation of processes that will seek environmental protection and sustainability as well as the implementation of actions that will allow for the recovery of those environmental aspects that have deteriorated in the last century (water pollution, destruction of natural spaces, increase of waste, etc.). Below more specific aspects that have appeared as highlights in this line:

- Changes in regulations and subsidies will affect how we understand the current Bio sector.
- It will be necessary to implement more efficient productive processes, replacing fossil fuels, which will be more and more expensive.
- Progress will be made in the implementation of circular economy models, which implies a reduction in primary products and a greater reuse of waste generated and by-products.
- The inclusion of technologies in the sector will continue to advance.
- The importance of controlling the traceability of the processes and the quality of the products will be linked to an increase in the collection of data.
- Biotechnology will continue to be an expanding sector, also linked to the use of bioinformatics as a key element in the growth of companies in the sector.
- Designing products that are more respectful of the environment, abiding the principles of the circular economy, with a tendency to reduce waste.
- Increasing the production of plant products with high protein value to be used in the food sector.
- Replacing products that are currently derived from chemical processes or with high economic and environmental costs of production by others that come from the field of Bio (biomass-derived polymers, cellulose for textile, bio-composites, etc.)
- Increase the efficiency of the production of bio-sustainable materials in order to reduce their cost and increase their presence in the market.
- Awareness of consumers about new types of products.
- Sharing knowledge will be a permanent dynamic in the future industries of the Bio sector as a basis for innovation.
- The integration of sectors. This implies that collaboration with industries that are currently far from the BIO sector will increase.
- The improvement in value chains will somehow force the integration of industries, thus allowing for a better efficiency in the scalability of production and responding more quickly to the needs of a changing market.
- The design of products with high added value will be a direct result of the inclusion of technology and process improvement in the sector. This can also be associated with the need to personalize products.

The collaboration between companies and the public sector is considered vital, as well as with educational systems. The integration of the processes between the different sectors and levels (regional, national or community) will be the key to achieve the sustainability of the aforementioned actions.

The needs of the advances in the sector will also be a facilitator for the emergence of spin-off and start-up companies, which is also related to an increase of the collaboration between the industry and the main stakeholders. Citizen participation is considered a key aspect in the generation of new products linked to sectors such as health or food, as is the incorporation of competencies linked to entrepreneurship into the educational system.

3.2. General competences of the bio-based industries

Both the focus groups and the interviews informed that the stakeholders consider that current education system does not train the necessary skills required by the industry. Furthermore, they considered that educational programmes changing pace is very slow in adjusting to new industrial requirements or the progress of the sector, highlighting the urgent need to increase collaboration between both sectors, which is also in the line of offering educational programmes that involve student's in-company training periods.

The stakeholders that participated in the first stage of the study considered that it is necessary that educational programmes traditionally linked to the bio sector (chemistry, biology, physics, etc.) include more general content. The analysis of the data obtained allowed to identify eleven general competences:

1. Management
2. Data management
3. Personal initiative and entrepreneurship
4. Soft skills
5. Sustainability and industry
6. Technology / STEM
7. Research and innovation
8. Basic scientific knowledge
9. Rules and regulation
10. Social responsibility
11. Sales and marketing.

A series of sub-competences were linked to each of these competences, as specified in tables 3 and 4 of this report.

Each of the competences are presented below, together with the associated sub-competences, providing the analysis of the results obtained in the questionnaire completed by the stakeholders in comparison with the results obtained in the analysis of the educational programmes through the template (EPT).

3.2.1. Management

In the case of the Management competence, the following sub-competences were identified:

- Development of business models
- Industrial linkers
- Life Cycle Assessment (LCA) of Bio-based industry processes
- Product / Logistics
- Project Management.
- Purchasing
- Quality
- Resources

Project Management and Development of Business Models were rated highest (over 90), whereas purchasing was rated lowest (under 35). The other sub-competences rates are between 63 and 79.

Sub-competences	Weighted score
Project Management	100
Development of business models	94
Resources	79
Quality	73
Industrial linkers	71
Product / Logistics	68
Life Cycle Assessment (LCA) of Bio-based industry processes	63
Purchasing	33

Figure 6: Results of the prioritising of sub-competences in the management.

Stakeholders believe that all sub-competences of the Management competence must be developed at the Master and PhD level, except for the Resources and Product / logistic sub-competences, where Undergraduate educational level is considered first.

It emphasizes that for the Life Cycle Assessment (LCA) of Bio-based industry processes competence is considered necessary in 36 at PhD level, followed by 51 at Masters. Moreover, Project Management and Development of Business Models scores close to 60 for Master and 20 for PhD.

Figure 7: The distribution of educational levels for employees, expected in 2030, in the management sub-competences.

The comparison between what the stakeholders expect for 2030 (figures 6 and 7) and the current offer of educational programmes (figure 8) allows us to observe that, in general, for the Management competence, there are no major differences in relation to the programmes where they are developed. However, the presence of some competences may not be balanced with the need expressed in the prioritization. They are detailed below where differences are observed:

- Development of Business Models: Despite being one of the most prioritized sub-competences by stakeholders for the year 2030, current educational programmes provide little development in this area.
- Industrial Linkers: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Life Cycle Assessment (LCA) of Bio-based industry processes: stakeholders prioritize this sub-competence in the second to last position, albeit with a score of 63 points. It is most valued at Master's educational level followed by PhD, although the analysis of educational programmes indicate a greater presence in PhDs than in Masters.
- Product / Logistics: This sub-competence is considered important for Undergraduate levels, although in the programmes analysed it seems to have a greater presence at the VET level.
- Project Management: It is the most demanded sub-competence for the year 2030, especially at the level of Master and PhD. The results allows us to observe that it is one of the most present in the Undergraduate levels at the moment, although in the Master and PhD levels it is also well represented.
- Purchasing: In general, it is the least valued competence by stakeholders, and at the same time it has very little presence in the educational programmes analysed.
- Quality: there is a relatively high priority among stakeholders (almost 75%), and above all at the Master levels, followed by Undergraduate. The results of analysed programmes allow us to observe that it is precisely in these educational levels where this sub-competence is most prominent.
- Resources: This is the third most prioritized competence by stakeholders, and they indicate that it should mainly be developed at the Undergraduate and Master level. The analysis of programmes allows us to observe that there is agreement between the demand of the stakeholders by 2030, and the educational levels where they are currently working.

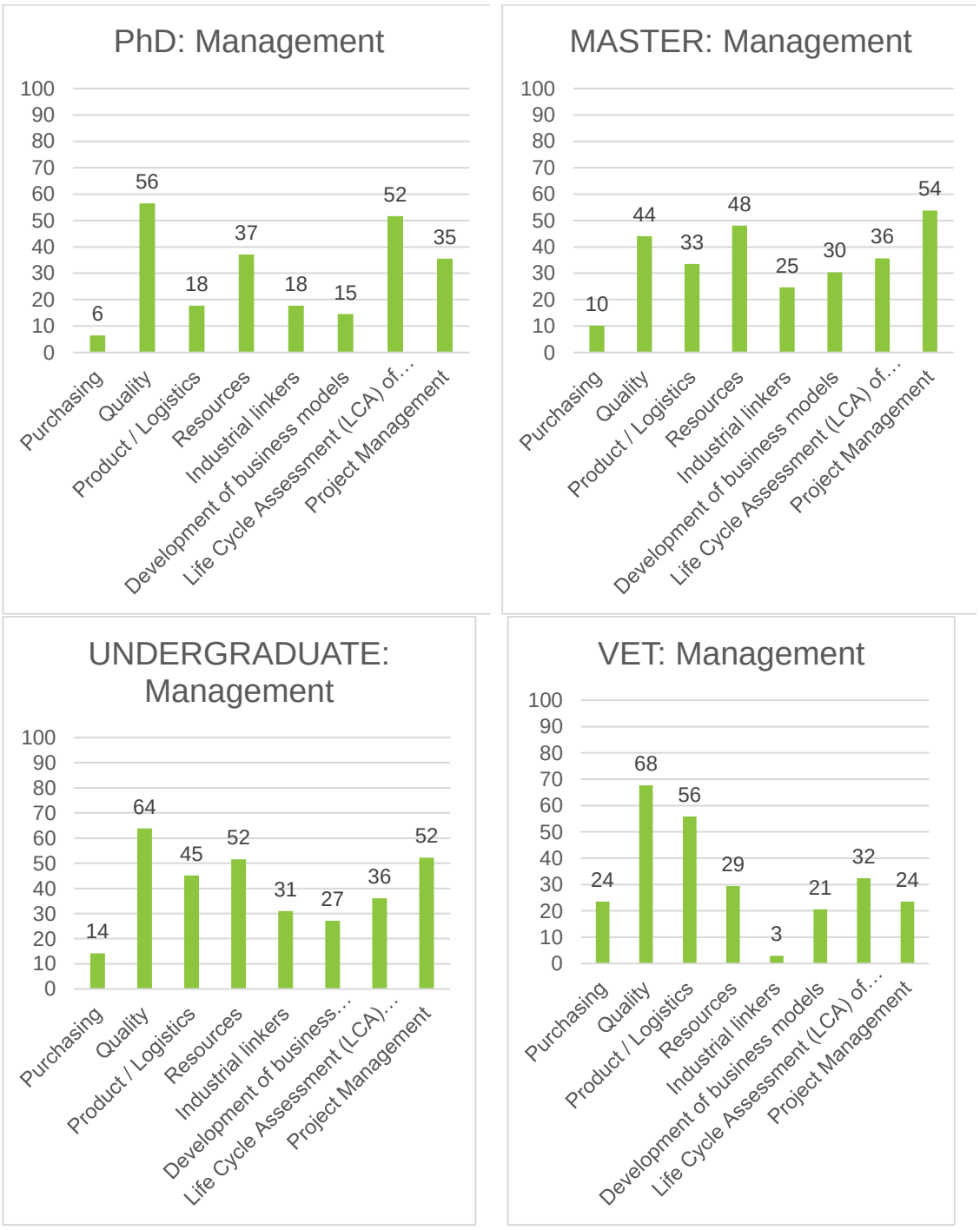


Figure 8: Management sub-competences at the four educational levels analysed with the template.

Guidelines

- Development of business models: It would be important to develop this sub-competence in all educational programmes, since it is underrepresented compared to the prioritization of stakeholders, especially at the Master and PhD levels.

- Industrial linkers: it is not considered necessary to introduce changes.

- Life Cycle Assessment (LCA) of Bio-based industry processes: This sub-competence should have a greater presence at the Master level.

- Product / Logistics: aspects related to this sub-competence should be introduced at the Undergraduate level.

- Project Management: although it is very present in Undergraduate, it should be analysed whether it would be necessary to make it more present at the PhD levels, perhaps highlighting the specificities of the projects that can be managed according to each educational level.

- Purchasing: it is not considered necessary to introduce changes.

- Quality: it is not considered necessary to introduce changes.

- Resources: it is not considered necessary to introduce changes.

3.2.2. Data management

The following sub-competences were identified under the Data management competence:

- Data Analytics & Advanced Analytics
- Data architecture
- Data Exploitation Technologies
- Data processing (carry out, retrieve, transform)
- Data sensing technologies
- Data transmission technologies & standards
- Information security and cybersecurity

Data analytics & advanced analytics is rated first under this competence, followed by Data Protecting rated 88. The sub-competences with the lower weight are Data Architecture and Information and Security and Cybersecurity, with rates of 40 and 59 respectively.

Sub-competences	Weighted score
Data Analytics & Advanced Analytics	100
Data processing (carry out, retrieve, transform)	88
Data Exploitation Technologies	73
Data sensing technologies	72
Data transmission technologies & standards	61
Information security and cybersecurity	59
Data architecture	40

Figure 9: Results of the prioritising of sub-competences in the data management.

In general, it is indicated that the educational levels in which these sub-competences should be developed are Undergraduate and Master, with differences in that of Data Analytics & Advanced Analytics, with a percentage above 32 in PhD and Data Exploitation Technologies, which concentrates 45 at the Master level.

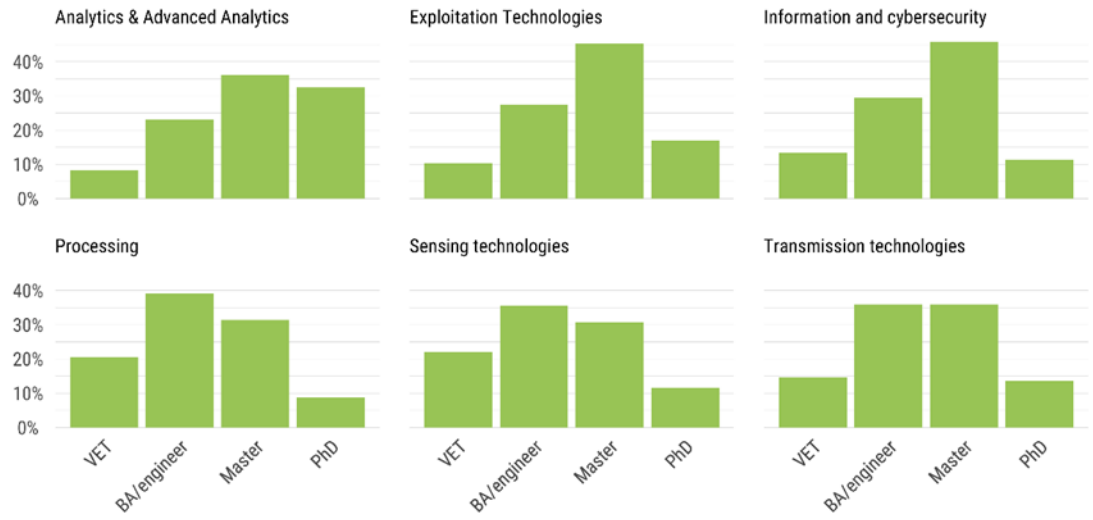
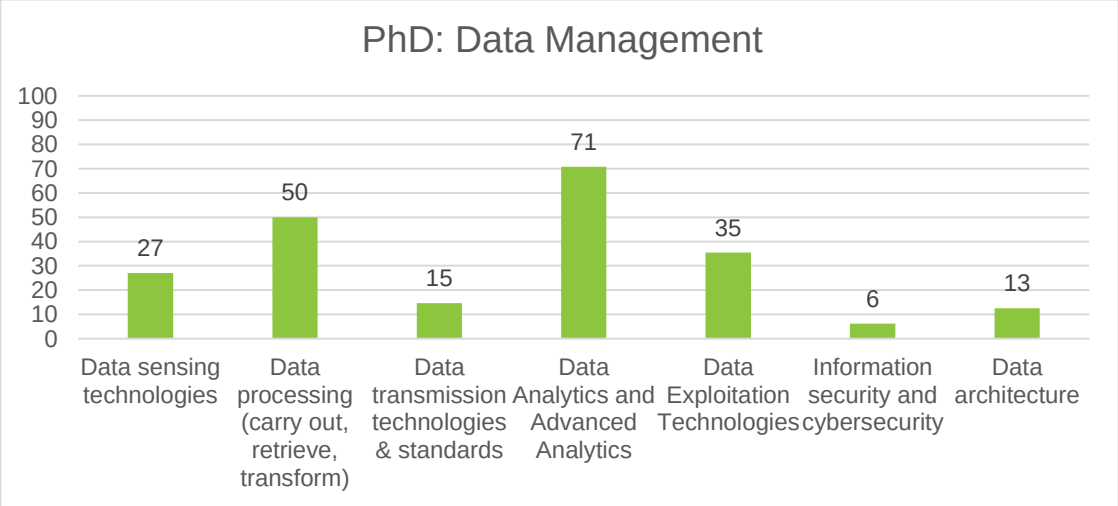
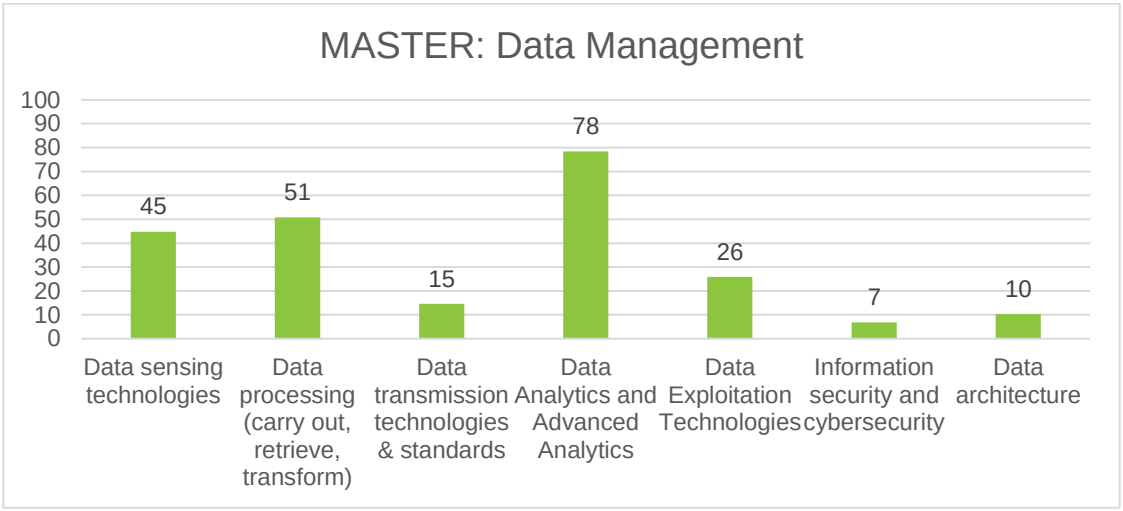


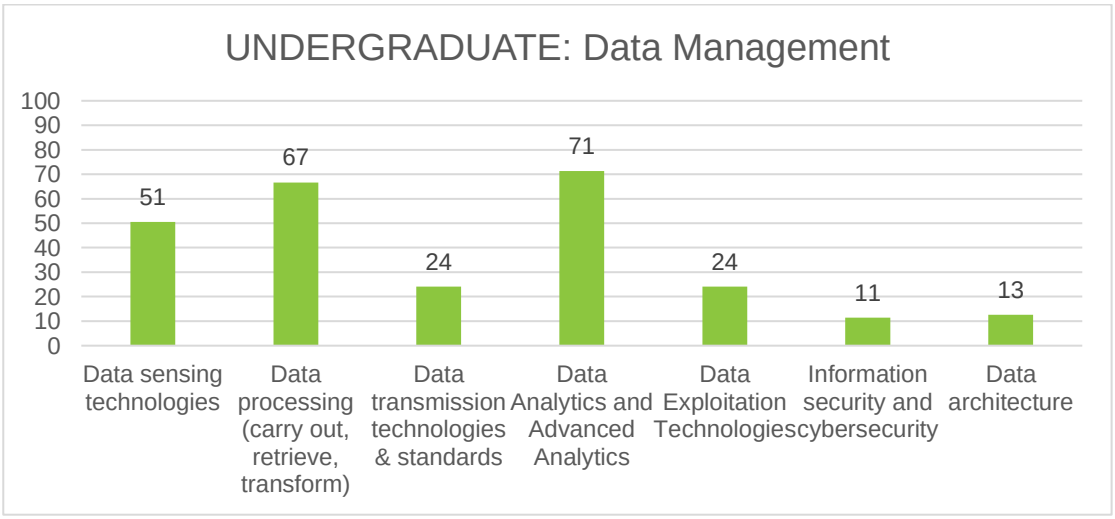
Figure 10: The distribution of educational levels for employees, expected in 2030, in the data management sub-competences.

The comparison between what the stakeholders expect for 2030 (figures 9 and 10) and the current offer of educational programmes (figure 11) allows us to observe that, in general, for the Data Management competence there are not large differences in relation to the programmes where it is developed, although we observe a low presence of the data exploitation technologies sub-competence in relation to the third position it occupies in the ranking. However, the presence of some competences may not be aligned with the need expressed in prioritization. The observed differences are analysed below:

- Data Analytics & Advanced Analytics: It is the most present sub-competence in all the educational levels of the programmes analysed, except in VET where occupies the second place, and they keep high level of presence in those levels demanded by stakeholders.
- Data Architecture: It is the least demanded sub-competence by the stakeholders and, at the same time, the least present in the educational programmes analysed.
- Data Exploitation Technologies: The presence in the analysed educational programmes is comparable to the need expressed by stakeholders at the VET, Undergraduate and PhD levels. It would be necessary to increase its presence at the Master level.
- Data Processing (carry out, retrieve, transform): It is one of the most developed sub-competences at the VET level, although it does not seem that the stakeholders demand it for professionals who have achieved this educational level.
- Data Sensing Technologies: The needs indicated for the different educational levels show values that follow the same trend as the presence in the educational programmes analysed.
- Data Transmission Technologies & Standards: In general, it is a sub-competence that is not highly valued, although it is observed that there is little presence at the Undergraduate level if we compare it with the anticipated need for this level.
- Information Security and Cybersecurity: The results obtained in the questionnaire and the template do not seem to show differences, although in the focus group and interviews phase the participating stakeholders highlighted this competence as a key element.







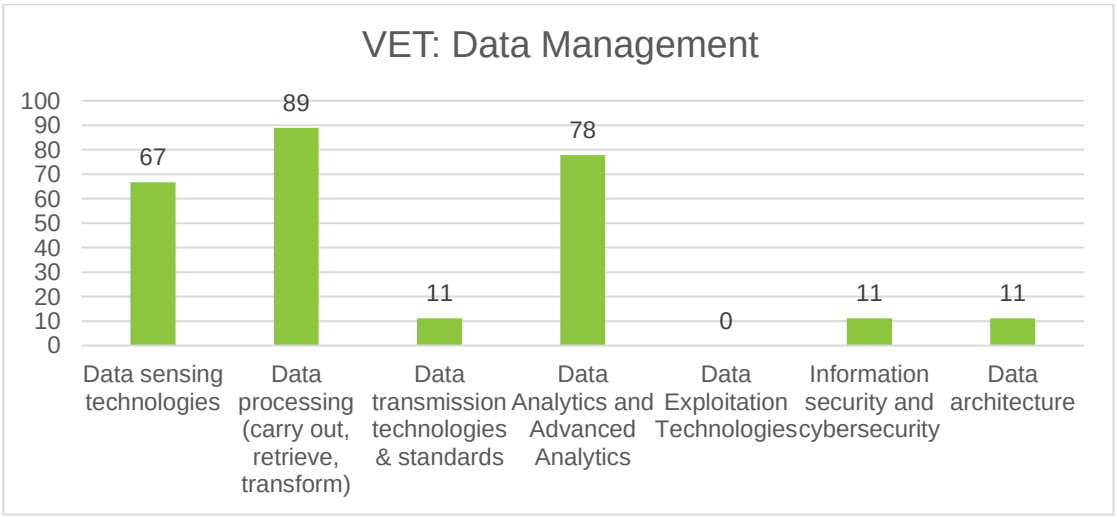


Figure 11: Data Management sub-competences at the four educational levels analysed with the template.

Guidelines:

- Data Analytics & Advanced Analytics: it is not considered necessary to introduce changes.

- Data Architecture: it is not considered necessary to introduce changes.

- Data Exploitation Technologies: more content linked to the development of this sub-competence should be incorporated, mainly at the Master level

- Data Processing (carry out, retrieve, transform): it is not considered necessary to introduce changes.

- Data Sensing Technologies: it is not considered necessary to introduce changes.

- Data Transmission Technologies & Standards: the presence at the Undergraduate level should be increased.

- Information Security and Cybersecurity: it is necessary to include more content linked to this competence at all educational levels.

3.2.3. Personal initiative and entrepreneurship

The following sub-competences were identified:

- Creativity
- Critical thinking
- Empathy
- Engagement capacity to involve different types of Stakeholders (clustering)
- Persuasion
- Proactivity
- Problem solving

Problem Solving and Critical Thinking were rated highest (100 and 90 respectively), whereas Empathy and Persuasion were rated lowest (46 and 32 respectively). The other sub-competences rates are rated pretty high as well, between 77 and 89.

Sub-competences	Weighted score
Problem solving	100
Critical thinking	90
Creativity	89
Engagement capacity to involve different types of Stakeholders (clustering)	85
Proactivity	77
Empathy	46
Persuasion	32

Figure 12: Results of the prioritising of sub-competences in the Personal initiative and entrepreneurship.

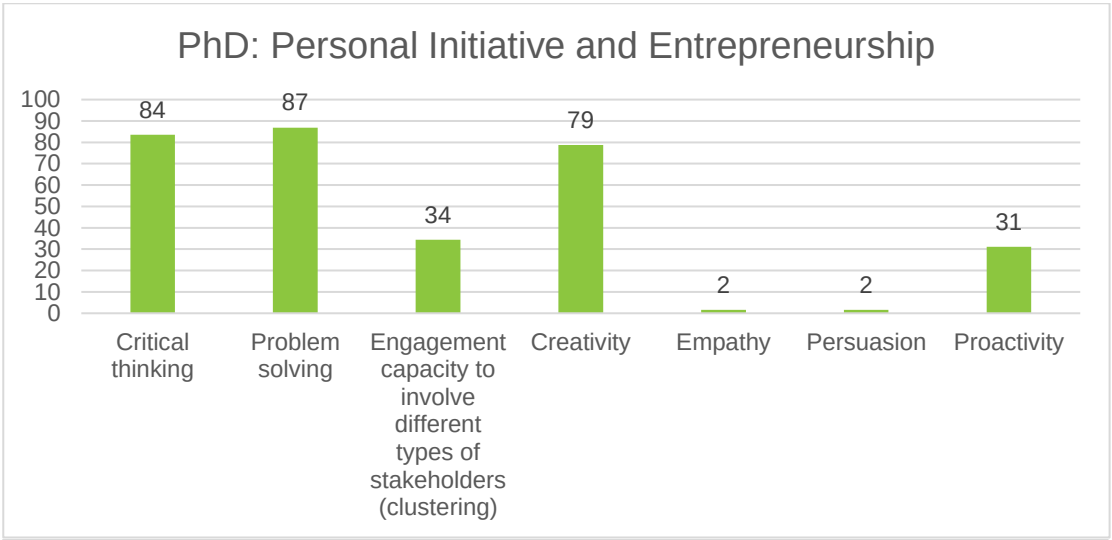
Stakeholders believe that most sub-competences of the Personal Initiative and Entrepreneurship must be developed at the Master level, except for Creativity, where Undergraduate educational level is considered first and Empathy, which is expected to be more relevant at VET level.

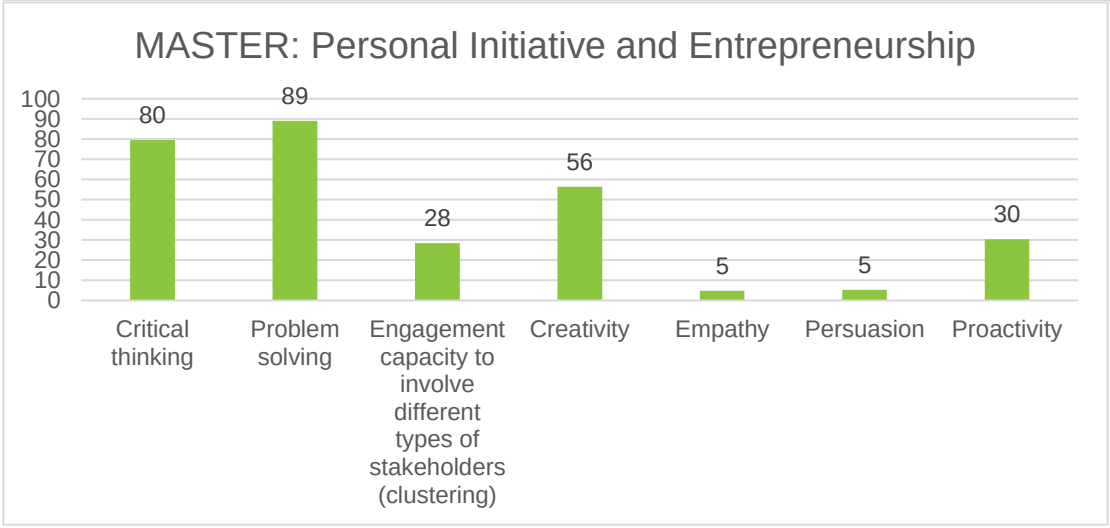
Figure 13: The distribution of educational levels for employees, expected in 2030, in the Personal initiative and entrepreneurship sub-competences

The comparison between what the stakeholders expect for 2030 (figures 12 and 13) and the current offer of educational programmes (figure 14) allows us to observe that, in general, for the Personal Initiative and Entrepreneurship competence, the presence of some sub-competences may not be balanced with the need expressed in the prioritization. They are detailed below where differences are observed:

- Problem solving: it is the most prioritized sub-competence by stakeholders for the year 2030 and current educational programmes provide intensive development in this area particularly at higher education levels.
- Critical thinking: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Creativity: stakeholders prioritize this sub-competence in the third position with a very high score of 89 points. It is most valued at Undergraduate educational level followed by Masters, although the analysis of educational programmes indicate a greater presence of creativity at PhD level.
- Engagement capacity to involve different types of Stakeholders (clustering): This sub-competence is considered important for Master levels, although in the programmes analysed it seems to have a greater presence at VET level.
- Proactivity: It is a demanded sub-competence for the year 2030 at all levels with less relevance at PhD. The results allows us to observe that it is present at all levels at the moment, with more intensity at VET level.

- Empathy and Persuasion: these are the least valued sub-competences by stakeholders, and at the same time they have very little present in the educational programmes analysed. They are more relevant at lower levels, though, whereas, according to stakeholders, Persuasion is required at Master's level.





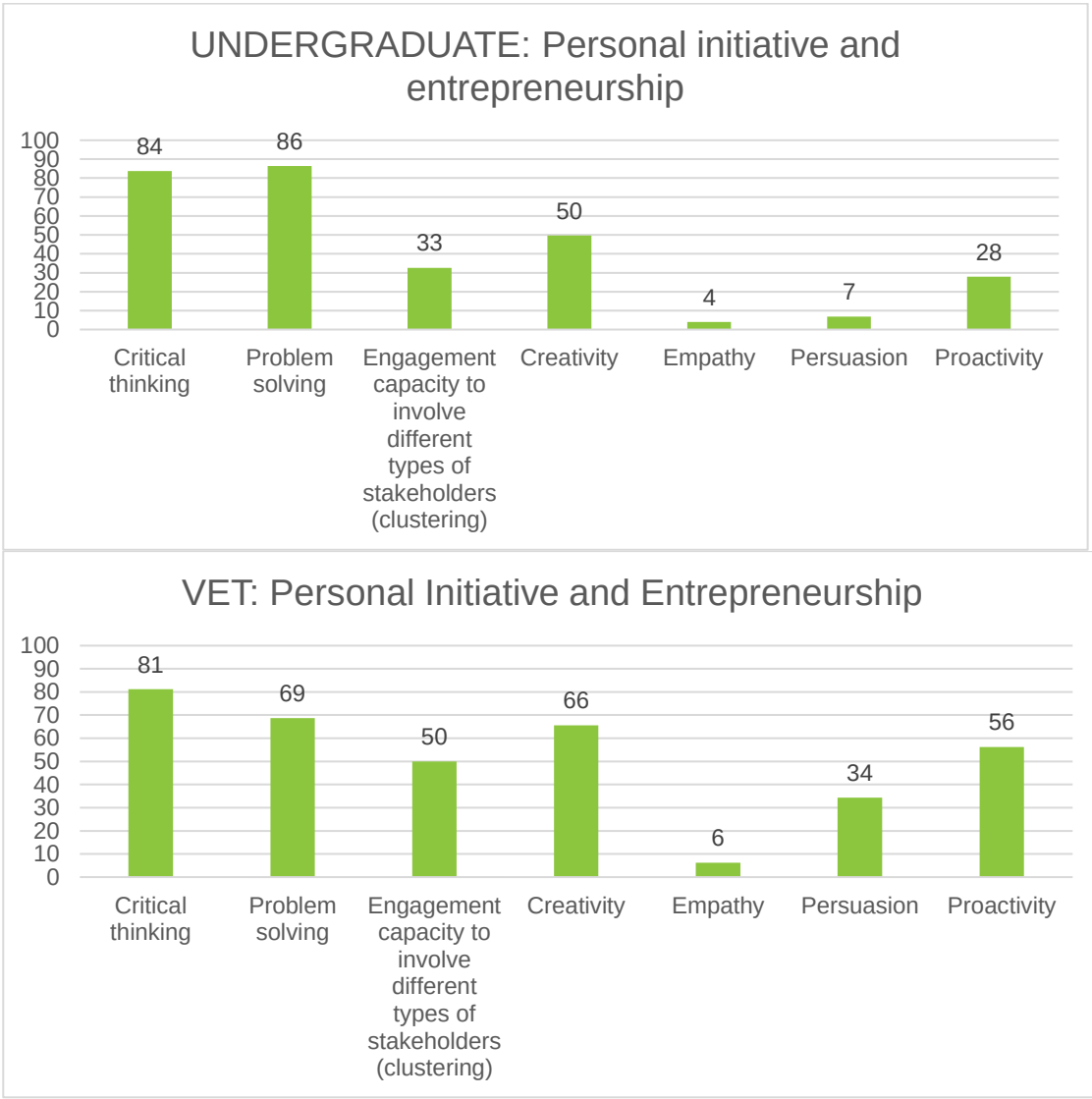


Figure 14: Personal Initiative and Entrepreneurship sub-competences at the four educational levels analysed with the template.

Guidelines:

- Creativity: the presence at the Undergraduate level should be increased.

- Critical thinking: it is not considered necessary to introduce changes.

- Empathy: it is not considered necessary to introduce changes.

- Engagement capacity to involve different types of Stakeholders (clustering): more content linked to the development of this sub-competence should be incorporated, mainly at the Master level

- Persuasion: the presence at the Master level should be increased.

- Proactivity: more content linked to the development of this sub-competence should be incorporated, mainly at the Master level

- Problem solving: it is not considered necessary to introduce changes

3.2.4. Soft skills

The following sub-competences were identified:

- Adaptability
- Collaboration
- Communication (public speaking)
- Communication (writing)
- Foreign languages competence
- Personal branding
- Relationship building
- Teamwork and conflict resolution

Teamwork and conflict resolution was rated highest (100), whereas Personal branding was rated lowest (29). The other sub-competences rates are between 56 and 86.

Sub-competences	Weighted score
Teamwork and conflict resolution	100
Collaboration	86
Adaptability	85
Relationship building	81
Communication (public speaking)	74
Foreign languages competence	63
Communication (writing)	56
Personal branding	29

Figure 15: The results of the prioritising of sub-competences in the Soft skills section.

Stakeholders believe that the soft skills must be developed at all levels but less intensively at PhD level, except for Communication (both writing and speaking) which seems to be more relevant at PhD level.

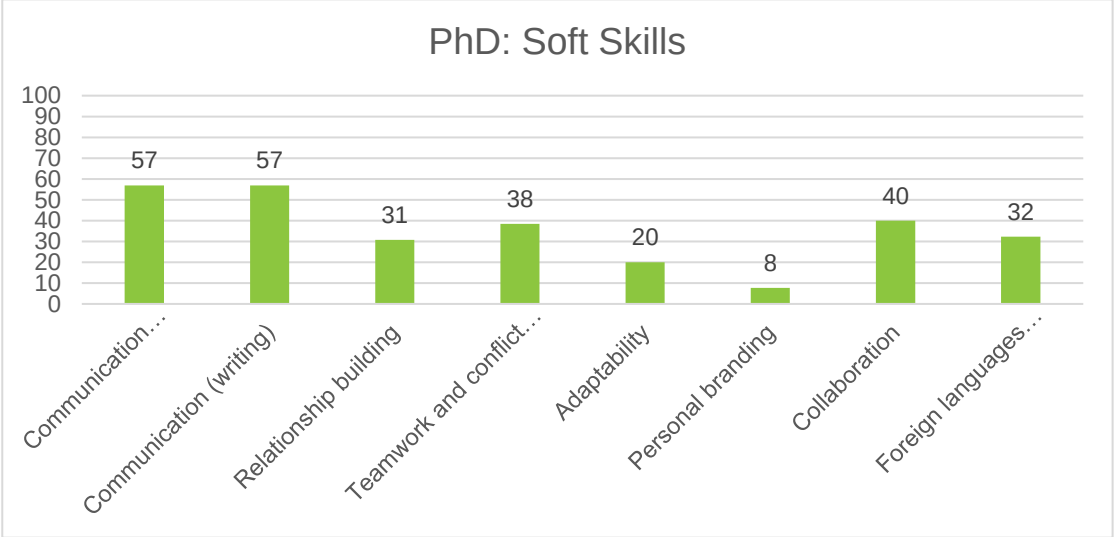
Foreign languages, collaboration and teamwork become more prominent at Master level, whereas Adaptability, Personal Branding and Relationships building are similarly required at VET, Undergraduate and Master's levels.

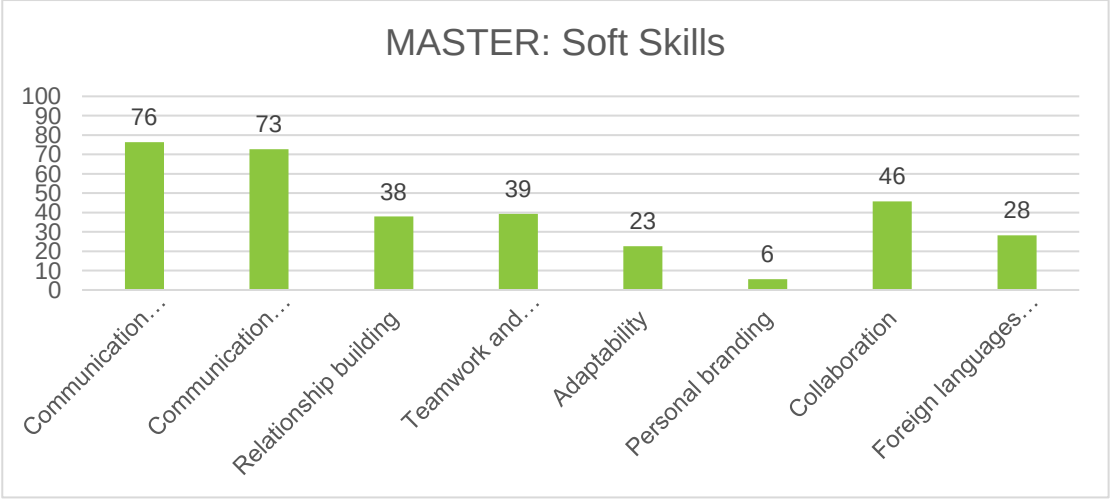
Figure 16: The distribution of educational levels for employees, expected in 2030, in the Soft skills sub-competences.

The comparison between what the stakeholders expect for 2030 (figures 15 and 16) and the current offer of educational programmes (figure 17) allows us to observe that, in general, for soft skills, there are no major differences in relation to the programmes where they are developed. However, the presence of some competences may not be balanced with the need expressed in the prioritization. They are detailed below where differences are observed:

- Teamwork and conflict resolution: Despite being the most prioritized sub-competences by stakeholders for the year 2030, current educational programmes provide little development in this area.
- Collaboration: this is the second important sub-competence according to stakeholders and most required at Master's level. However, it is not so prominent I educational programmes and it is more present in Undergraduate programmes.
- Adaptability: According to stakeholders, this sub-competence is considered quite important at all levels, although less relevant at PhD. Its presence in the programmes analysed is not as intense as expected, although it has a greater presence at the VET level.
- Relationship building: This sub-competence is considered important for all levels except for PhD, and it has similar presence in the programmes analysed at all levels, including PhD.

- Communication (public speaking): a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Foreign languages competence: according to stakeholders, becoming competent in foreign language is more relevant at Master's and VET level.
- Communication (writing): a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Personal branding: It is the least demanded sub-competence by the stakeholders and, at the same time, the least present in the educational programmes analysed, except for VET where it is widely represented.





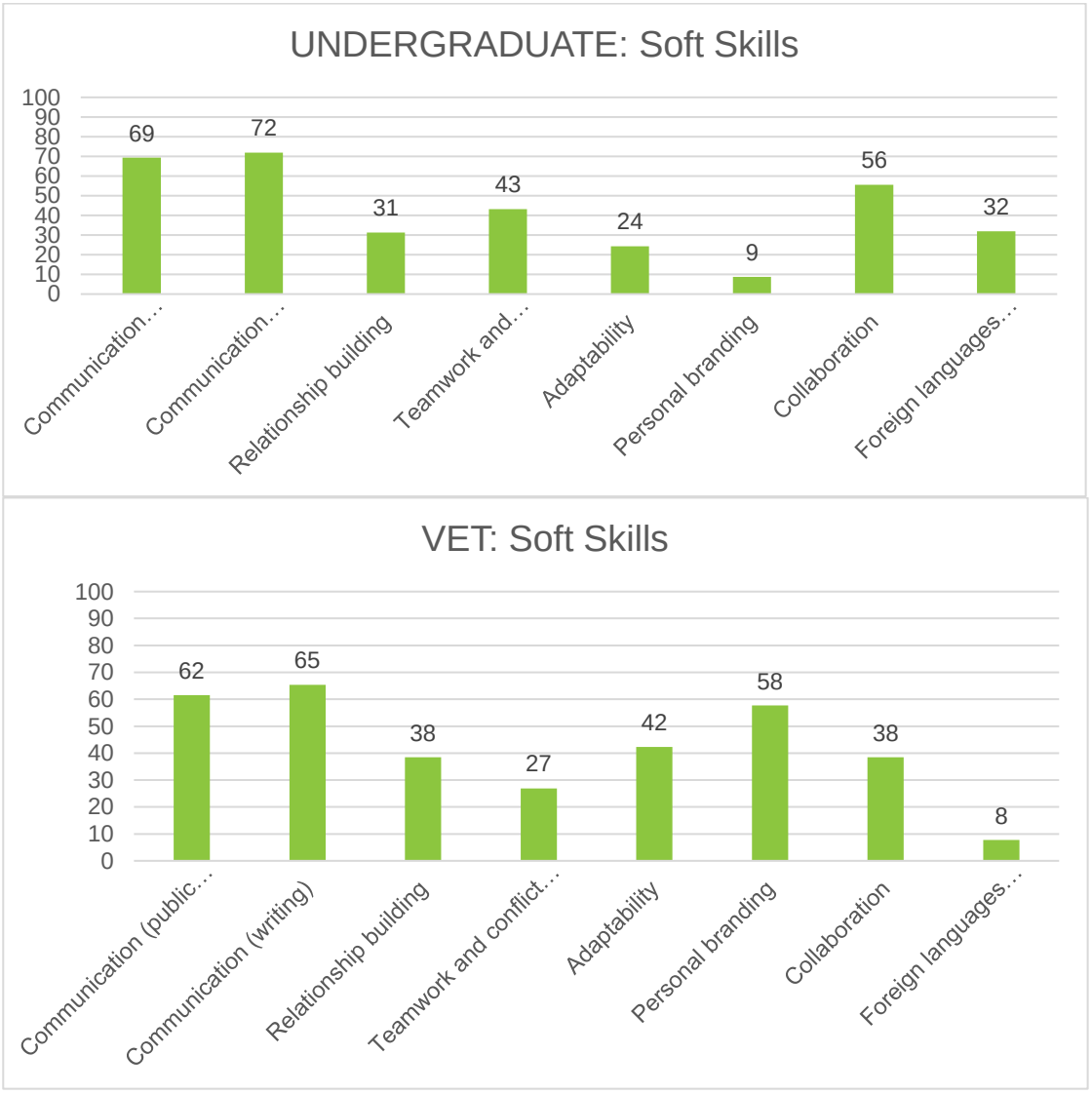


Figure 17: Soft Skills sub-competences at the four educational levels analysed with the template.

Guidelines:

- Adaptability: training for the acquisition of this sub-competence should be intensified at all educational levels except for VET, particularly Undergraduate and Masters.

- Collaboration: this sub-competence needs to be more present at Master's level.

- Communication (public speaking): it is not considered necessary to introduce changes.

- Communication (writing): it is not considered necessary to introduce changes.

- Foreign languages competence: should be increased at all levels, particularly at Master's and VET.

- Personal branding: more presence of Personal Branding skills are required at Undergraduate and Master's levels.

- Relationship building: it is not considered necessary to introduce changes.

- Teamwork and conflict resolution: should be increased at all levels, particularly at Master's level.

3.2.5. Sustainability and industry

The following sub-competences were identified:

- Circular economy / Zero waste industry
- Ecological perspective
- Monitoring contaminants in the products
- Recyclability concepts for bio-based materials
- Secure bio-based materials and residues stability, availability, transport and storage
- Sustainable competitiveness / Economy

Circular economy / Zero waste industry was rated highest (100), whereas Monitoring contaminants in the products was rated lowest (31). The rest of sub-competences rates are between 56 and 79.

Sub-competences	Weighted score
Circular economy / Zero waste industry	100
Sustainable competitiveness / Economy	85
Secure bio-based materials and residues stability, availability, transport and storage	66
Ecological perspective	60
Recyclability concepts for bio-based materials	56
Monitoring contaminants in the products	31

Figure 18: The results of the prioritising of sub-competences in the Sustainability and industry section.

Stakeholders believe that all sub-competences of the Sustainability and Industry competence must be developed at the Undergraduate and Master's levels.

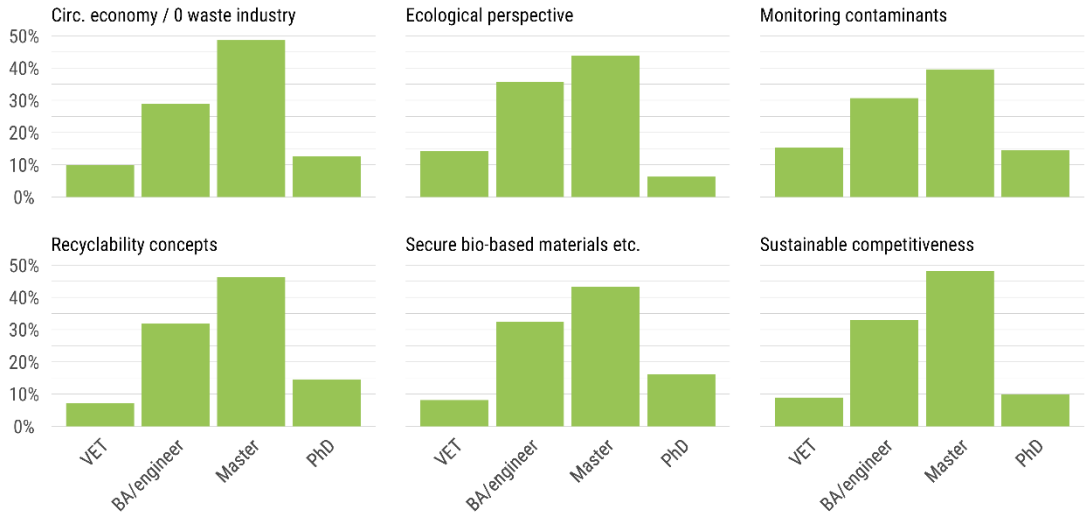
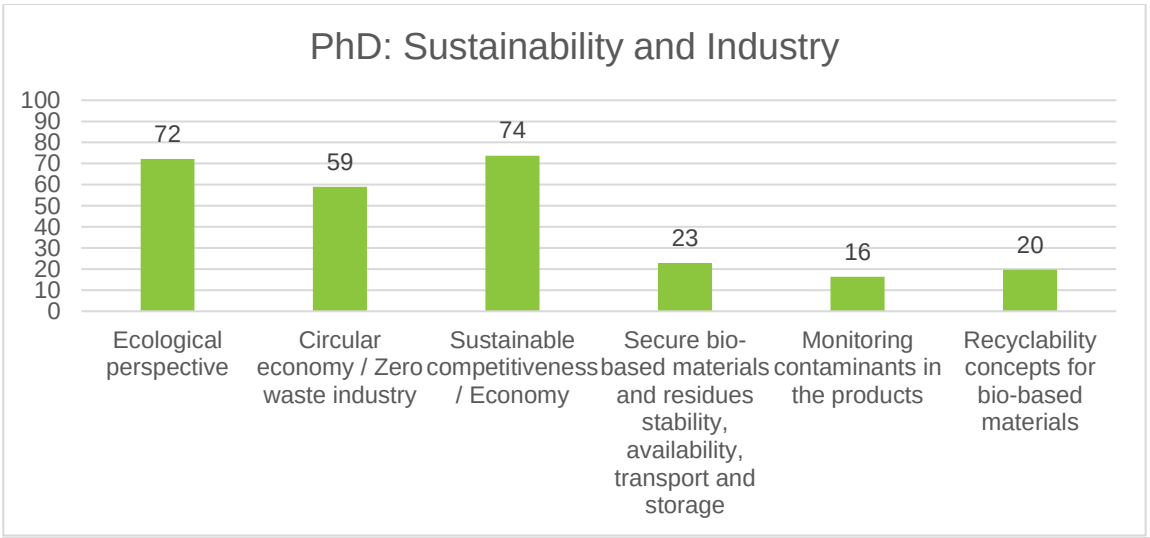
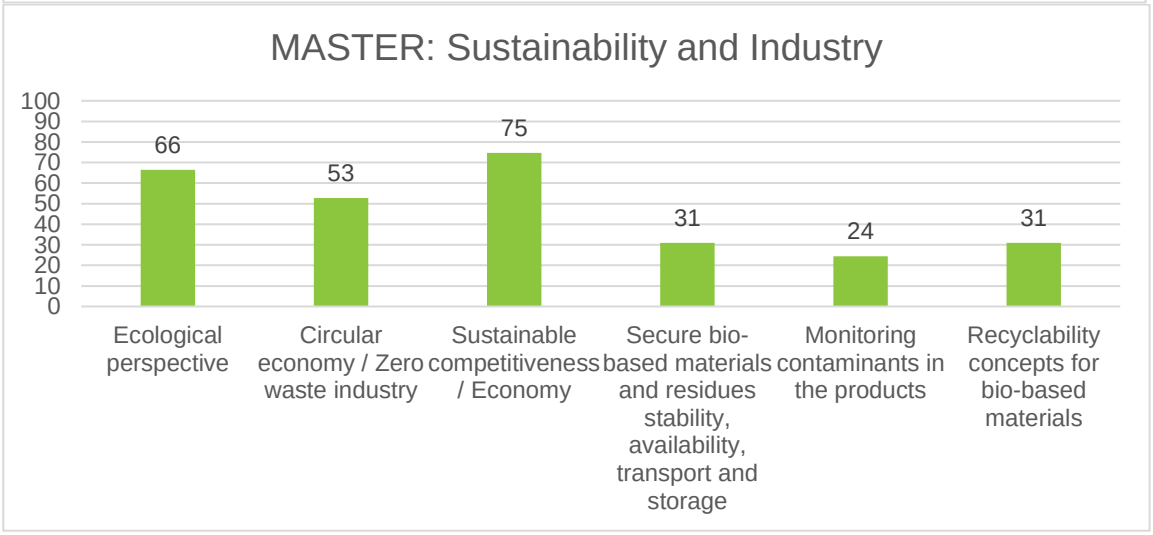


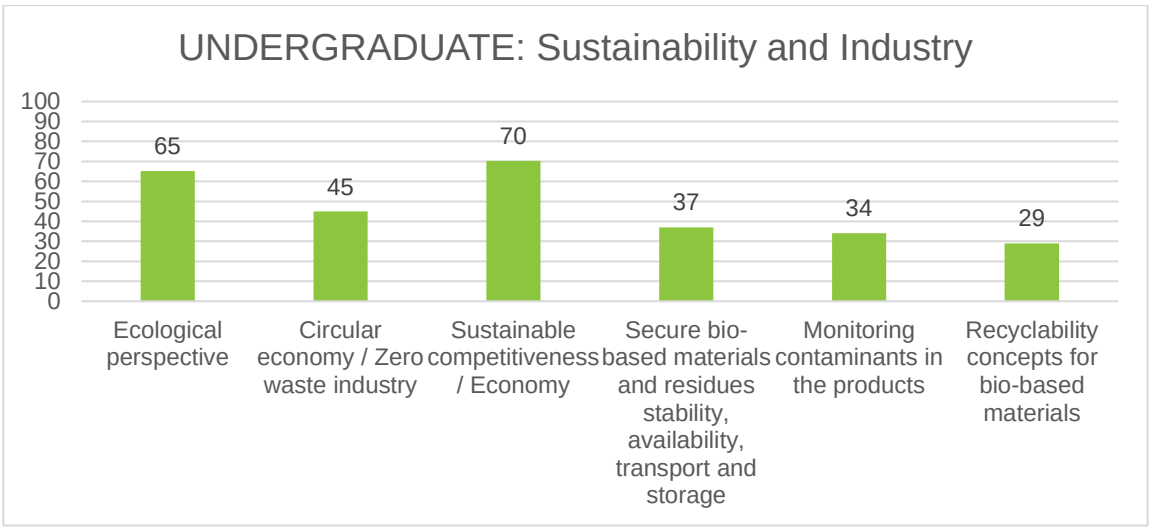
Figure 19: The distribution of educational levels for employees, expected in 2030, in the Sustainability and industry sub-competences.

The comparison between what the stakeholders expect for 2030 (figures 18 and 19) and the current offer of educational programmes (figure 20) allows us to observe that, for the Sustainability and Industry competence, there are some differences in relation to the programmes where they are developed. The presence of some competences may not be balanced with the need expressed in the prioritization. They are detailed below where differences are observed:

- Circular economy / Zero waste industry: this is the most prioritized sub-competences by stakeholders for the year 2030. However, current educational programmes provide more development in Sustainable competitiveness / Economy and Ecological perspective.
- Sustainable competitiveness / Economy: it is the second rated sub-competence by stakeholders and the most intensively developed at all educational levels.
- Secure bio-based materials and residues stability, availability, transport and storage: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Ecological perspective: this is not a top priority for stakeholders. However it is very relevant at all educational levels, according to the programmes analysed.
- Recyclability concepts for bio-based materials: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Monitoring contaminants in the products: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.


PhD: Sustainability and Industry
100
90
80
70
60
50
40
30
20
10
0
72
59
74
23
16
20
Ecological perspective
Circular economy / Zero waste industry
Sustainable competitiveness / Economy
Secure bio-based materials and residues stability, availability, transport and storage
Monitoring contaminants in the products
Recyclability concepts for bio-based materials


MASTER: Sustainability and Industry
100
90
80
70
60
50
40
30
20
10
0
66
53
75
31
24
31
Ecological perspective
Circular economy / Zero waste industry
Sustainable competitiveness / Economy
Secure bio-based materials and residues stability, availability, transport and storage
Monitoring contaminants in the products
Recyclability concepts for bio-based materials


UNDERGRADUATE: Sustainability and Industry
100
90
80
70
60
50
40
30
20
10
0
65
45
70
37
34
29
Ecological perspective
Circular economy / Zero waste industry
Sustainable competitiveness / Economy
Secure bio-based materials and residues stability, availability, transport and storage
Monitoring contaminants in the products
Recyclability concepts for bio-based materials

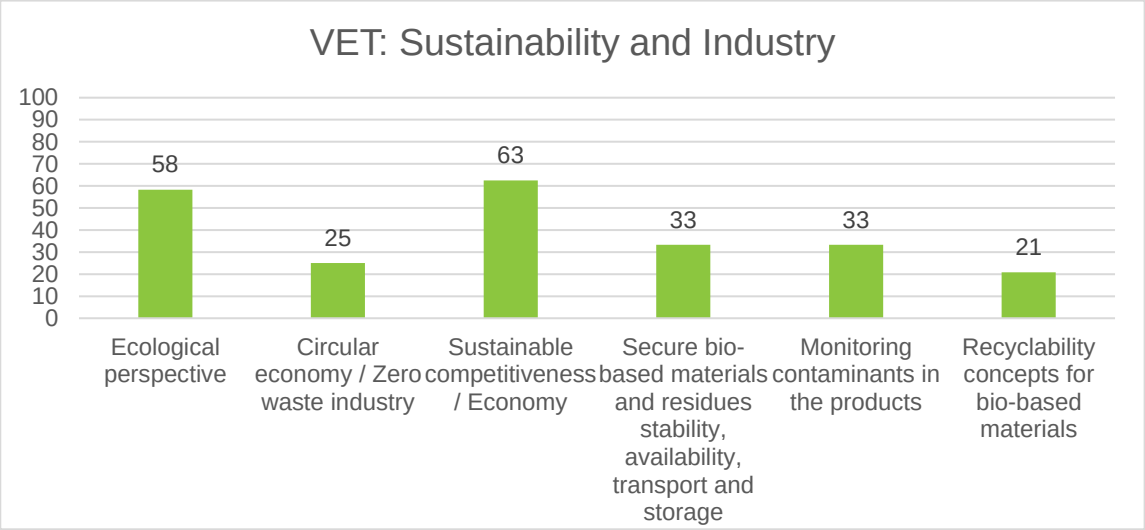


Figure 20: Sustainability and Industry sub-competences at the four educational levels analysed with the template.

Guidelines:

- Circular economy / Zero waste industry: educational programmes at all levels should increase the presence of this competence in their curricula.

- Ecological perspective: it is not considered necessary to introduce changes.

- Monitoring contaminants in the products: it is not considered necessary to introduce changes

- Recyclability concepts for bio-based materials: it is not considered necessary to introduce changes

- Secure bio-based materials and residues stability, availability, transport and storage: it is not considered necessary to introduce changes

- Sustainable competitiveness / Economy: it is not considered necessary to introduce changes

3.2.6. Technology / STEM

The following sub-competences were identified:

- Artificial Intelligence technologies
- Cybersecurity
- Data mining tools/strategies
- Digital skills
- DLT (Distributed ledger technology) & Blockchain technologies
- Information and Communication Technology
- Key Enabling Technologies for the Bio-Based Industry
- Traceability and logistics

Key Enabling Technologies for the bio-based industry was rated highest (100), followed by Digital skills (92) whereas DLT (Distributed ledger technology) & blockchain technologies was rated lowest (49), and followed by Cybersecurity (55). The other sub-competences rates are between 63 and 84.

Sub-competences	Weighted score
Key Enabling Technologies for the bio-based industry	100
Digital skills	92
Information and Communication Technology	84
Data mining tools/strategies	74
Traceability and logistics	64
Artificial Intelligence technologies	63
Cybersecurity	55
DLT (Distributed ledger technology) & blockchain technologies	49

Figure 21: The results of the prioritising sub-competences in the Technology / STEM (Science, Technology, Engineering and Maths) section.

Stakeholders believe that all sub-competences of the Technology/STEM competence must be developed at different levels depending on the skill level. Key enabling technologies and AI Technologies are quite prominent at PhD level, whereas Digital skills and IT and Communication Technology are required at Undergraduate level and Data mining tools/strategies and Traceability and logistics are more required at Master's level.

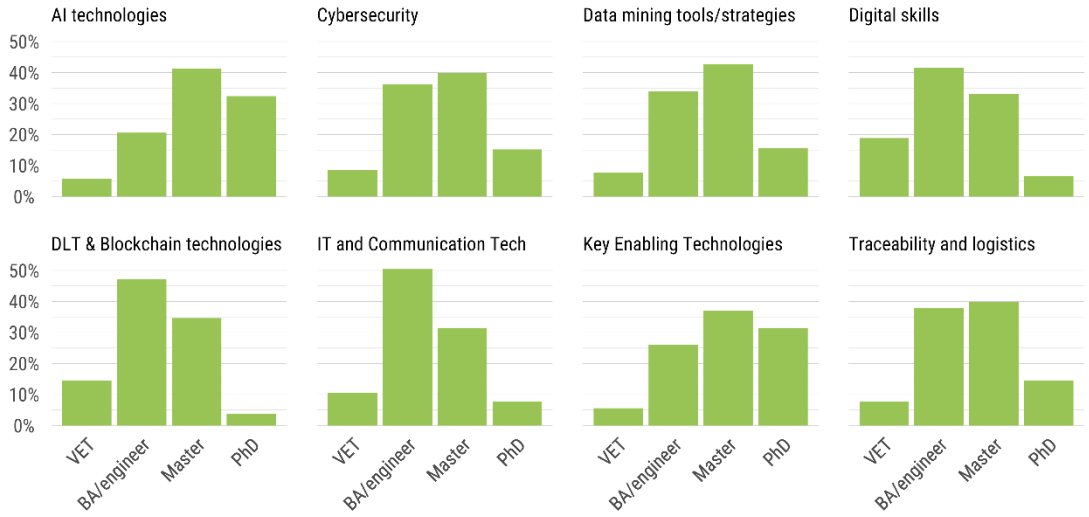
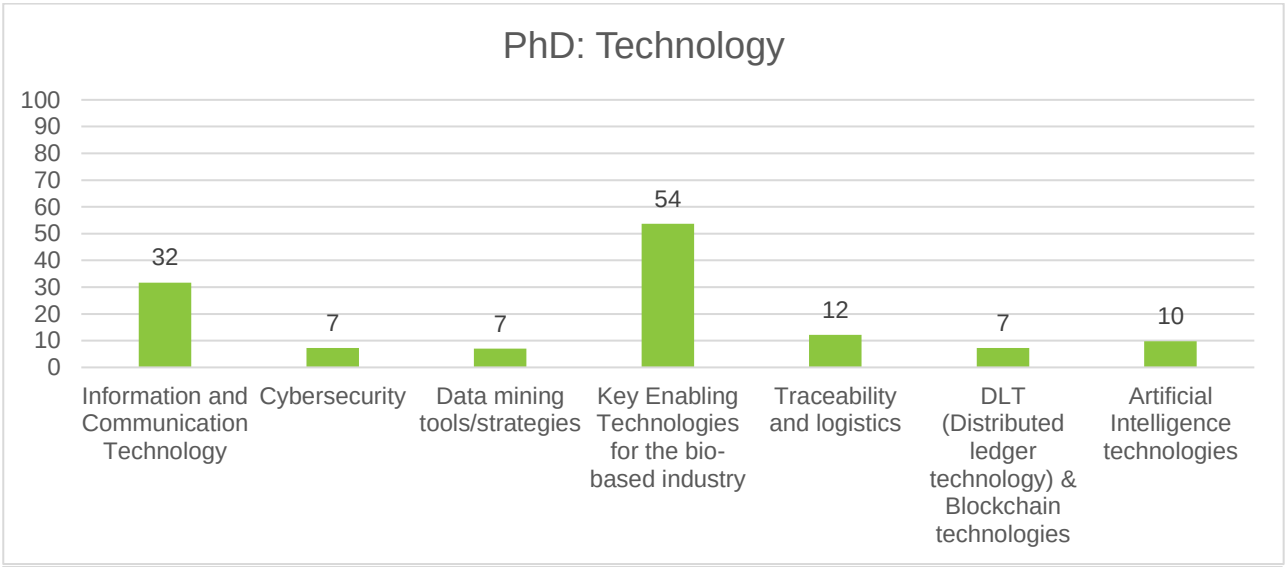
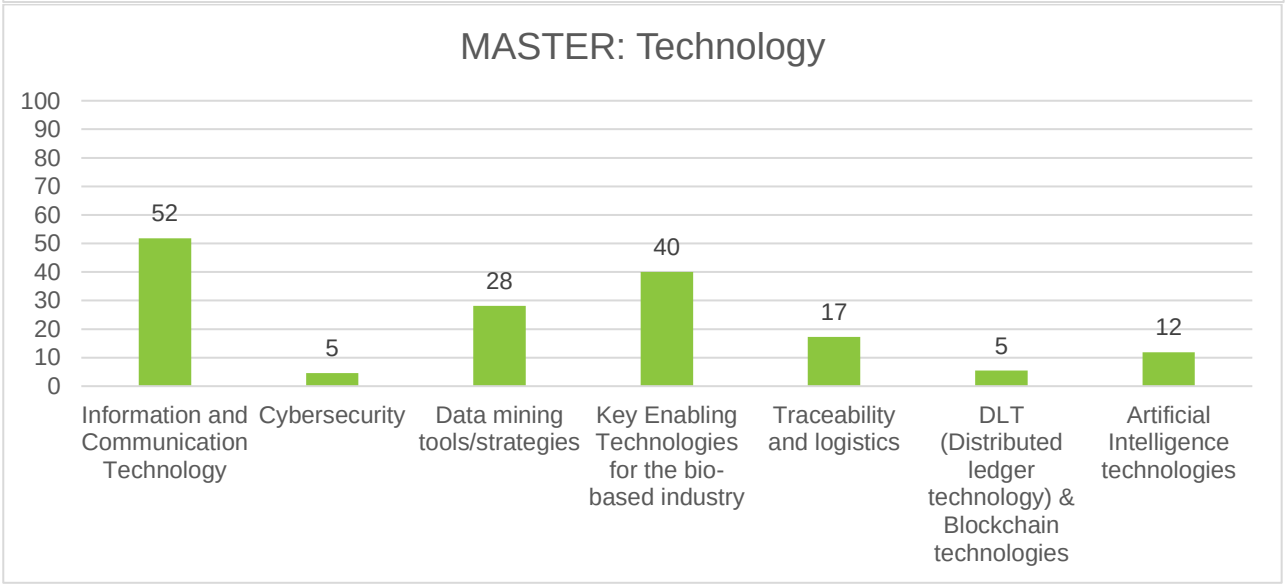


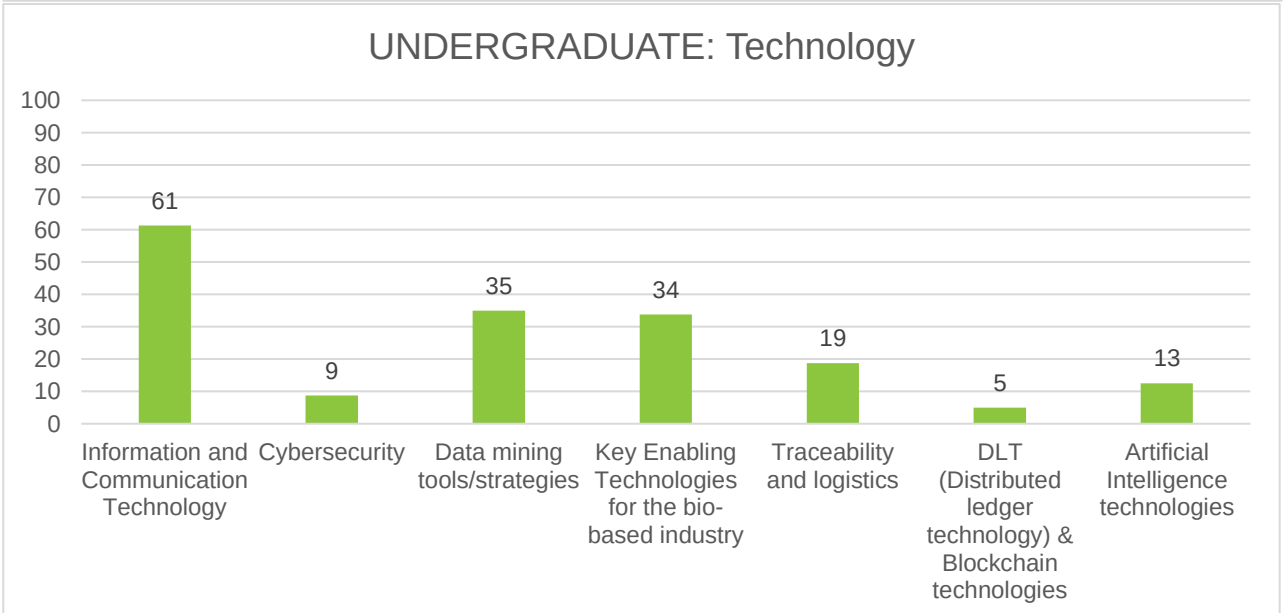
Figure 22: The distribution of educational levels for employees, expected in 2030, in the Technology / STEM sub-competences.

The comparison between what the stakeholders expect for 2030 (figures 21 and 22) and the current offer of educational programmes (figure 23) allows us to observe that, for the Technology / STEM competence, there are some differences in relation to the programmes where they are developed. The presence of some sub-competences may not be balanced with the need expressed in the prioritization. They are detailed below where differences are observed:

- Key Enabling Technologies for the bio-based industry: It is the highest rated sub-competence within the context of Technology/STEM. However, educational programmes at lower levels do not seem to consider it. It is virtually absent at VET and but the most prominent at PhD. Its presence at Masters and Undergraduate degrees seems to be more aligned with the industrial demand.
- Digital skills: These are highly rated skills by stakeholders and they are required at all levels, particularly VET and Undergraduate. However, very little effort is put in these skills by the educational programmes. It is virtually null at VET level.
- Information and Communication Technology: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Data mining tools/strategies: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Traceability and logistics: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the Undergraduate, Master's and PhD programmes analysed. However, it is the most relevant sub-competence at VET level, where stakeholders do not seem to require it so extensively.
- Artificial Intelligence technologies: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed. However, when looking at the distribution across educational programmes, the offer does not match the demand of this skill particularly at Master's level.
- Cybersecurity a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed. However, when looking at the distribution across educational programmes, the offer does not match the demand of this skill particularly at Master's level.


PhD: Technology
100
90
80
70
60
50
40
30
20
10
0
32
7
7
54
12
7
10
Information and Communication Technology
Cybersecurity
Data mining tools/strategies
Key Enabling Technologies for the bio-based industry
Traceability and logistics
DLT (Distributed ledger technology) & Blockchain technologies
Artificial Intelligence technologies


MASTER: Technology
100
90
80
70
60
50
40
30
20
10
0
52
5
28
40
17
5
12
Information and Communication Technology
Cybersecurity
Data mining tools/strategies
Key Enabling Technologies for the bio-based industry
Traceability and logistics
DLT (Distributed ledger technology) & Blockchain technologies
Artificial Intelligence technologies


UNDERGRADUATE: Technology
100
90
80
70
60
50
40
30
20
10
0
61
9
35
34
19
5
13
Information and Communication Technology
Cybersecurity
Data mining tools/strategies
Key Enabling Technologies for the bio-based industry
Traceability and logistics
DLT (Distributed ledger technology) & Blockchain technologies
Artificial Intelligence technologies

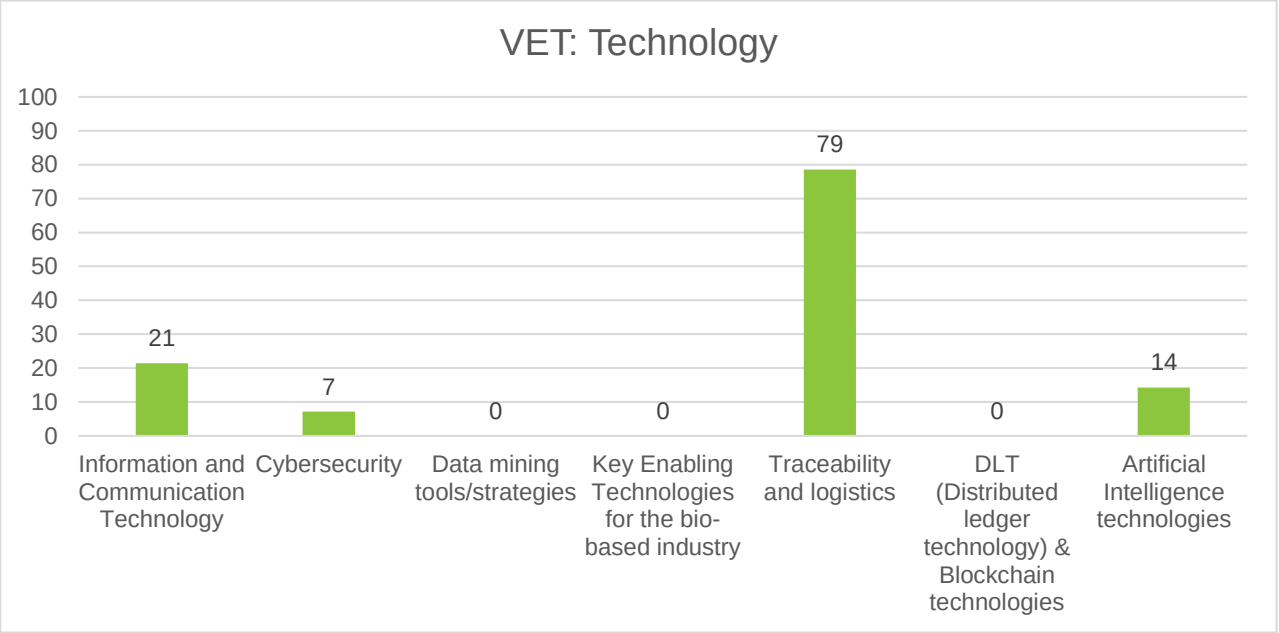


Figure 23: Technology sub-competences at the four educational levels analysed with the template.

Guidelines:

- Artificial Intelligence technologies: this sub-competence needs to be more present at Master's level.

- Cybersecurity: this sub-competence needs to be more present at Master's level.

- Data mining tools/strategies: it is not considered necessary to introduce changes.

- Digital skills: educational programmes at all levels should place a lot more emphasis in developing these skills. Special efforts should be placed at VET, where these competences seem to be neglected according to this analysis.

- Information and Communication Technology: it is not considered necessary to introduce changes.

- Key Enabling Technologies for the Bio-Based Industry: Special efforts should be placed at VET, where these competences seem to be neglected according to the programmes analysed.

- Traceability and logistics: There is an unbalance at VET level, where this sub-competence is very relevant at educational programmes, but does not seem to be so much in demand by stakeholders at this level.

3.2.7. Research and innovation

The following sub-competences were identified:

- Analytical capacity
- Fundamental research
- Innovation and change
- Knowledge Transfer: From LAB to Industry
- Management and development of research

Innovation and change was rated highest (100), followed by Knowledge transfer: From lab to industry (92) and Management and development of research (84), whereas Fundamental research was rated lowest (37), followed by Analytical capacity (49).

Sub-competences	Weighted score
Innovation and change	100
Knowledge transfer: From lab to industry	92
Management and development of research	84
Analytical capacity	49
Fundamental research	37

Figure 24: The results of the prioritising sub-competences in the Research and Innovation section.

Stakeholders believe that sub-competences of the Research and Innovation competence must be developed at the Master and PhD level. Fundamental Research needs to be fully developed at PhD level, whereas Analytical Capacity and Innovation and Change need to be acquired at Master's level. This set of Research and Innovation competences become less relevant at VET level.

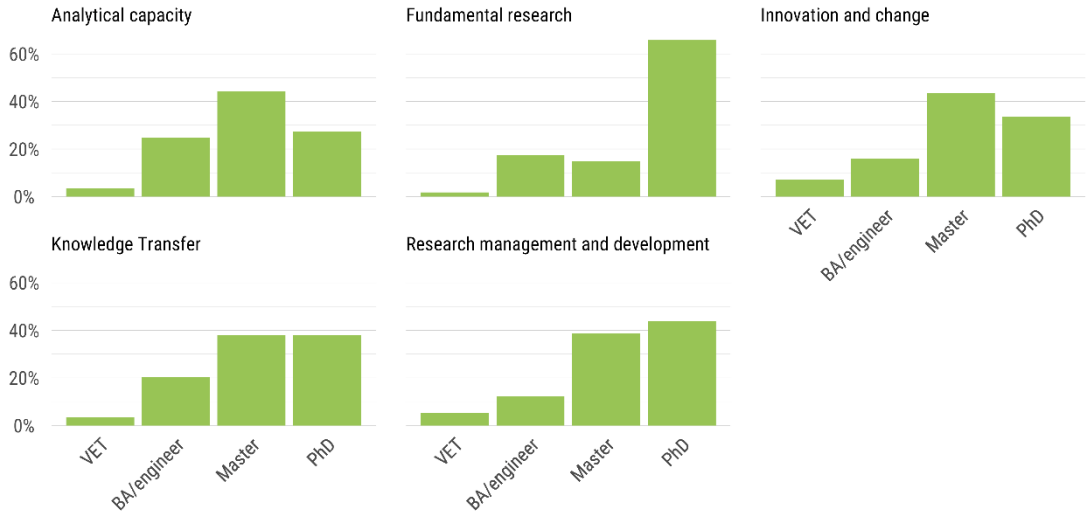


Figure 25: The distribution of educational levels for employees, expected in 2030, in the Research and Innovation sub-competences.

The comparison between what the stakeholders expect for 2030 (figures 24 and 25) and the current offer of educational programmes (figure 26) allows us to observe that, for the Research and Innovation competence, there are some differences in relation to the programmes where they are developed. The presence of some competences may not be balanced with the need expressed in the prioritization. They are detailed below where differences are observed:

- Innovation and change: this is the most prioritized sub-competence by stakeholders for the year 2030. They also inform that it should be present at all educational levels, but more intensively developed at Master's level.
- Knowledge transfer: From lab to industry: its need is a very high priority for stakeholders, whereas it is the least relevant from this group at all educational levels, with the exception of VET, where it matches the demand.
- Management and development of research: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Analytical capacity: it is the second to last rated in this group by stakeholders. However, it is the most important for educational programmes at all levels, including VET.
- Fundamental research: this sub-competence is the least rated among this group. It is considered extremely relevant at PhD level. However, it is equally developed at Undergraduate, Master's and PhD level. It is virtually non-existing at VET level.

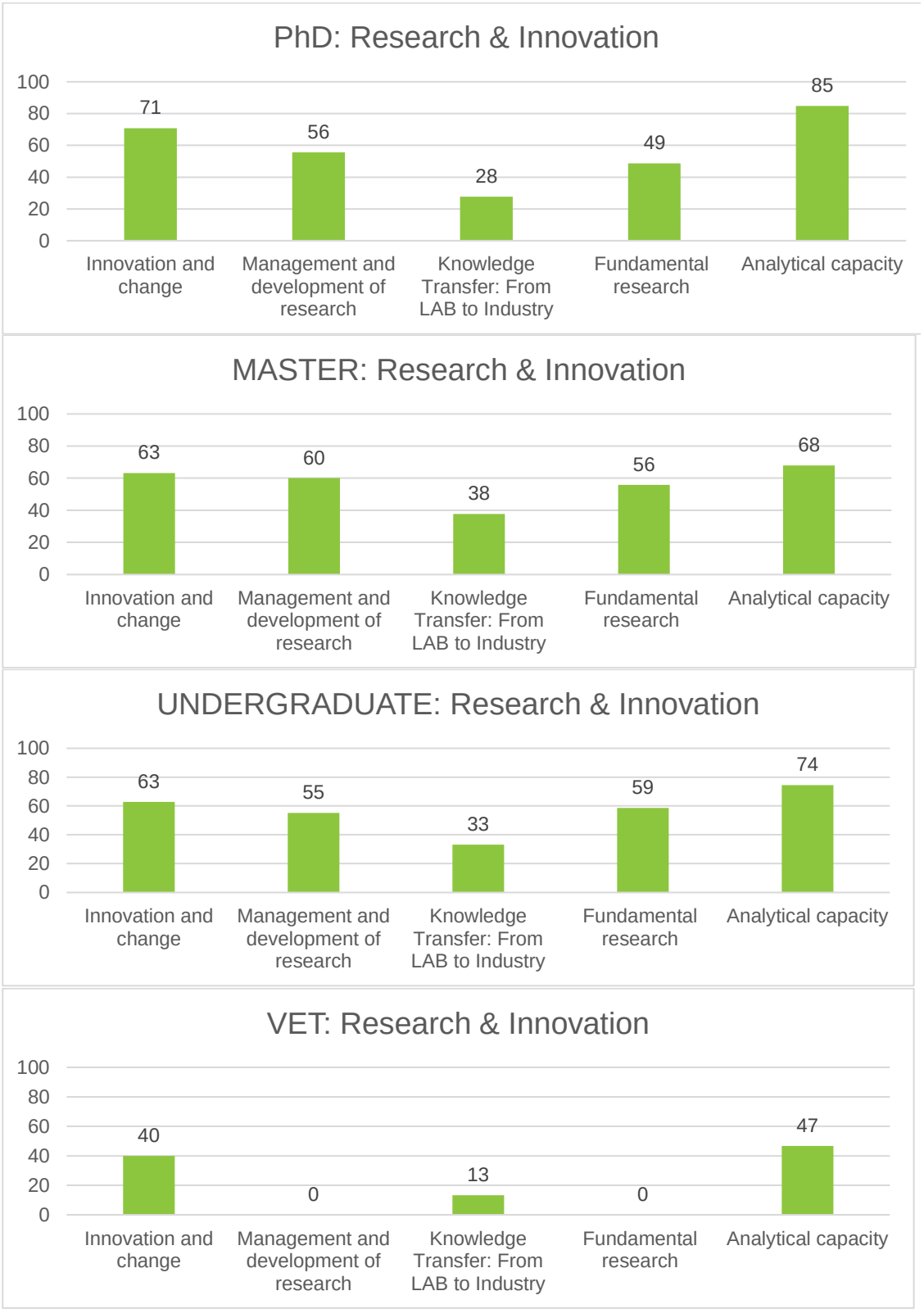


Figure 26: Research and Innovation sub-competences at the four educational levels analysed with the template.

Guidelines:

- Analytical capacity: an unbalance is observed between stakeholders' priority for this sub-competence and academia, where it is the most developed sub-competence of this group at all educational levels.

- Fundamental research: this sub-competence needs to be more present at PhD level.

- Innovation and change: this sub-competence needs to be more present at Master's level.

- Knowledge Transfer: From LAB to Industry: Undergraduate, Master's and PhD educational programmes should place a lot more emphasis in developing these skills.

- Management and development of research: it is not considered necessary to introduce changes.

3.2.8. Basic scientific knowledge

The following sub-competences were identified:

- Biology
- Biotechnology
- Chemical Engineering
- Chemistry
- Information and Communication Technologies.
- Maths
- Nanotechnology
- Physics

Biotechnology was rated highest (100), whereas Nanotechnology was rated lowest (44), followed by Physics (45) and Maths (47). The other sub-competences rates are between 52 and 83.

Sub-competences	Weighted score
Biotechnology	100
Chemistry	83
Chemical Engineering	79
Biology	78
Information and Communication Technologies.	52
Maths	47
Physics	45
Nanotechnology	44

Figure 27: The results of the prioritising sub-competences in the Basic scientific knowledge section.

Stakeholders emphasize that Biotechnology should be fully developed at PhD level, whereas Biology, Chemical Engineering and Nanotechnology are more relevant at Master's level. Physics, IT and Communication Technologies are more required at Undergraduate level, whereas Chemistry seems to be more transversal to all educational levels and Math becomes very relevant at Undergraduate and Master's level.

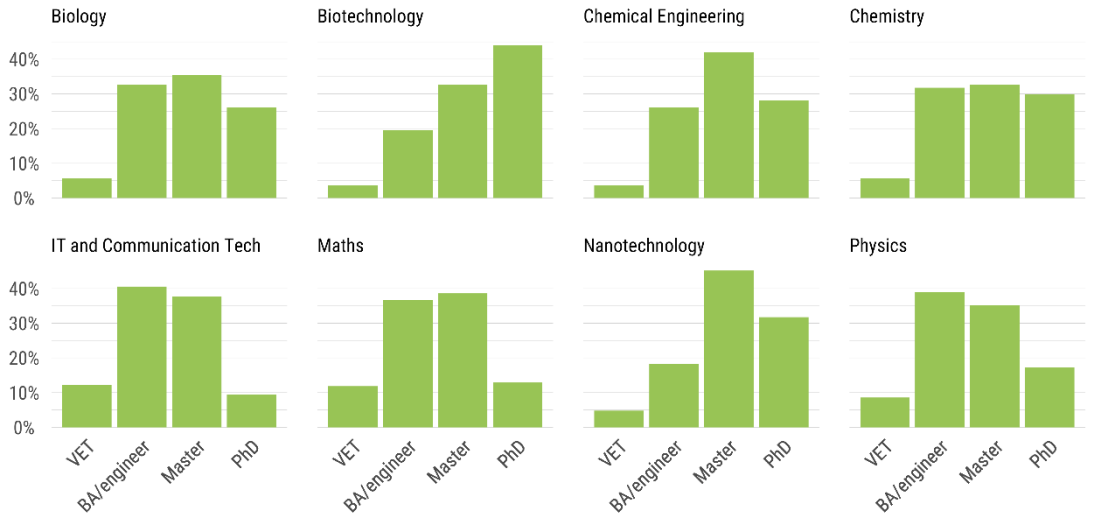
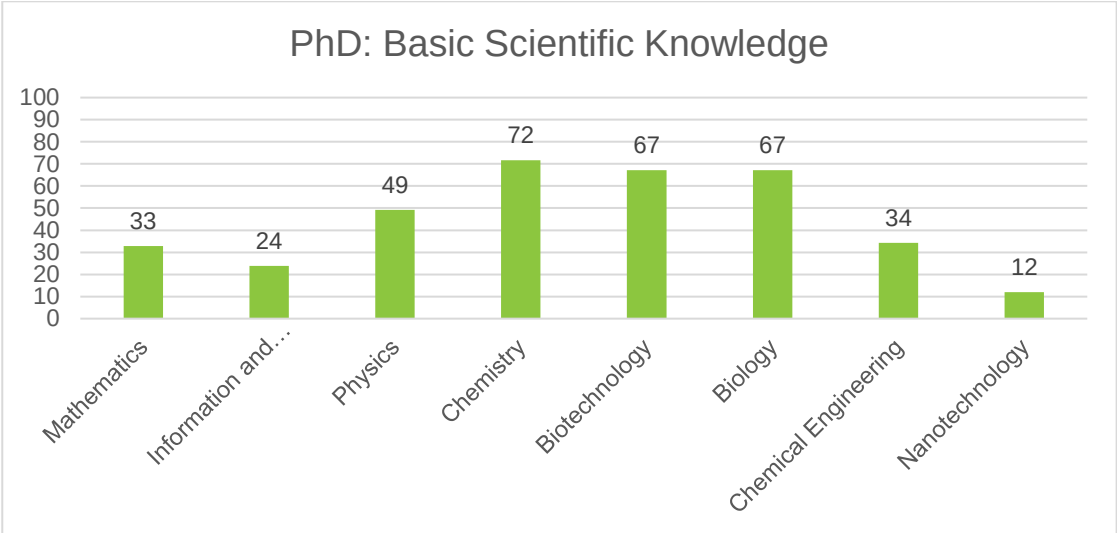


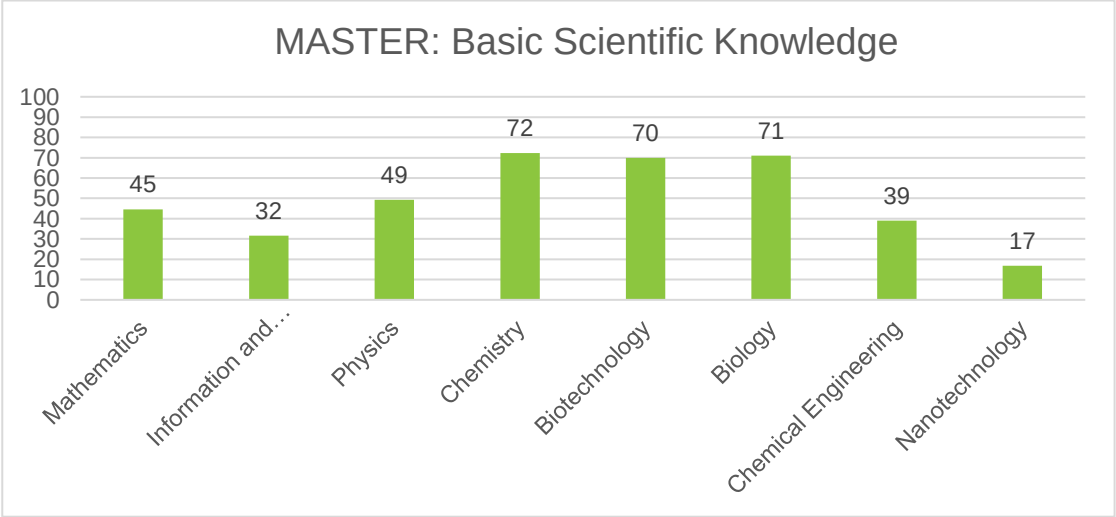
Figure 28: The distribution of educational levels for employees, expected in 2030, in the Basic scientific knowledge sub-competences.

The comparison between what the stakeholders expect for 2030 (figures 27 and 28) and the current offer of educational programmes (figure 29) allows us to observe that, for the Basic Scientific Knowledge competence, there are some differences in relation to the programmes where they are developed. The presence of some sub-competences may not be balanced with the need expressed in the prioritization. They are detailed below where differences are observed:

- Biotechnology: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Chemistry: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Chemical Engineering: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Biology: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Information and Communication Technologies: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.

- Maths: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Physics: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Nanotechnology: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.





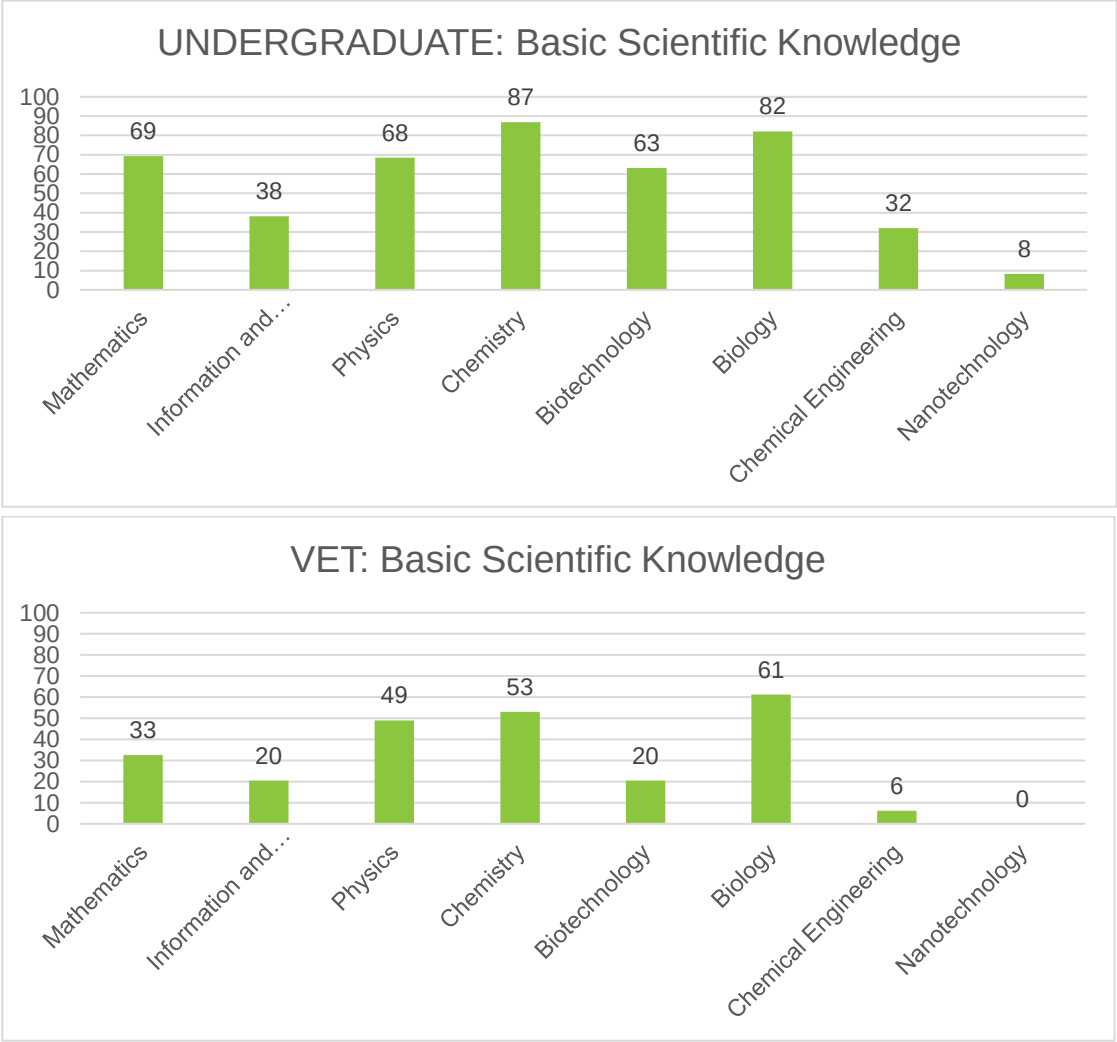


Figure 29: Basic Scientific Knowledge sub-competences at the four educational levels analysed with the template.

Guidelines:

- Biology: it is not considered necessary to introduce changes.

- Biotechnology: it is not considered necessary to introduce changes.

- Chemical Engineering: it is not considered necessary to introduce changes.

- Chemistry: it is not considered necessary to introduce changes.

- Information and Communication Technologies: it is not considered necessary to introduce changes.

- Maths: it is not considered necessary to introduce changes.

- Nanotechnology: it is not considered necessary to introduce changes.

- Physics: it is not considered necessary to introduce changes.

3.2.9. Rules and regulation

The following sub-competences were identified:

- Bio-based products legal framework
- Common EU regulations
- Digital Compliance
- IPR - Intellectual Property Rights
- Local legal regulations
- Patent regulations
- Quality, safety and security regulations
- Waste regulations

Common EU regulations was rated highest (100), followed by Bio-based products legal framework (96) and Quality, safety and security regulations (90), whereas Digital Compliance was rated lowest (33). The other sub-competences rates are between 69 and 79.

Sub-competences	Weighted score
Common EU regulations	100
Bio-based products legal framework	96
Quality, safety and security regulations	90
IPR - Intellectual Property Rights	79
Waste regulations	77
Patent regulations	71
Local legal regulations	69
Digital Compliance	33

Figure 30: The results of the prioritising the sub-competences in the Rules and Regulation section.

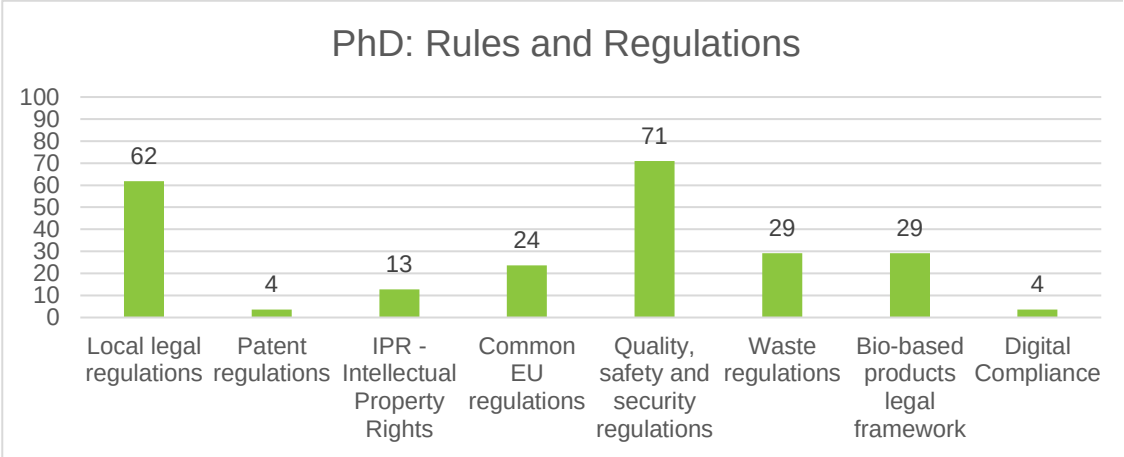
Stakeholders believe that all sub-competences of the Rules and Regulations competence must be developed at the Master's level. None of these sub-competences are expected at PhD level and some are quite relevant at VET. Digital Compliance, Quality, safety and security and Waste regulations are also demanded at Undergraduate level.

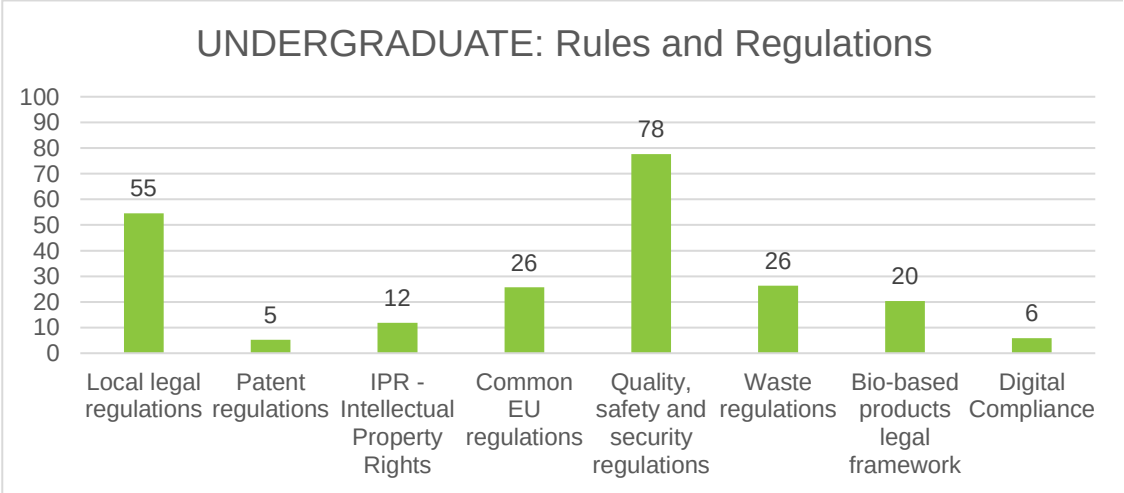
Figure 31: The distribution of educational levels for employees, expected in 2030, in the Basic scientific knowledge sub-competences.

The comparison between what the stakeholders expect for 2030 (figures 30 and 31) and the current offer of educational programmes (figure 32) allows us to observe that, in general, for the Rules and regulation competence, there are some differences in relation to the programmes where they are developed. The presence of some sub-competences may not be balanced with the need expressed in the prioritization. They are detailed below where differences are observed:

- Common EU regulations: an unbalance is observed between stakeholders' top priority for this sub-competence and academia, where it is less developed at all educational levels.
- Bio-based products legal framework: an unbalance is observed between stakeholders' priority for this sub-competence and academia, where it is less developed at all educational levels.
- Quality, safety and security regulations: an unbalance is observed between stakeholders' priority for this sub-competence and academia, where it is most developed at all educational levels. According to stakeholders, this sub-competence is less required at PhD level as compared to Undergraduate and Master's.
- IPR - Intellectual Property Rights: an unbalance is observed between stakeholders' priority for this sub-competence and academia, where it is less developed at all educational levels.
- Waste regulations: an unbalance is observed between stakeholders' priority for this sub-competence and academia, where it is equally developed at all educational levels, whereas stakeholders consider it more relevant at Undergraduate and Master's level.
- Patent regulations: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.

- Local legal regulations: an unbalance is observed between stakeholders' priority for this sub-competence and academia, where it is much more developed and to a similar intensity at all educational levels.
- Digital Compliance: an unbalance is observed between stakeholders' priority for this sub-competence and academia, where it is less developed at all educational levels.





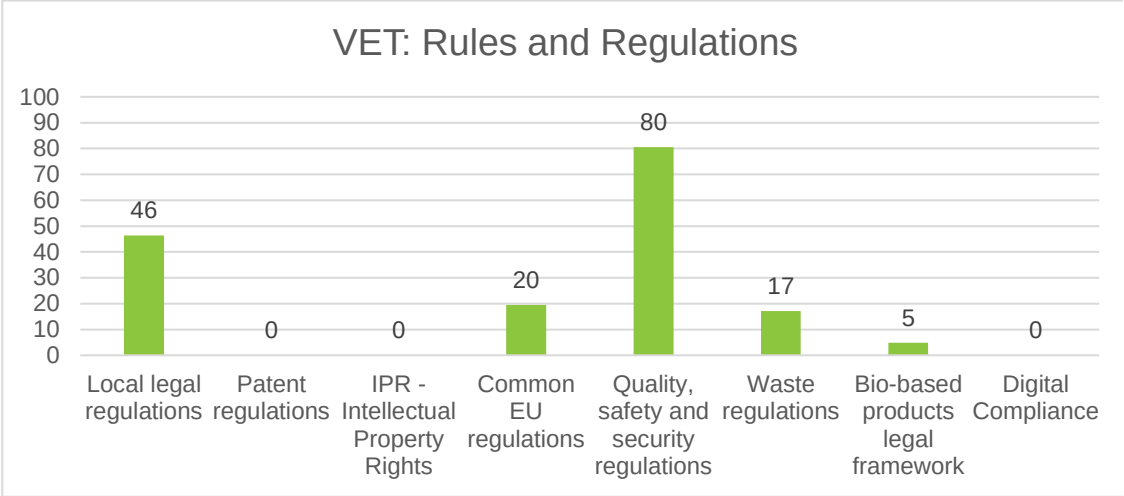


Figure 32: Rules and Regulations sub-competences at the four educational levels analysed with the template.

Guidelines:

- Bio-based products legal framework: its presence should be intensified at all educational levels, particularly at Master's level.

- Common EU regulations: its presence should be intensified at all educational levels, particularly at Master's level.

- Digital Compliance: its presence should be intensified at all educational levels, particularly at Undergraduate and Master's level.

- IPR - Intellectual Property Rights: its presence should be intensified, particularly at Master's level.

- Local legal regulations: the presence of this sub-competence at all levels seems to exceed its demand, particularly at PhD level.

- Patent regulations: it is not considered necessary to introduce changes.

- Quality, safety and security regulations: the presence of this sub-competence at all levels seems to exceed its demand.

- Waste regulations: the presence of this sub-competence at PhD level seems to exceed its demand.

3.2.10. Social responsibility

The following sub-competences were identified:

- Economic responsibilities
- Environmental responsibility
- Ethical responsibilities
- Green engineering awareness
- Health Responsibilities
- Legal responsibilities
- Philanthropic responsibilities
- Self-consumption energies

Environmental responsibility was rated highest (100), whereas Philanthropic responsibilities was rated lowest (under 22). The other sub-competences rates are between 38 and 84.

Sub-competences	Weighted score
Environmental responsibility	100
Ethical responsibilities	84
Legal responsibilities	75
Economic responsibilities	75
Health Responsibilities	73
Green engineering awareness	66
Self-consumption energies	38
Philanthropic responsibilities	22

Figure 33: The results of the prioritising the sub-competences in the Rules and Regulation section.

Stakeholders believe that all sub-competences of the Social Responsibility competence must be developed mainly at the Master's level. Ethical, Health, Philanthropic responsibilities and Self-consumption energies are also very relevant at Undergraduate level.

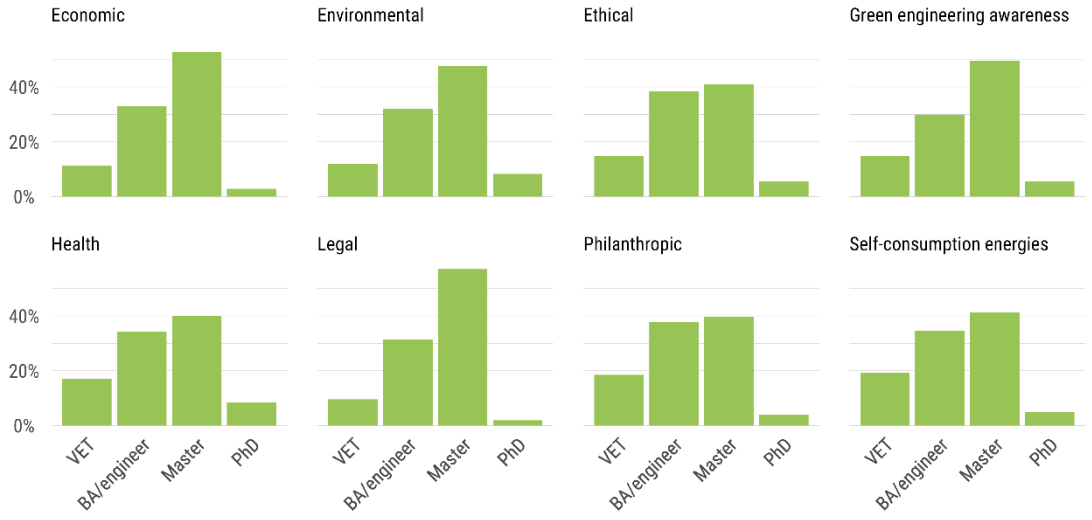
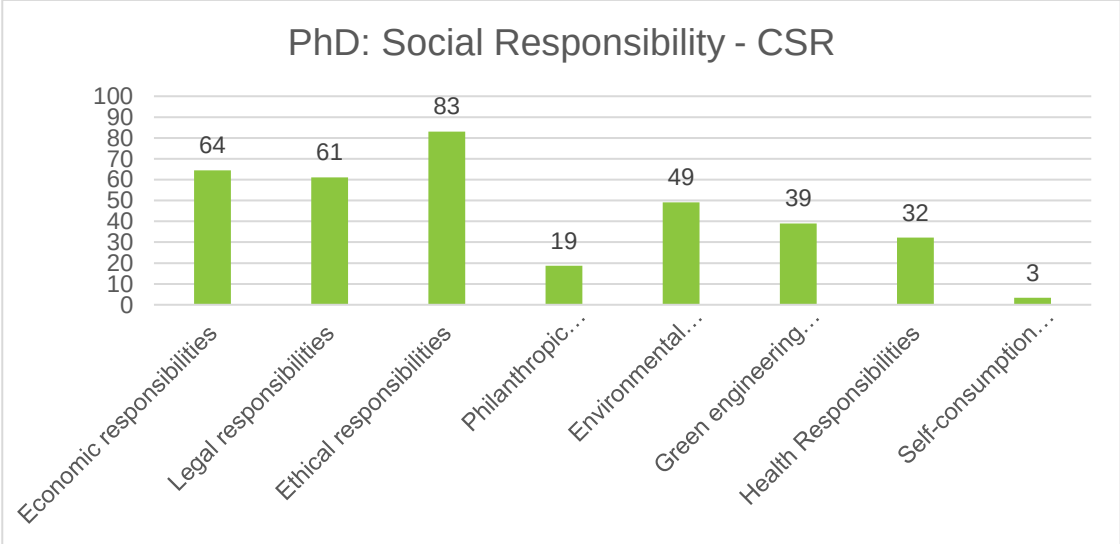


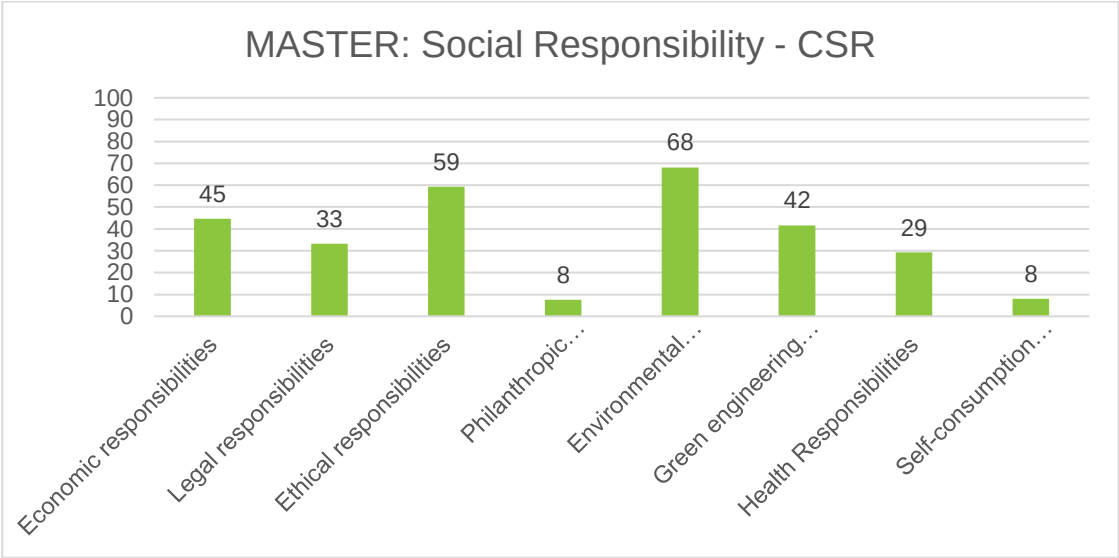
Figure 34: The distribution of educational levels for employees, expected in 2030, in the Social Responsibility - CSR sub-competences.

The comparison between what the stakeholders expect for 2030 (figures 33 and 34) and the current offer of educational programmes (figure 35) allows us to observe that, for the Social Responsibility competence, there are some differences in relation to the programmes where they are developed. The presence of some sub-competences may not be balanced with the need expressed in the prioritization. They are detailed below where differences are observed:

- Environmental responsibility: this is the most prioritized sub-competence by stakeholders for the year 2030. It is more intensively developed at Master's level, which matches the stakeholders' opinion for this sub-competence.
- Ethical responsibilities: this is the second priority for stakeholders and we observe its presence at all educational levels. However, it is the most present at PhD programmes, whereas stakeholders consider it is more needed at Undergraduate and Master's level.
- Legal responsibilities: Stakeholders identify this sub-competence as a clear need for Master level. However, educational programmes show more presence of this sub-competence at VET and PhD levels.
- Economic responsibilities: Stakeholders identify this sub-competence as a need for Master's level. However, it is more present at PhD educational programmes, although quite relevant at all levels.
- Health Responsibilities: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Green engineering awareness: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed. It is the most present sub-competence at VET educational programmes.
- Self-consumption energies: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.

- Philanthropic responsibilities: this is the least prioritised sub-competence and the least present across educational programmes at all levels. A balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.





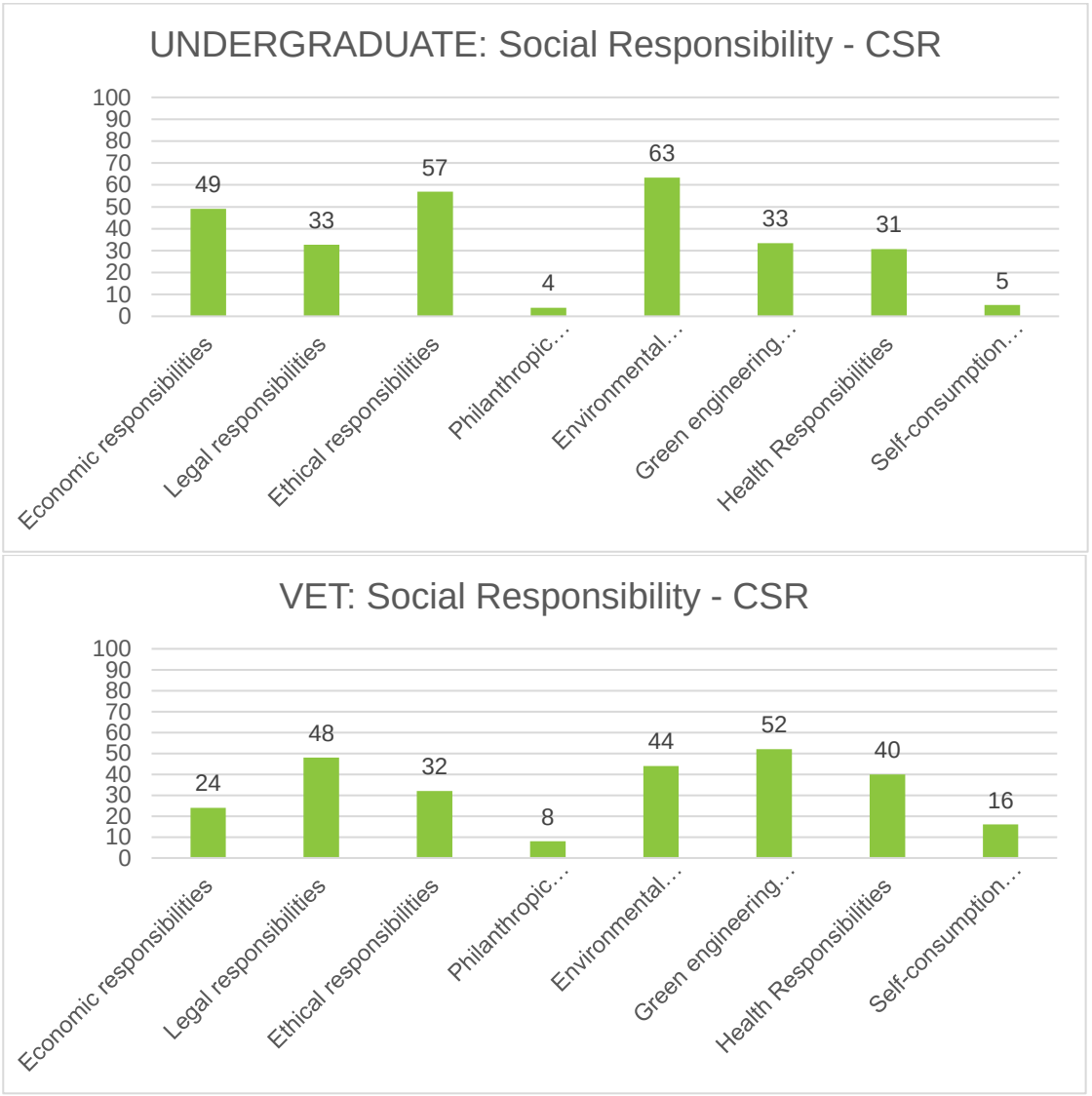


Figure 35: Social Responsibility - CSR sub-competences at the four educational levels analysed with the template.

Guidelines:

- Economic responsibilities: its presence should be intensified at Master's levels.

- Environmental responsibility: it is not considered necessary to introduce changes.

- Ethical responsibilities: its presence should be intensified at Undergraduate and Master's levels.

- Green engineering awareness: it is not considered necessary to introduce changes.

- Health Responsibilities: it is not considered necessary to introduce changes.

- Legal responsibilities: its presence should be intensified at Master's levels.

- Philanthropic responsibilities: it is not considered necessary to introduce changes.

- Self-consumption energies: it is not considered necessary to introduce changes.

3.2.11. Sales and marketing

The following sub-competences were identified:

- Adapting the products to new targets
- Increasing consumer/society awareness on bio-based products
- Market globalization
- Marketing online and Social Media
- Openness of the industrial processes and products
- Packaging solutions derived from bio-based materials

Increasing consumer / society awareness on bio-based products was rated highest (100) followed by Adapting the products to new targets (97) , whereas Packaging solutions derived from bio-based materials was rated lowest (52). The other sub-competences rates are between 56 and 84.

Sub-competences	Weighted score
Increasing consumer / society awareness on bio-based products	100
Adapting the products to new targets	97
Openness of the industrial processes and products	84
Market globalization	74
Marketing online and Social Media	56
Packaging solutions derived from bio-based materials	52

Figure 36: The results of the prioritising the sub-competences in the Sales and Marketing section.

Stakeholders believe that all sub-competences of the Sales and Marketing competence must be developed at the Master's level, except for Openness of the industrial processes and products Marketing online and Social Media sub-competences, where Undergraduate educational level is considered more relevant.

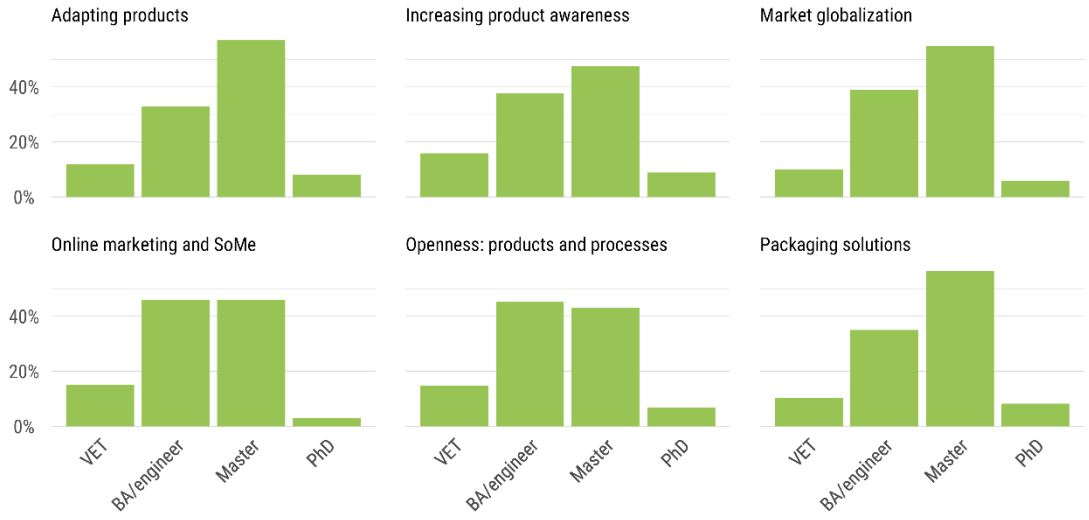
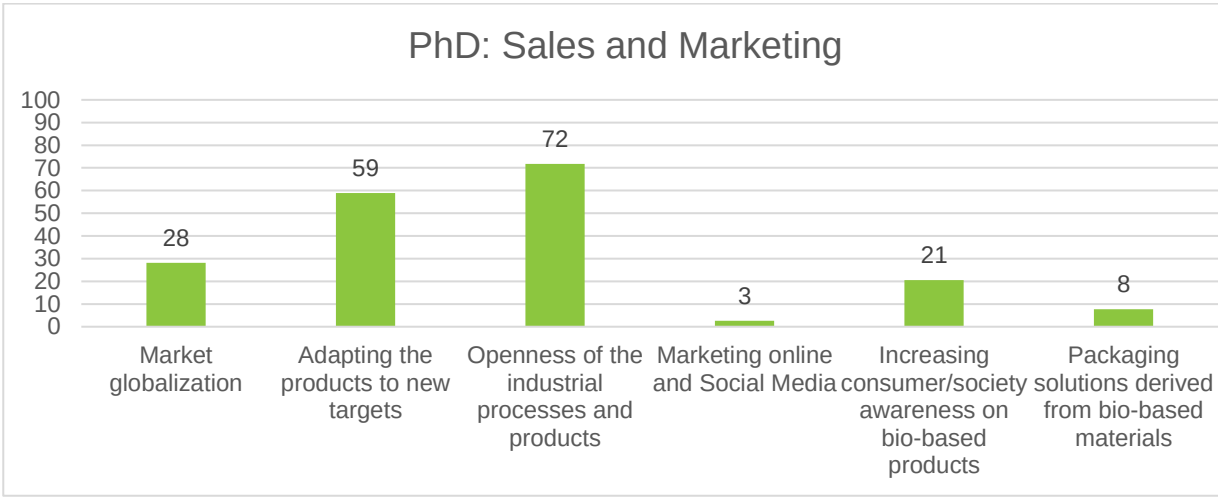
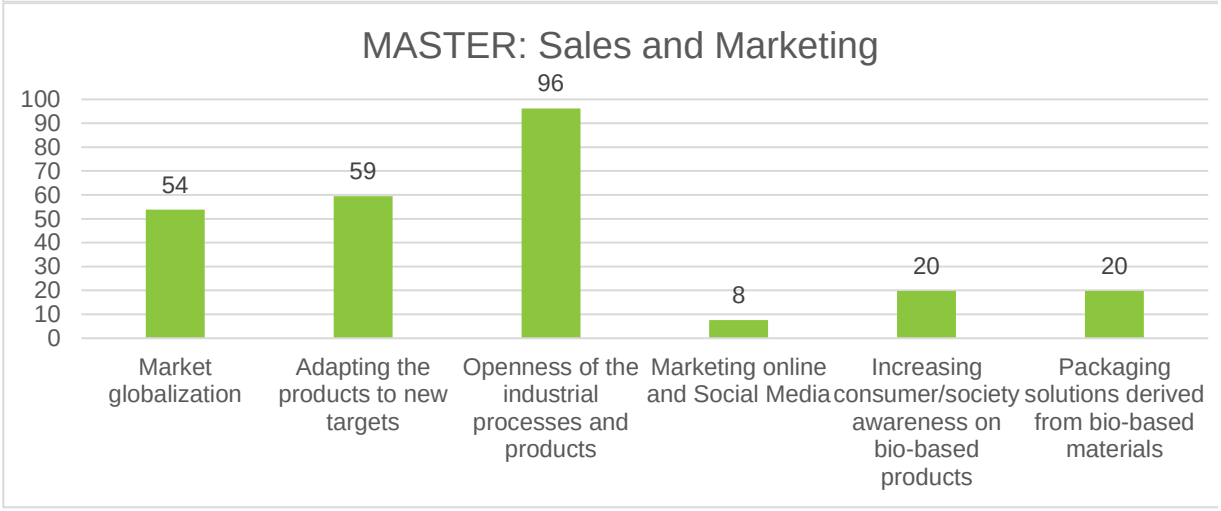


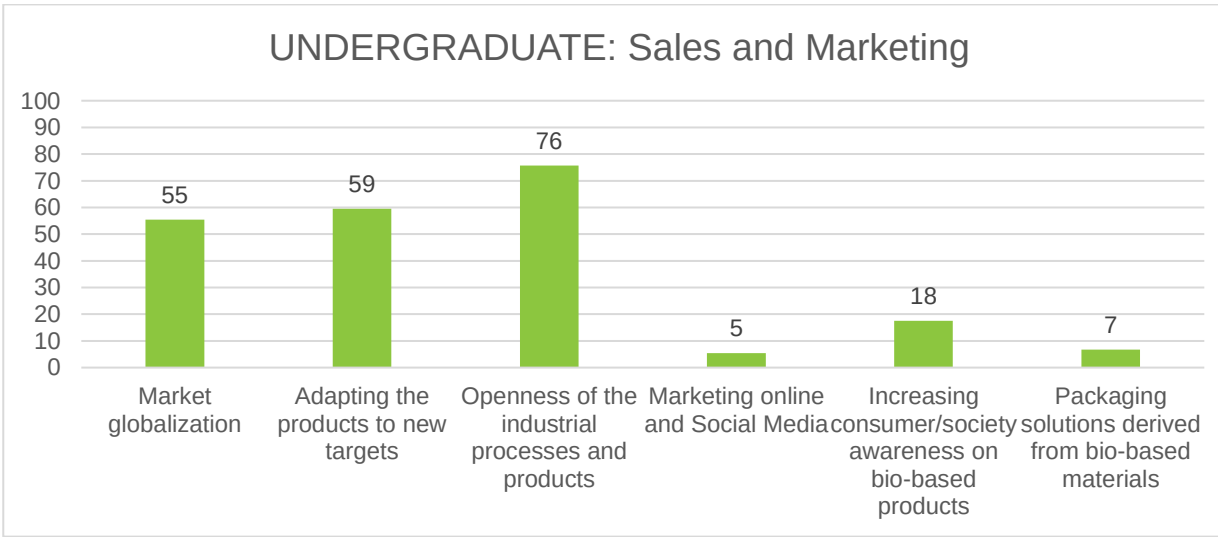
Figure 37: The distribution of educational levels for employees, expected in 2030, in Sales and Marketing sub-competences.

The comparison between what the stakeholders expect for 2030 (figures 36 and 37) and the current offer of educational programmes (figure 38) allows us to observe that, for the Sales and marketing competence, there are some differences in relation to the programmes where they are developed. The presence of some competences may not be balanced with the need expressed in the prioritization. They are detailed below where differences are observed:

- Increasing consumer / society awareness on bio-based products: an unbalance is observed between stakeholders' top priority for this sub-competence and academia, where there is very little presence at all educational levels.
- Adapting the products to new targets: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Openness of the industrial processes and products: an unbalance is observed between stakeholders' priority for this sub-competence and academia, where it is the most developed at all educational levels.
- Market globalization: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Marketing online and Social Media: an unbalance is observed between stakeholders' priority for this sub-competence and academia, where it is less developed at all educational levels.
- Packaging solutions derived from bio-based materials: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed, except for VET level, where it is not represented.


PhD: Sales and Marketing
100
90
80
70
60
50
40
30
20
10
0
28
59
72
3
21
8
Market globalization
Adapting the products to new targets
Openness of the industrial processes and products
Marketing online and Social Media
Increasing consumer/society awareness on bio-based products
Packaging solutions derived from bio-based materials


MASTER: Sales and Marketing
100
90
80
70
60
50
40
30
20
10
0
54
59
96
8
20
20
Market globalization
Adapting the products to new targets
Openness of the industrial processes and products
Marketing online and Social Media
Increasing consumer/society awareness on bio-based products
Packaging solutions derived from bio-based materials


UNDERGRADUATE: Sales and Marketing
100
90
80
70
60
50
40
30
20
10
0
55
59
76
5
18
7
Market globalization
Adapting the products to new targets
Openness of the industrial processes and products
Marketing online and Social Media
Increasing consumer/society awareness on bio-based products
Packaging solutions derived from bio-based materials

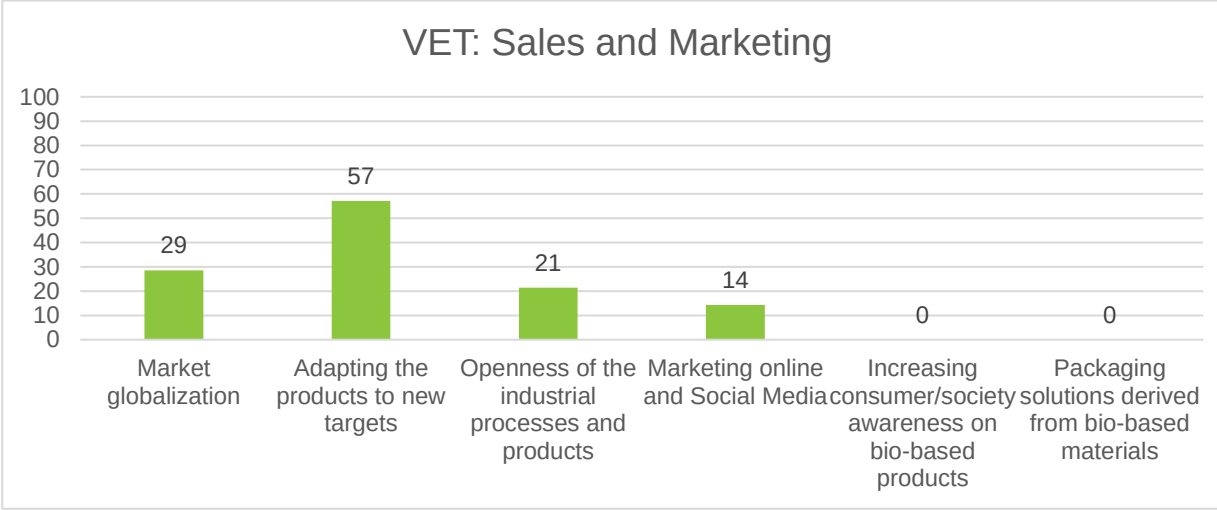


Figure 38: Sales and Marketing sub-competences at the four educational levels analysed with the template.

Guidelines:

- Adapting the products to new targets: it is not considered necessary to introduce changes.

- Increasing consumer/society awareness on bio-based products: the presence of this sub-competence must be increased at all educational levels.

- Market globalization: it is not considered necessary to introduce changes.

- Marketing online and Social Media: the presence of this sub-competence should be increased at all educational levels.

- Openness of the industrial processes and products: this sub-competence is not required by stakeholders to the level of intensity developed at all educational levels.

- Packaging solutions derived from bio-based materials: the presence of this sub-competence must be increased at VET level.

3.3. Specific competences of the bio-based industries

In general terms, we can argue that the specific competences identified in this project are mostly required at higher education levels, particularly Master and PhD. They do not seem to be so extensively required at VET level. With some exceptions that will be pointed out in the following sections, the same pattern is observed in the analysis of educational levels regarding the presence of these specific competences.

3.3.1. Specialists in bio-based sector business/market development

The following sub-competences were identified:

- Bio-based-market knowledge & techno-economic expertise
- Identify and create market applications for new bio-based products
- New Bio-based Business Models based on technological surveillance, competitive intelligence and funding attraction
- New Blue-Bio-based Business models and Value chains
- To raise society's awareness on circular bio-based economy

Bio-based-market knowledge & techno-economic expertise was rated highest (100), whereas New bio-based business models based on technological surveillance, competitive intelligence and funding attraction and was rated lowest (under 65). The other sub-competences rates are between 66 and 80.

Sub-competences	Weighted score
Bio-based-market knowledge & techno-economic expertise	100
Identify and create market applications for new bio-based products	80
New Blue-Bio-based Business models and Value chains	67
To raise society's awareness on circular bio-based economy	66
New bio-based business models based on technological surveillance, competitive intelligence and funding attraction	65

Figure 39: The results of the prioritising the sub-competences in the specialists in bio-based sector business/market development.

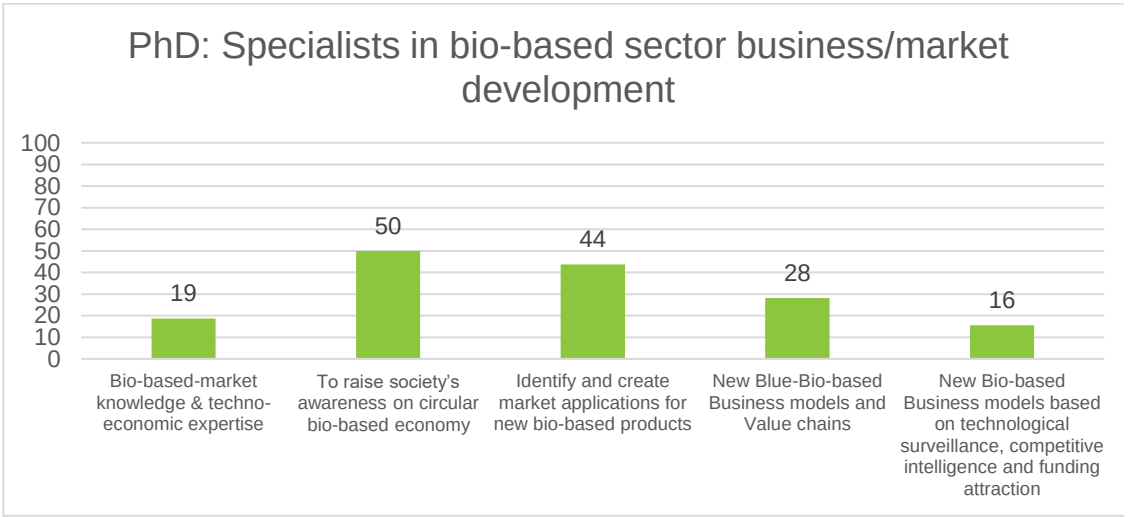
Stakeholders believe that all sub-competences of the Specialists in bio-based sector business/market development competence must be developed at Master's level, except

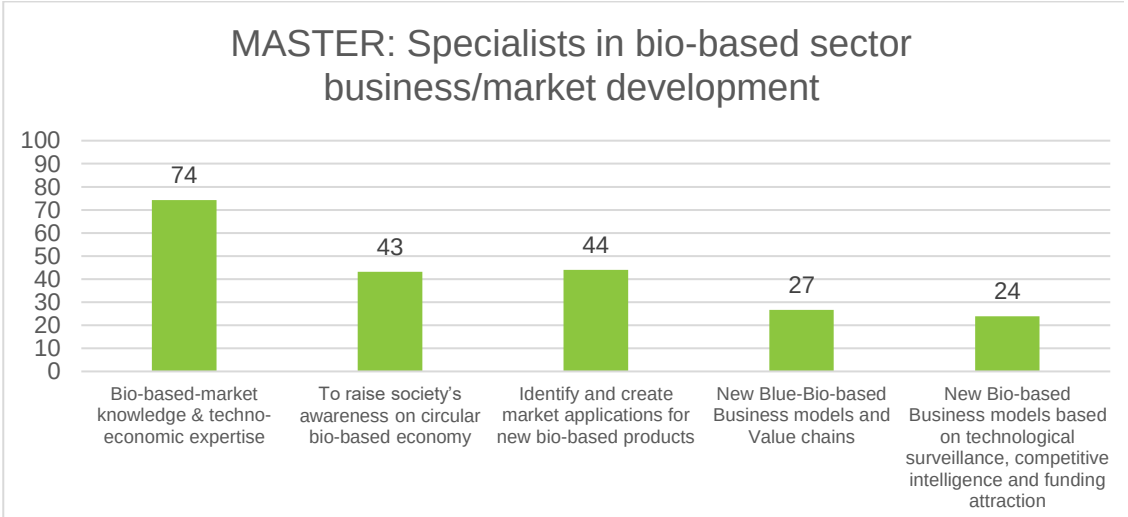
for raising society's awareness on circular bio-based economy sub-competence, where Undergraduate educational level is also considered quite relevant.

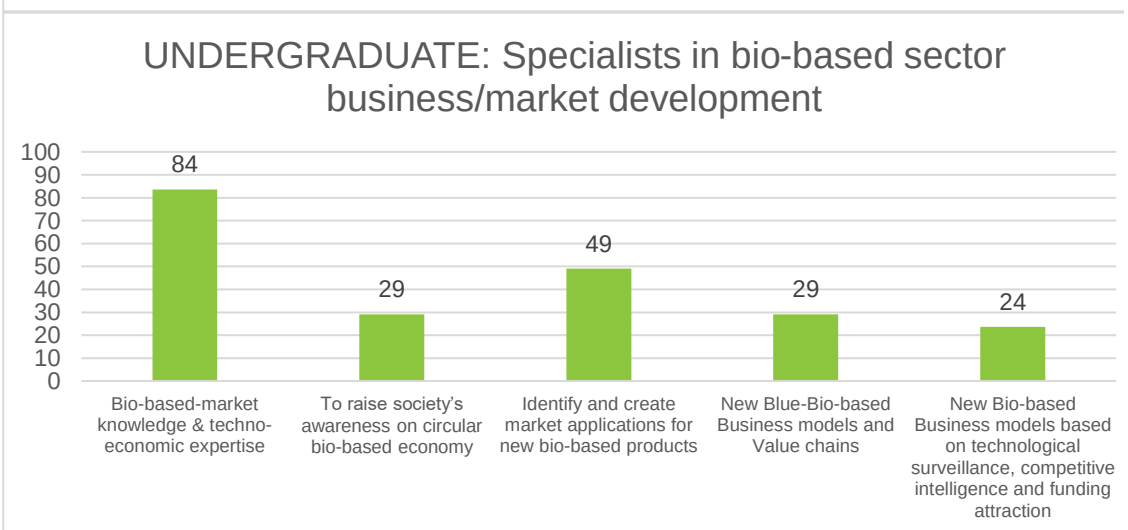
Figure 40: The distribution of educational levels for employees, expected in 2030, in specialists in bio-based sector business/market development sub-competences.

The comparison between what the stakeholders expect for 2030 (figures 39 and 40) and the current offer of educational programmes (figure 41) allows us to observe that, for the Specialists in bio-based sector business/market development competence, there are some differences in relation to the programmes where they are developed. The presence of some sub-competences may not be balanced with the need expressed in the prioritization. They are detailed below where differences are observed:

- Bio-based-market knowledge & techno-economic expertise: this is the first priority for stakeholders, which matches its presence at Undergraduate and Master's. However, it seems to be lacking at PhD level and non-existing at VET educational programmes.
- Identify and create market applications for new bio-based products: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- New Blue-Bio-based Business models and Value chains: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- To raise society's awareness on circular bio-based economy: an unbalance is observed between stakeholders' least priority for this sub-competence and academia, where it is more intensively developed at all educational levels.
- New bio-based business models based on technological surveillance, competitive intelligence and funding attraction: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.


PhD: Specialists in bio-based sector business/market development
100
90
80
70
60
50
40
30
20
10
0
19
50
44
28
16
Bio-based-market knowledge & techno-economic expertise
To raise society's awareness on circular bio-based economy
Identify and create market applications for new bio-based products
New Blue-Bio-based Business models and Value chains
New Bio-based Business models based on technological surveillance, competitive intelligence and funding attraction


MASTER: Specialists in bio-based sector business/market development
100
90
80
70
60
50
40
30
20
10
0
74
43
44
27
24
Bio-based-market knowledge & techno-economic expertise
To raise society's awareness on circular bio-based economy
Identify and create market applications for new bio-based products
New Blue-Bio-based Business models and Value chains
New Bio-based Business models based on technological surveillance, competitive intelligence and funding attraction


UNDERGRADUATE: Specialists in bio-based sector business/market development
100
90
80
70
60
50
40
30
20
10
0
84
29
49
29
24
Bio-based-market knowledge & techno-economic expertise
To raise society's awareness on circular bio-based economy
Identify and create market applications for new bio-based products
New Blue-Bio-based Business models and Value chains
New Bio-based Business models based on technological surveillance, competitive intelligence and funding attraction

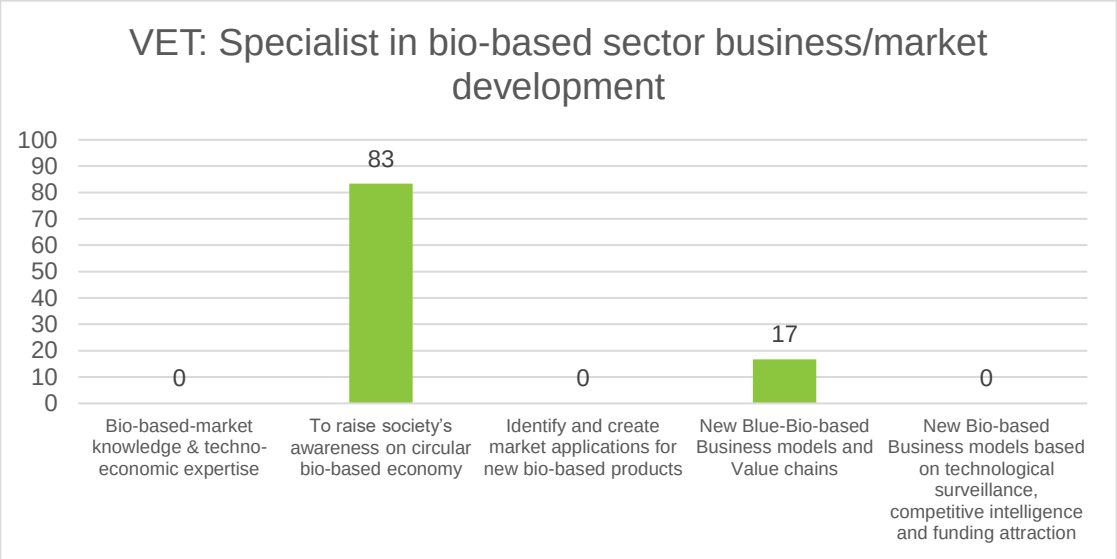


Figure 41: Specialist in bio-based sector business/market development sub-competences at the four educational levels analysed with the template.

Guidelines

- Bio-based-market knowledge & techno-economic expertise: the presence of this sub-competence should be increased at PhD and VET level.

- Identify and create market applications for new bio-based products: there should be some presence of this sub-competence at VET educational programmes.

- New Bio-based Business Models based on technological surveillance, competitive intelligence and funding attraction: there should be some presence of this sub-competence at VET educational programmes.

- New Blue-Bio-based Business models and Value chains: it is not considered necessary to introduce changes.

- To raise society's awareness on circular bio-based economy: the presence of this sub-competence should be slightly increased at Undergraduate level. It is well represented at all levels in relation to the second to last priority indicated by stakeholders.

3.3.2. Technical expertise in sustainable biomass production

The following sub-competences were identified:

- Advance ICT applications to logistic/storage (IoT, industry 4.0 ...)
- Advanced pre-treatments at harvest-storage stage
- Feedstock-specific & market driven cascade valorisation
- Life Cycle assessment of processes, bio-refineries and bio-based value chains
- New varieties of macro- micro- organisms for cost-effective bio-products
- Precision equipment for biomass harvest/collection
- Precision farming
- Techno-economic assessment of processes, bio-refineries and bio-based value chains

Techno-economic assessment of processes, bio-refineries and bio-based value chains was rated highest (100), whereas Precision farming and Advance ICT applications to logistic/storage (IoT, industry 4.0 ...) were rated lowest (under 59 and 54). The other sub-competences rates are between 67 and 86.

Sub-competences	Weighted score
Techno-economic assessment of processes, bio-refineries and bio-based value chains	100
Life Cycle assessment of processes, bio-refineries and bio-based value chains	86
New varieties of macro- micro-organisms for cost-effective bio-products	84
Feedstock-specific & market driven cascade valorisation	79
Advanced pre-treatments at harvest-storage stage	71
Precision equipment for biomass harvest/collection	67
Precision farming	59
Advance ICT applications to logistic/storage (IoT, industry 4.0 ...)	54

Figure 42: The results of the prioritising the sub-competences in the technical expertise in primary conversion processes.

Stakeholders believe that Advance ICT applications to logistic/storage (IoT, industry 4.0 ...), Feedstock-specific & market driven cascade valorisation, Life Cycle assessment of processes, bio-refineries and bio-based value chains and Techno-economic assessment of processes, bio-refineries and bio-based value chains sub-competences must be

developed at the Master's level, whereas New varieties of macro- micro- organisms for cost-effective bio-products is needed at PhD level and Precision equipment for biomass harvest/collection, Precision farming and Advanced pre-treatments at harvest-storage stage are more relevant at Undergraduate level.

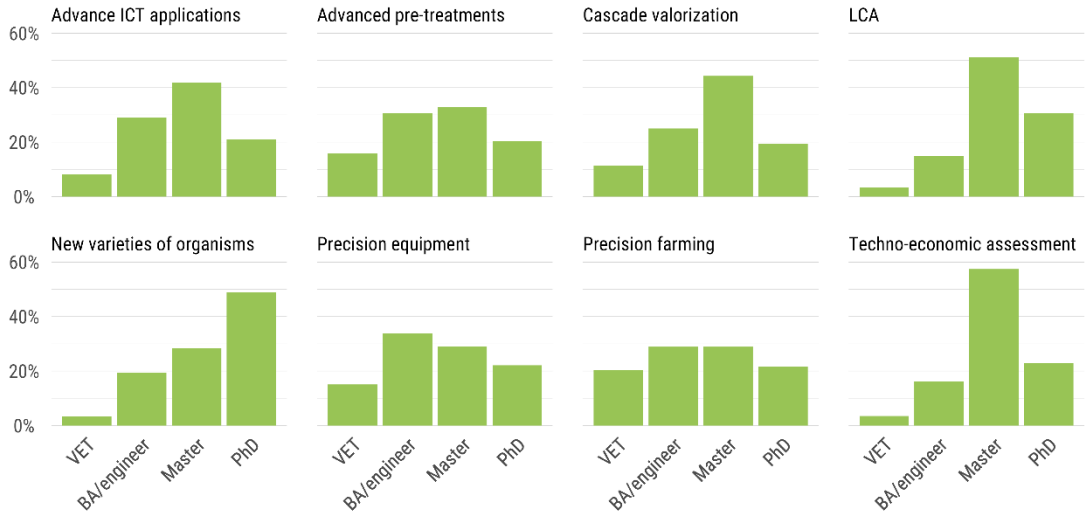
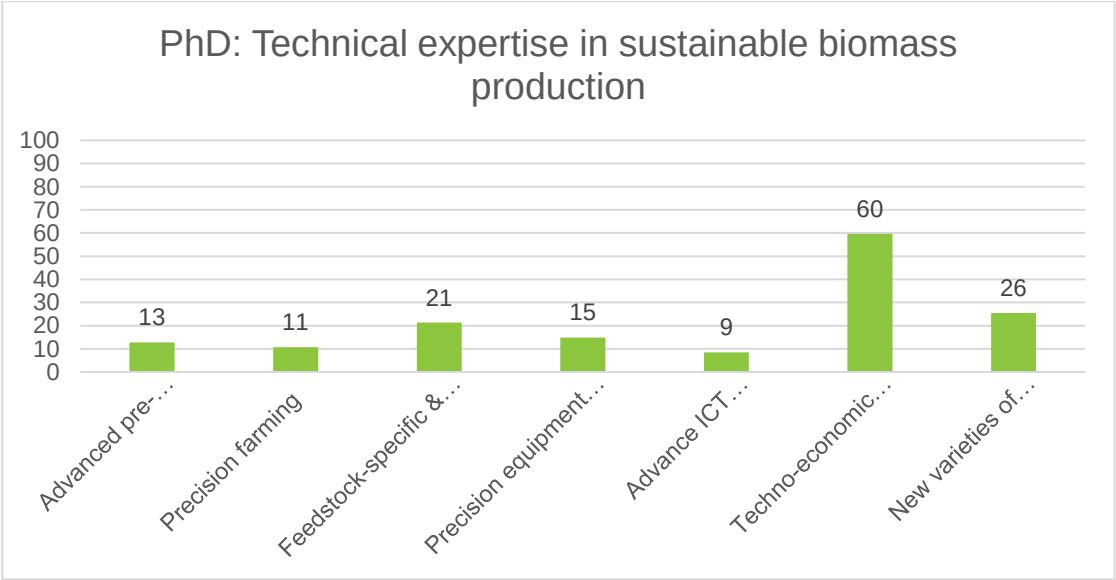


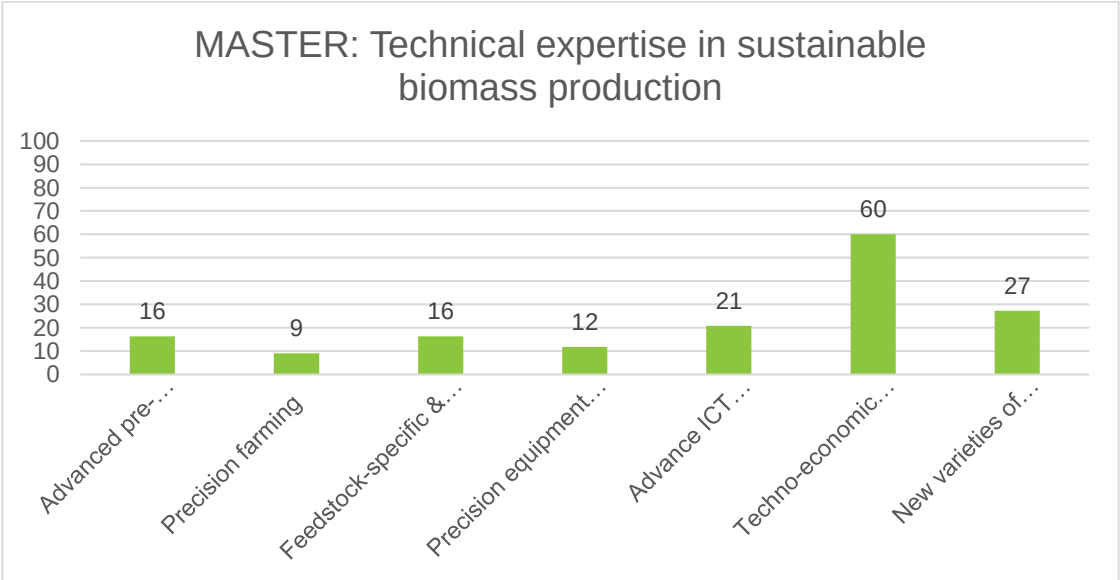
Figure 43: The distribution of educational levels for employees, expected in 2030, in technical expertise in primary conversion processes sub-competences.

The comparison between what the stakeholders expect for 2030 (figures 42 and 43) and the current offer of educational programmes (figure 44) allows us to observe that, in general, for the Technical expertise in sustainable biomass production competence, there are some differences in relation to the programmes where they are developed. The presence of some sub-competences may not be balanced with the need expressed in the prioritization. They are detailed below where differences are observed:

- Techno-economic assessment of processes, bio-refineries and bio-based value chains: a balance is observed between the top prioritization made by the stakeholders and the high presence of this sub-competence in the educational programmes analysed.
- Life Cycle assessment of processes, bio-refineries and bio-based value chains: this sub-competence is second priority for stakeholders, and it also appears as one of the most important during the focus group and dynamic workshop, so it must be present at all educational levels.
- New varieties of macro- micro- organisms for cost-effective bio-products: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Feedstock-specific & market driven cascade valorisation: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Advanced pre-treatments at harvest-storage stage: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed, except for VET programmes, where it is not represented.

- Precision equipment for biomass harvest/collection: an unbalance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Precision farming: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed, except for VET programmes, where it is not represented.
- Advance ICT applications to logistic/storage (IoT, industry 4.0 ...): an unbalance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed, where this sub-competence is more present than other sub-competences with a higher priority as informed by stakeholders.





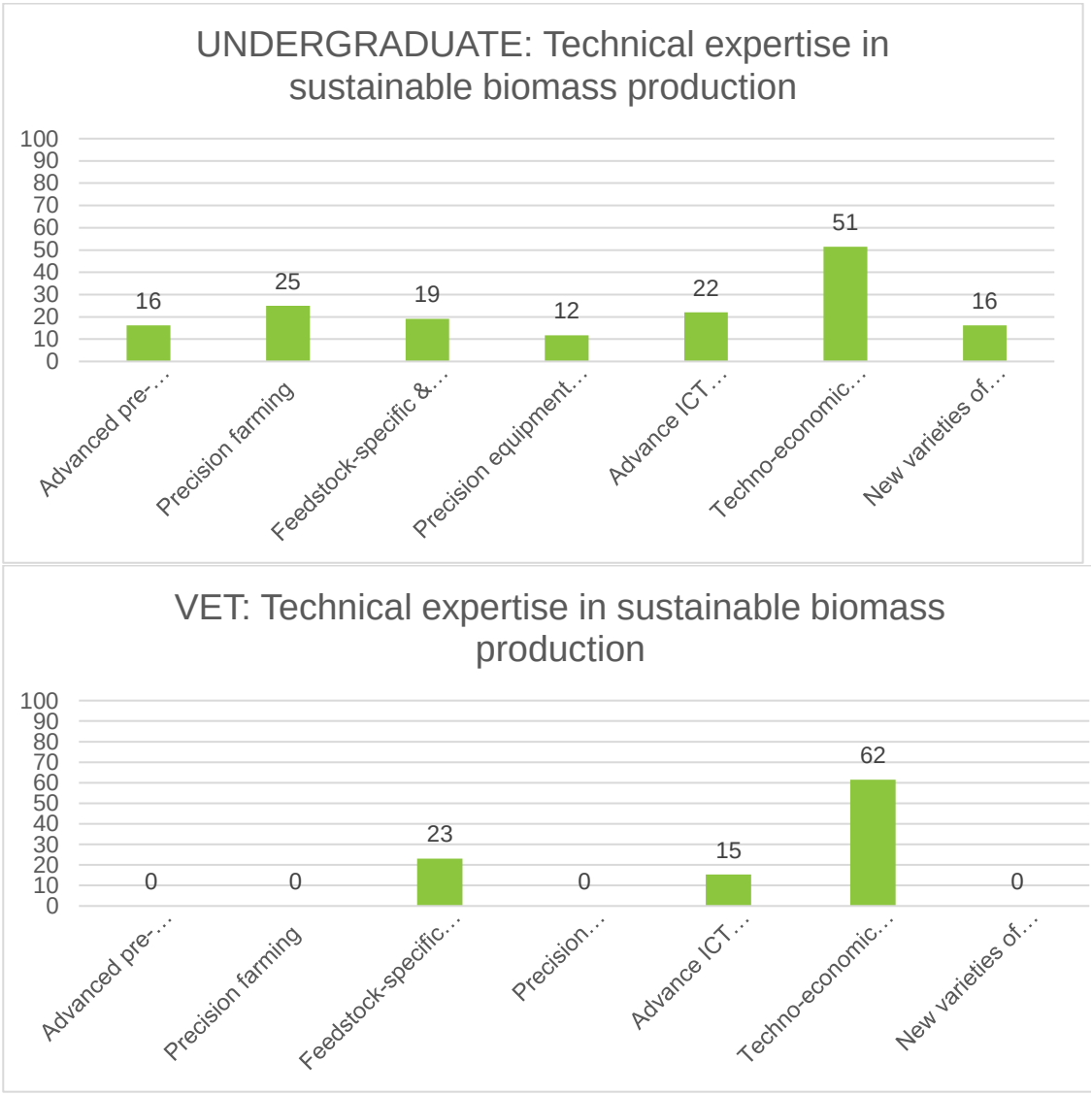


Figure 44: Technical expertise in sustainable biomass production sub-competences at the four educational levels analysed with the template.

Guidelines:

- Advance ICT applications to logistic/storage (IoT, industry 4.0 ...): it is not considered necessary to introduce changes.

- Advanced pre-treatments at harvest-storage stage: there should be presence of this sub-competence at VET's level.

- Feedstock-specific & market driven cascade valorisation: the presence of this sub-competence should be increased at Master's level.

- Life Cycle assessment of processes, bio-refineries and bio-based value chains: this sub-competence should be present in all educational programmes, more intensively at Master's and PhD level.

- New varieties of macro- micro- organisms for cost-effective bio-products: the presence of this sub-competence should be increased at PhD level.

- Precision equipment for biomass harvest/collection: the presence of this sub-competence should be increased at Undergraduate level and there should be presence of this sub-competence at VET's level.

- Precision farming: there should be presence of this sub-competence at VET's level.

- Techno-economic assessment of processes, bio-refineries and bio-based value chains: it is not considered necessary to introduce changes.

3.3.3. Technical expertise in primary conversion processes

The following sub-competences were identified:

- Advanced technologies to mildly extract or separate functional components
- Biotechnologies to convert C02 effluents to bio-chemicals
- Implementation of cascade biomass valorisation approach in integrated bio-refineries
- Market flexible and feedstock adaptable multiproduct integrated bio-refineries
- Methods for efficient and cost-effective biomass' production
- New Industrial symbiosis designs and implementation in integrated bio-refineries
- New processes to improve bio-products yield from bio-waste

New processes to improve bio-products yield from bio-waste was rated highest (100), followed by Methods for efficient and cost-effective biomass' production (93) whereas New Industrial symbiosis designs and implementation in integrated bio-refineries was rated lowest (66). The other sub-competences rates are between 67 and 84.

Sub-competences	Weighted score
New processes to improve bio-products yield from bio-waste	100
Methods for efficient and cost-effective biomass' production	93
Advanced technologies to mildly extract or separate functional components	84
Market flexible and feedstock adaptable multiproduct integrated bio-refineries	73
Biotechnologies to convert C02 effluents to bio-chemicals	70
Implementation of cascade biomass valorisation approach in integrated bio-refineries	67
New Industrial symbiosis designs and implementation in integrated bio-refineries	66

Figure 45: The results of the prioritising the sub-competences in the technical expertise in primary conversion processes.

Stakeholders believe that all sub-competences of the Technical expertise in primary conversion processes competence must be developed at the Master's level. However, Biotechnologies to convert C02 effluents to bio-chemicals, New processes to improve bio-products yield from bio-waste, New Industrial symbiosis designs and implementation in integrated bio-refineries and Advanced technologies to mildly extract or separate functional components are highly relevant at PhD level.

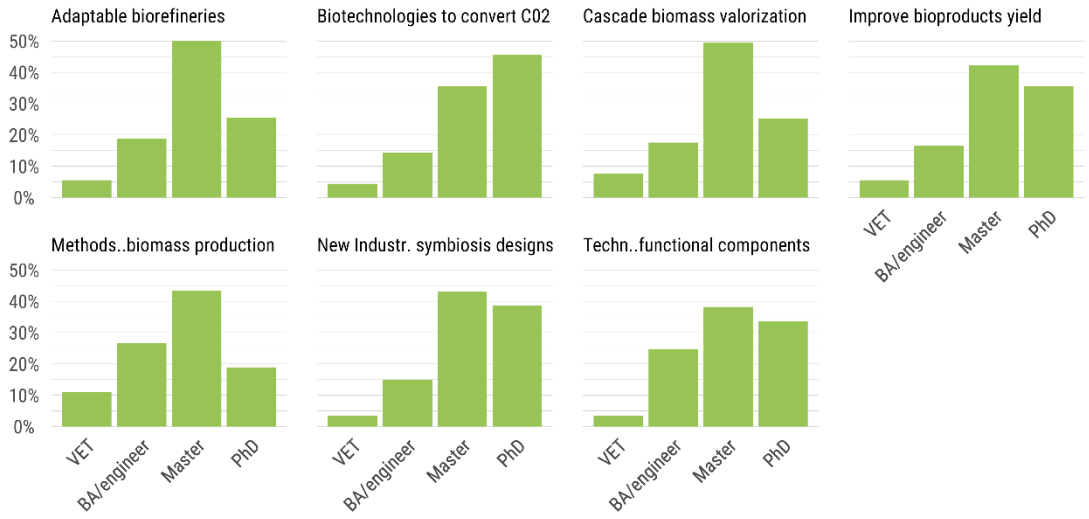
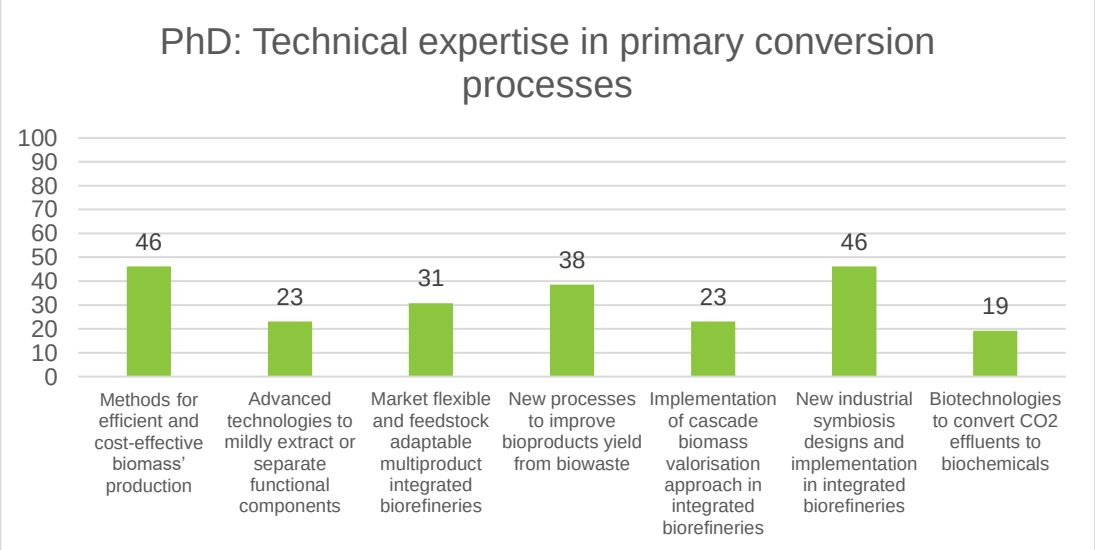


Figure 46: The distribution of educational levels for employees, expected in 2030, in technical expertise in primary conversion processes sub-competences.

The comparison between what the stakeholders expect for 2030 (figures 45 and 46) and the current offer of educational programmes (figure 47) allows us to observe that, in general, for the Technical expertise in primary conversion processes competence, there are some differences in relation to the programmes where they are developed. The presence of some sub-competences may not be balanced with the need expressed in the prioritization. They are detailed below where differences are observed:

- New processes to improve bio-products yield from bio-waste: according to stakeholders, this sub-competence is top priority from this group of sub-competences, whereas the educational programmes analysed consider it second priority.
- Methods for efficient and cost-effective biomass' production: this sub-competence is second priority for stakeholders and first priority at all educational programmes analysed.
- Advanced technologies to mildly extract or separate functional components: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed, except for VET programmes, where it is not represented.
- Market flexible and feedstock adaptable multiproduct integrated bio-refineries: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed, except for VET programmes, where it is not represented.
- Biotechnologies to convert C02 effluents to bio-chemicals: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed, except for VET programmes, where it is not represented and PhD, where it should be increased.
- Implementation of cascade biomass valorisation approach in integrated bio-refineries: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed, except for VET programmes, where it is not represented.
- New Industrial symbiosis designs and implementation in integrated bio-refineries: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed, except for VET programmes, where it is not represented.



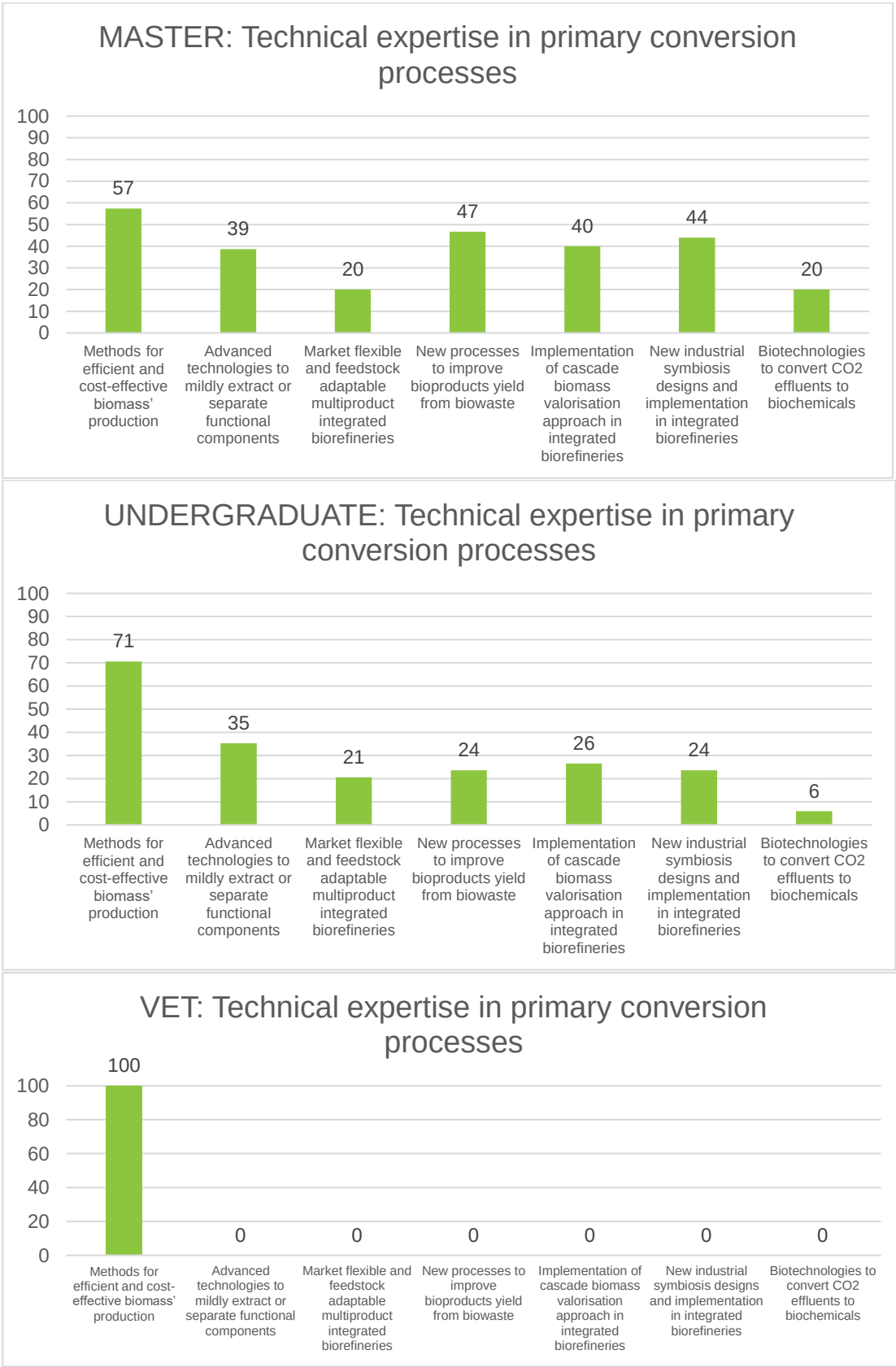


Figure 47: Technical expertise in primary conversion processes sub-competences at the four educational levels analysed with the template.

Guidelines:

- Advanced technologies to mildly extract or separate functional components: this sub-competence should be represented at VET level.

- Biotechnologies to convert C02 effluents to bio-chemicals: this sub-competence should be represented at VET level and its presence should increase at PhD level.

- Implementation of cascade biomass valorisation approach in integrated bio-refineries: this sub-competence should be represented at VET level.

- Market flexible and feedstock adaptable multiproduct integrated bio-refineries: this sub-competence should be represented at VET level.

- Methods for efficient and cost-effective biomass' production: it is not considered necessary to introduce changes.

- New Industrial symbiosis designs and implementation in integrated bio-refineries: this sub-competence should be represented at VET level.

- New processes to improve bio-products yield from bio-waste: the presence of this sub-competence should be increased at all levels. It must also be represented at VET level.

3.3.4. Technical expertise in secondary conversion processes

The following sub-competences were identified:

- Advanced methods to preserve and generate functional natural macromolecular polymers'
- Biopolymer processing to obtain different materials (films, fibres, structural composites) for automotive, agriculture, building, etc...
- Chemo-catalysis & Thermo-chemical processes to obtain functionalised chemicals and products
- Design of control systems for robust, stable and sustainable production, quality and contaminants monitoring
- Hybridization of processes for different feedstock valorisation
- New more efficient methods to recover/convert bio-based chemicals including cascade valorisation and circular economy approaches
- Oleochemistry (fatty acids conversion technologies) including chemistry and biotechnology
- Polymerisation processes based on new bio-based monomers

New more efficient methods to recover/convert bio-based chemicals including cascade valorisation and circular economy applications was rated highest (100), whereas Oleo-chemistry (fatty acids conversion technologies) including chemistry and biotechnology was rated lowest (52). The other sub-competences rates are between 67 and 88.

Sub-competences	Weighted score
New more efficient methods to recover/convert bio-based chemicals including cascade valorisation and circular economy applications	100
Biopolymer processing to obtain different materials (films, fibres, structural composites) for automotive, agriculture, building, etc.	88
Chemo-catalysis & Thermo-chemical processes to obtain functionalised chemicals and products	79
Design of control systems for robust, stable and sustainable production, quality and contaminants monitoring	75
Advanced methods to preserve and generate functional natural macromolecular polymers	74
Hybridization of processes for different feedstock valorisation	74
Polymerisation processes based on new bio-based monomers	67
Oleo-chemistry (fatty acids conversion technologies) including chemistry and biotechnology	52

Figure 48: The results of the prioritising the sub-competences in the technical expertise in secondary conversion processes

Stakeholders believe that all sub-competences of the Technical expertise in secondary conversion processes competence must be developed similarly at the Master and PhD level, except for Design of Control Systems, where Master level is considered first followed by Undergraduate. This sub-competence is not considered so relevant at PhD level.

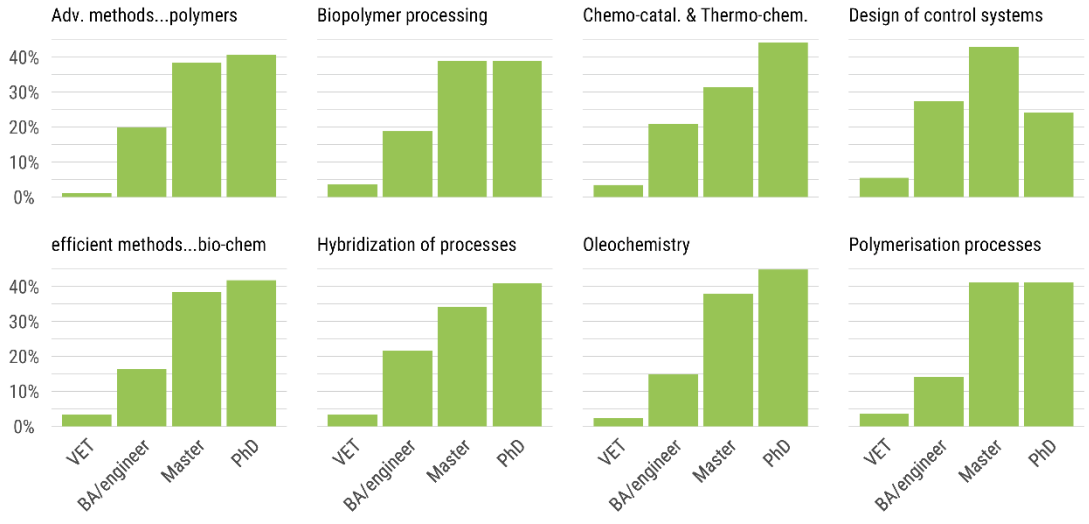
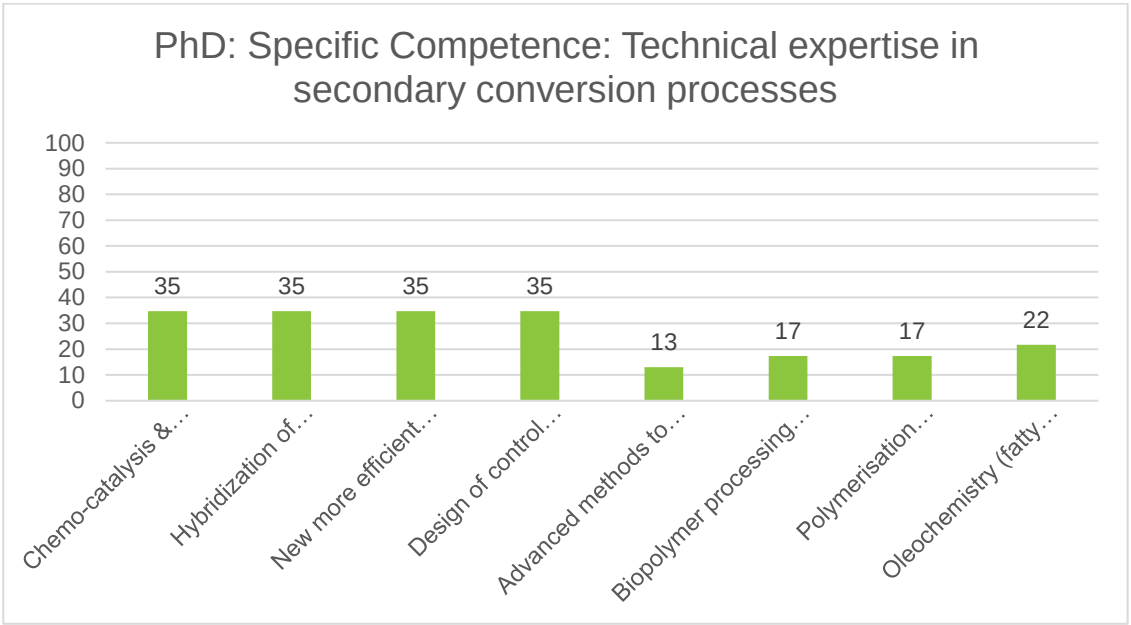
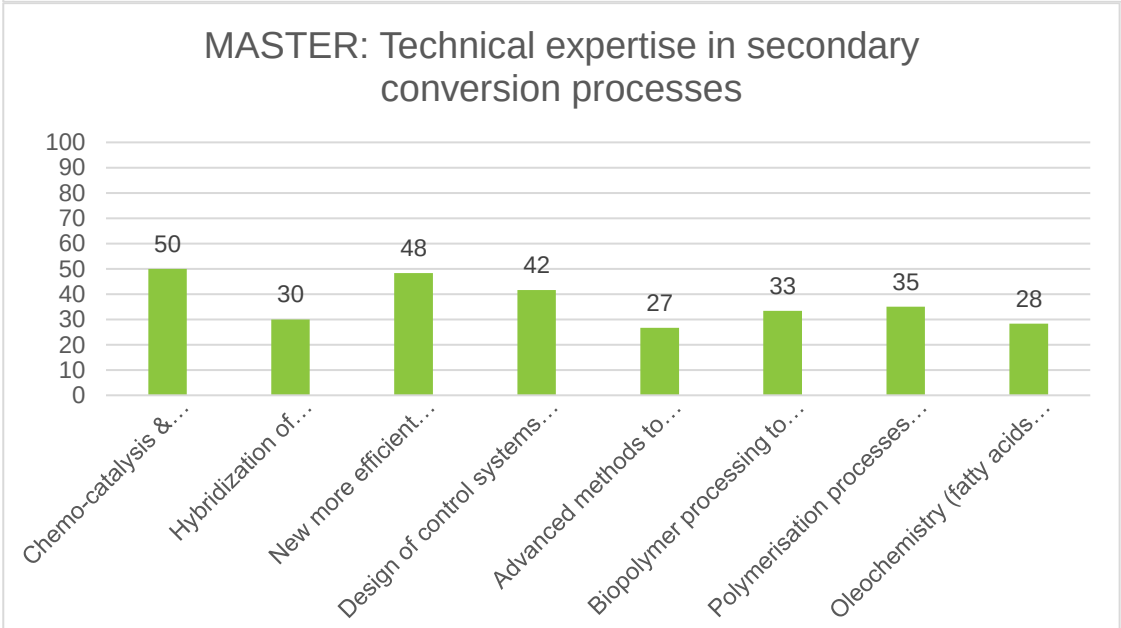


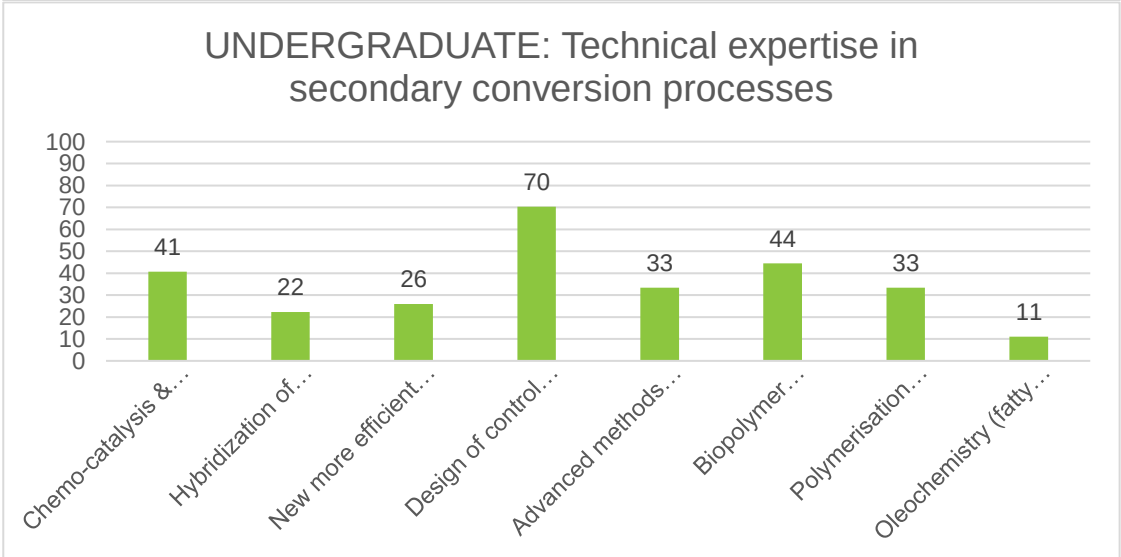
Figure 49: The distribution of educational levels for employees, expected in 2030, in technical expertise in secondary conversion processes sub-competences.

The comparison between what the stakeholders expect for 2030 (figures 48 and 49) and the current offer of educational programmes (figure 50) allows us to observe that, for the Technical expertise in secondary conversion processes competence, there are some differences in relation to the programmes where they are developed. The presence of some sub-competences may not be balanced with the need expressed in the prioritization. They are detailed below where differences are observed:

- New more efficient methods to recover/convert bio-based chemicals including cascade valorisation and circular economy applications: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed, except for VET, where it is not represented.
- Biopolymer processing to obtain different materials (films, fibres, structural composites) for automotive, agriculture, building, etc.: this sub-competence is second priority in the stakeholders ranking and extremely relevant at Master and PhD level. However, PhD educational programmes do not seem to develop this sub-competence so broadly.
- Chemo-catalysis & Thermo-chemical processes to obtain functionalised chemicals and products:
- Design of control systems for robust, stable and sustainable production, quality and contaminants monitoring: an unbalance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed, where this sub-competence is more present than other sub-competences with a higher priority as informed by stakeholders.
- Advanced methods to preserve and generate functional natural macromolecular polymers
- Hybridization of processes for different feedstock valorisation: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed.
- Polymerisation processes based on new bio-based monomers
- Oleo-chemistry (fatty acids conversion technologies) including chemistry and biotechnology


PhD: Specific Competence: Technical expertise in secondary conversion processes
100
90
80
70
60
50
40
30
20
10
0
35
35
35
35
13
17
17
22
Chemo-catalysis &…
Hybridization of…
New more efficient…
Design of control…
Advanced methods to…
Biopolymer processing…
Polymerisation…
Oleochemistry (fatty…


MASTER: Technical expertise in secondary conversion processes
100
90
80
70
60
50
40
30
20
10
0
50
30
48
42
27
33
35
28
Chemo-catalysis &…
Hybridization of…
New more efficient…
Design of control systems…
Advanced methods to…
Biopolymer processing to…
Polymerisation processes…
Oleochemistry (fatty acids…


UNDERGRADUATE: Technical expertise in secondary conversion processes
100
90
80
70
60
50
40
30
20
10
0
41
22
26
70
33
44
33
11
Chemo-catalysis &…
Hybridization of…
New more efficient…
Design of control…
Advanced methods…
Biopolymer…
Polymerisation…
Oleochemistry (fatty…

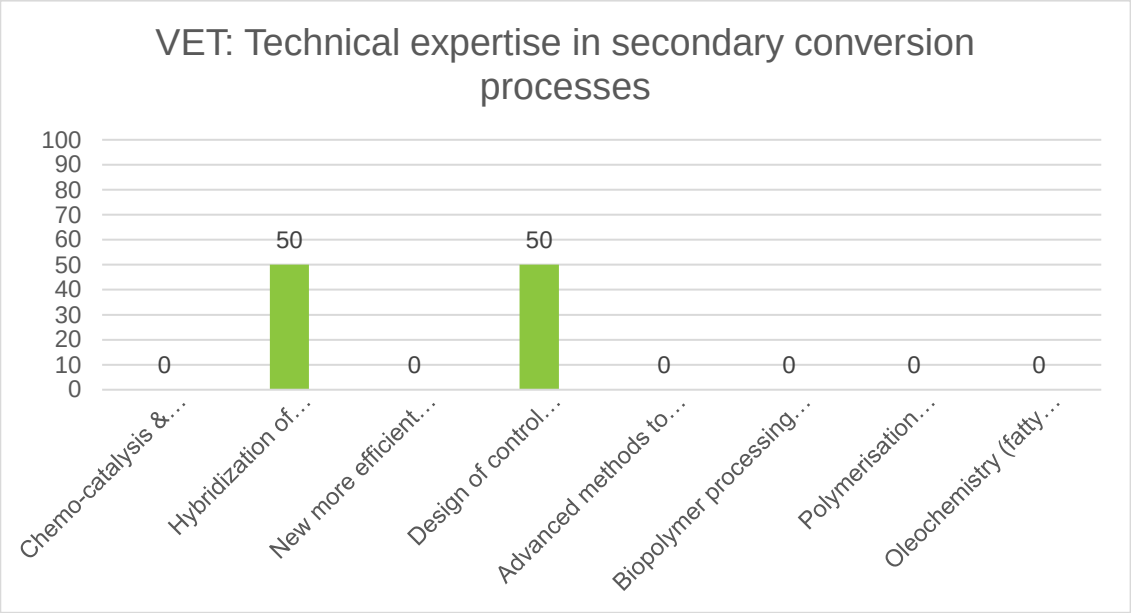


Figure 50: Technical expertise in secondary conversion processes sub-competences at the four educational levels analysed with the template.

Guidelines:

- Advanced methods to preserve and generate functional natural macromolecular polymers: this sub-competence should be represented at VET level.

- Biopolymer processing to obtain different materials (films, fibres, structural composites) for automotive, agriculture, building, etc...: the presence of this sub-competence should be increased at PhD level and it should also be represented at VET level.

- Chemo-catalysis & Thermo-chemical processes to obtain functionalised chemicals and products: this sub-competence should be represented at VET level.

- Design of control systems for robust, stable and sustainable production, quality and contaminants monitoring: this sub-competence is highly present at all educational levels, whereas stakeholders show less priority for it.

- Hybridization of processes for different feedstock valorisation: it is not considered necessary to introduce changes.

- New more efficient methods to recover/convert bio-based chemicals including cascade valorisation and circular economy approaches: this sub-competence should be represented at VET level.

- Oleochemistry (fatty acids conversion technologies) including chemistry and biotechnology: this sub-competence should be represented at VET level.

- Polymerisation processes based on new bio-based monomers: this sub-competence should be represented at VET level.

3.3.5. Technical expertise in materials, products and functionalization

The following sub-competences were identified:

- Bio-based alternatives for existing polymers and innovative polymers from new bio-based monomers.
- Extraction techniques to obtain High added-value biomolecules from marine, agri-food or forest biomass for pharmaceutical, nutraceutical and cosmetic sectors
- Materials based on lignin (and bio-aromatic) chemistry
- Materials based on oils and fats from plants and animals (bio-based lubricants, surfactants, solvents
- New (chemical) building blocks from renewable resources.
- New functional bio-based materials and products: plastics, composites, based on lignin, starch, (nano-) cellulose or carbon fibres.
- New packaging solutions derived from bio-based materials
- New products design from bio-waste

New functional bio-based materials and products: plastics, composites based on lignin, starch, (nano-) cellulose or carbon fibre was rated highest (100), whereas Materials based on oils and fats from plants and animals (bio-based lubricants, surfactants, solvents (70). We could divide this set of sub-competences in two groups of priorities (90-100 and 70 to 85) as listed below:

Sub-competences	Weighted score
New functional bio-based materials and products: plastics, composites based on lignin, starch, (nano-) cellulose or carbon fibre	100
New (chemical) building blocks from renewable resources.	96
Bio-based alternatives for existing polymers and innovative polymers from new bio-based monomers.	94
New products design from bio-waste.	90
Extraction techniques to obtain High added-value biomolecules from marine, agri-food or forest biomass for pharmaceutics	85
New packaging solutions derived from bio-based materials	71
Materials based on lignin (and bio-aromatic) chemistry	71
Materials based on oils and fats from plants and animals (bio-based lubricants, surfactants, solvents	70

Figure 51: The results of the prioritising the sub-competences in the technical expertise in materials, products and functionalisation.

Stakeholders believe that all sub-competences of the Technical expertise in materials, products and functionalization competence must be developed at the Master and PhD level. Only New Packaging Solutions becomes more relevant at Undergraduate level.

It emphasizes that New bio-based materials and New (chemical) building blocks are considered very necessary at PhD level, followed by Masters, whereas New products design and Oil-based materials would be more relevant at Masters level, followed by PhD level.

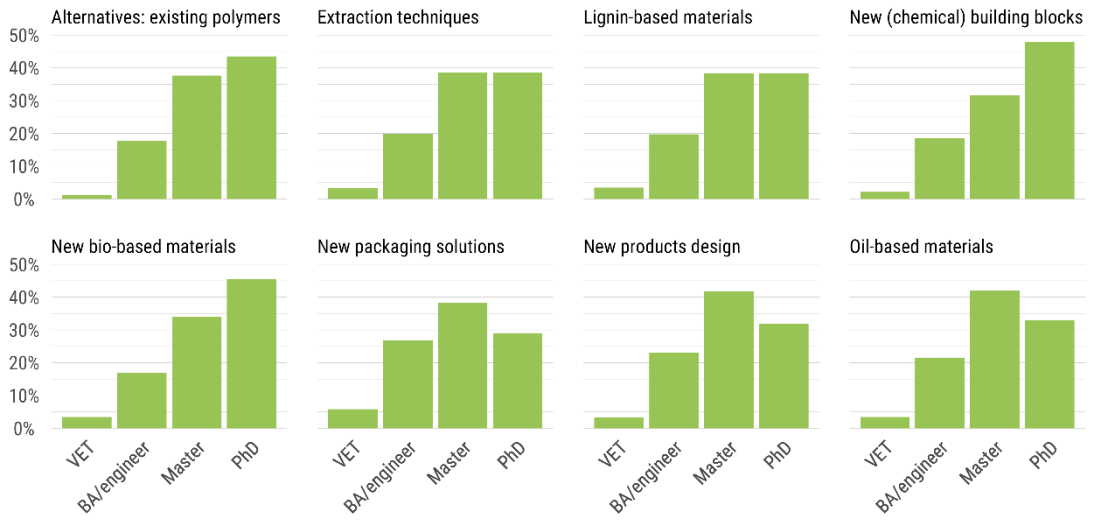


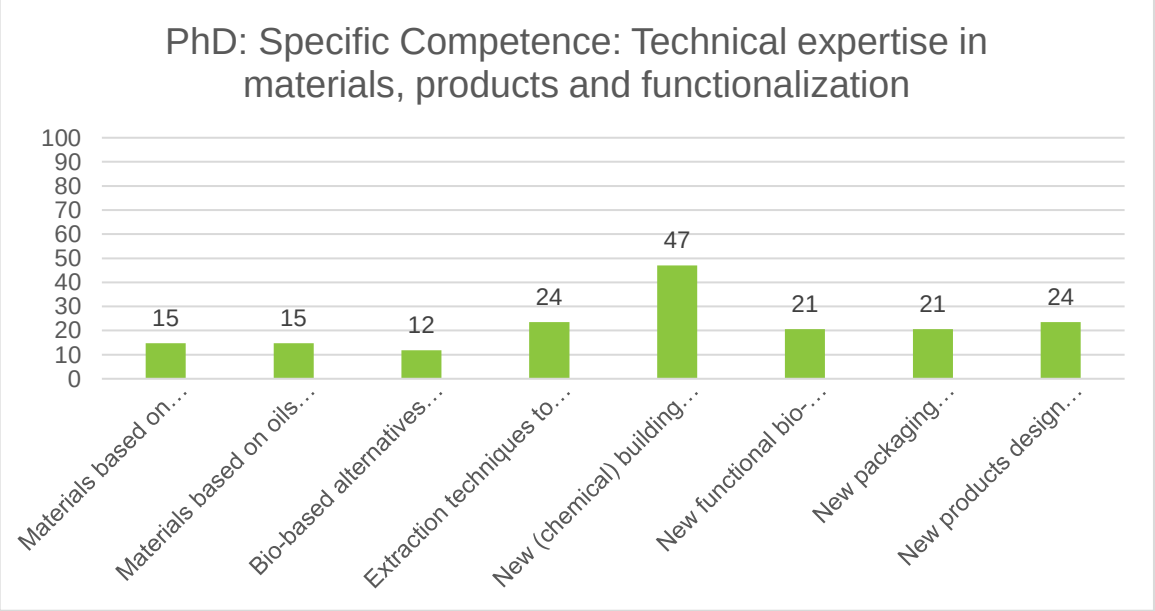
Figure 52: The distribution of educational levels for employees, expected in 2030, in technical expertise in materials, products and functionalisation sub-competences.

The comparison between what the stakeholders expect for 2030 (figures 51 and 52) and the current offer of educational programmes (figure 53) allows us to observe that for the Technical expertise in materials, products and functionalization competence, there are some differences in relation to the programmes where they are developed. The presence of some sub-competences may not be balanced with the need expressed in the prioritization. They are detailed below where differences are observed:

- New functional bio-based materials and products: plastics, composites based on lignin, starch, (nano-) cellulose or carbon fibre: an unbalance is observed between the top prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed. It is highly required at PhD level, followed by Master's and Undergraduate levels. However, it is most present at Undergraduate educational programmes.
- New (chemical) building blocks from renewable resources: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed, except for VET, where it is not represented.
- Bio-based alternatives for existing polymers and innovative polymers from new bio-based monomers: an unbalance is observed between the prioritization made

by the stakeholders and the presence of this sub-competence in the educational programmes analysed. It is highly required at PhD level.

- New products design from bio-waste: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed, except for VET, where it is not represented.
- Extraction techniques to obtain High added-value biomolecules from marine, agri-food or forest biomass for pharmaceutics: an unbalance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed. It is highly required at PhD level.
- New packaging solutions derived from bio-based materials: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed, except for VET, where it is not represented.
- Materials based on lignin (and bio-aromatic) chemistry: an unbalance is observed between the top prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed. It is highly required at PhD and Master's. However, it is most present at Undergraduate educational programmes.
- Materials based on oils and fats from plants and animals (bio-based lubricants, surfactants, solvents: a balance is observed between the prioritization made by the stakeholders and the presence of this sub-competence in the educational programmes analysed, except for VET, where it is not represented.



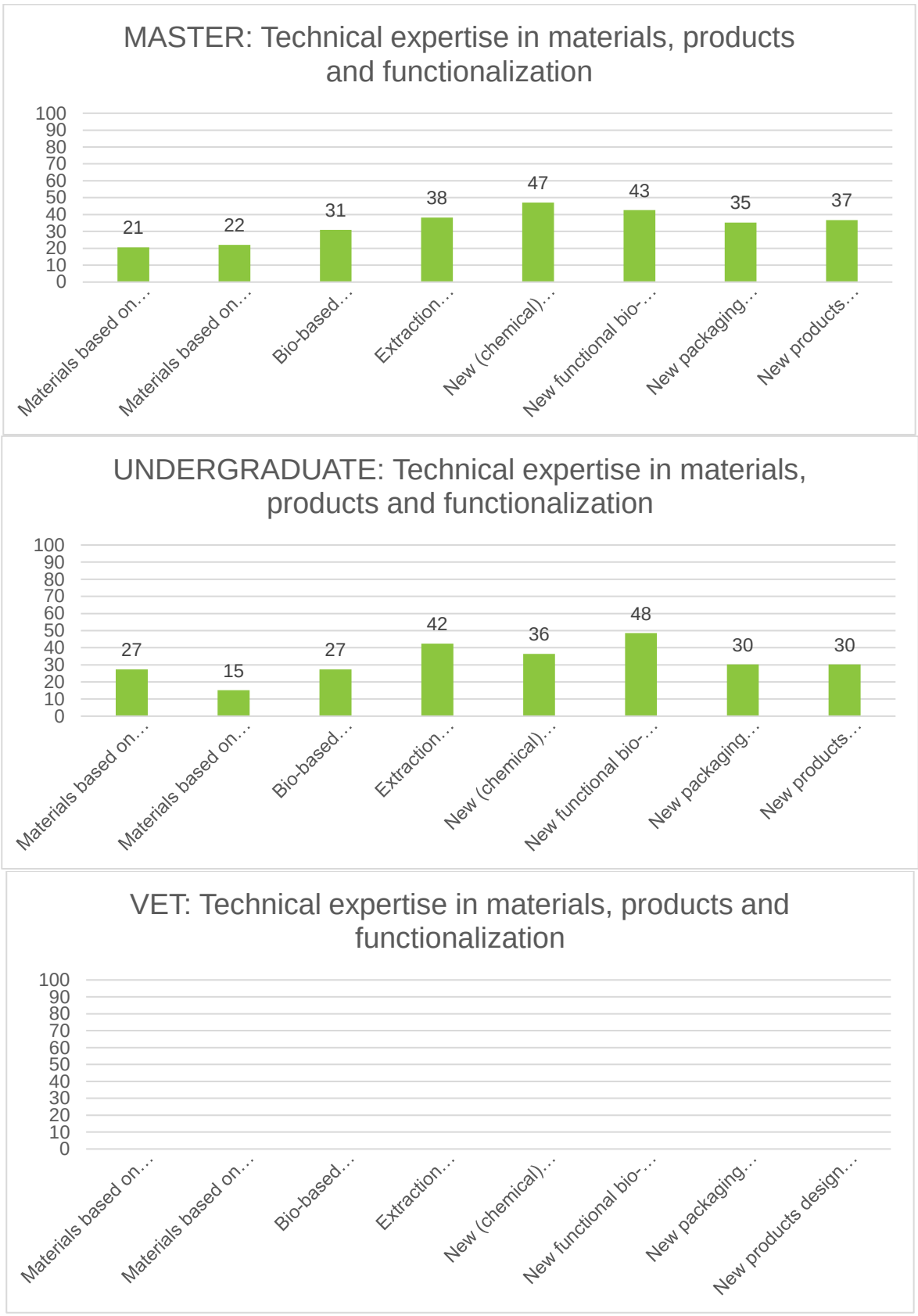


Figure 53: Technical expertise in materials, products and functionalization sub-competences at the four educational levels analysed with the template.

Guidelines:

- Bio-based alternatives for existing polymers and innovative polymers from new bio-based monomers: this sub-competence should be represented in VET educational programmes and its presence should be increased at all educational levels, particularly at PhD.

- Extraction techniques to obtain High added-value biomolecules from marine, agri-food or forest biomass for pharmaceutical, nutraceutical and cosmetic sectors: the presence of this sub-competence should be increased at PhD level and also represented in VET educational programmes.

- Materials based on lignin (and bio-aromatic) chemistry: the presence of this sub-competence should increase at Master's and PhD levels. This sub-competence should also be represented in VET educational programmes

- Materials based on oils and fats from plants and animals (bio-based lubricants, surfactants, solvents: this sub-competence should be represented in VET educational programmes

- New (chemical) building blocks from renewable resources: this sub-competence should be represented in VET educational programmes.

- New functional bio-based materials and products: plastics, composites, based on lignin, starch, (nano-) cellulose or carbon fibres: the presence of this sub-competence should be increased at Master's and PhD level. It should also be represented at VET level.

- New packaging solutions derived from bio-based materials: this sub-competence should be represented in VET educational programmes

- New products design from bio-waste: this sub-competence should be represented in VET educational programmes.

4. Discussion and Conclusions

The conclusions presented below are a descriptive and faithful synthesis of the most significant contributions from the different sources of information. Their elaboration are a result of the object and the design of the data gathering instruments as well as the final composition of the participants in the information gathering phase and by the limitations of the analysis inherent of the data obtained. The following considerations must be taken into account:

1. The diversity of the European reality and the current and future development of the bio-industries constrains the finding of common points between the different situations, at the same time that it fosters the interpretation of the generic aspects that have been identified in the context of this study. We cannot ignore that data should always be interpreted from the meaning and perspectives of the sources of information.

2. The global analysis carried out advises that any specific analysis of a particular context (a country, a region or a specific aspect of the bio-industries) should start from contrasting the general data with the specific aspects of that reality.

3. We understand that the data collected reflects a sufficiently concrete scenario that will allow for the development of training recommendations based on and adjusted to the existing realities.

We present a synthesis of the contributions according to the analysis of the results, emphasising the most relevant aspects and providing additional comments where we considered necessary.

The gap identifies dysfunctions between the current reality (existing educational programmes and the skills required by the bio-based industries) and the 2030 scenario, which continues to be considered as a plausible hypothesis. The future is certainly unpredictable, but we must approach it if we want to carry out planning that, although contingent, allows us to provide a structure to the development of the industry and anticipate its needs. We are aware that the planned scenario may change, but we do not believe that the tendency to generate customized products and production systems in different more robotized contexts and with more efficient and environmentally friendly systems will.

Furthermore, it is important to identify and try to fill the gaps on educational programmes and skills shortcomings. However, we cannot ignore the need to promote, in parallel, the development of a culture of entrepreneurship related to efficient, sustainable and environmentally friendly management. Moreover, we must bear in mind that the changes are slow and require a certain degree of sustainability to be effective. The reasons why they are slow respond to the need for attitude changes as well as modifications in procedures and concepts.

A more complete, more versatile and more flexible training that meets the demands of the industrial reality requires the effective incorporation of new general and specific competences in the educational programmes related to the bio-based economy. The general competences identified as important are highlighted in green (bold) in the following table (the order of priority marked with the number in parenthesis - 1 meaning highest priority):

Competence (general competences)	Sub-competence (specific skills)
Management (3)	Purchasing Quality Product / Logistics Resources Industrial linkers **Development of business models** Life Cycle Assessment (LCA) of Bio-based industry processes **Project Management.**
Data management (15)	Data sensing technologies Data processing (carry out, retrieve, transform) Data transmission technologies & standards Data Analytics & Advanced Analytics Data Exploitation Technologies Information security and cybersecurity Data architecture
Personal initiative and entrepreneurship (2)	**Critical thinking** **Problem solving** Engagement capacity to involve different types of Stakeholders (clustering) Creativity Empathy Persuasion Proactivity
Soft skills (10)	Communication (public speaking) Communication (writing) Relationship building Teamwork and conflict resolution Adaptability Personal branding Collaboration Foreign Languages Competence
Sustainability and industry (4)	Ecological perspective **Circular economy / Zero waste industry** **Sustainable competitiveness / Economy** Secure bio-based materials and residues stability, availability, transport and storage Monitoring contaminants in the products Recyclability concepts for bio-based materials
Technology (6)	Digital skills Information and Communication Technology Cybersecurity Data mining tools/strategies Key Enabling Technologies for the Bio-Based Industry Traceability and logistics DLT (Distributed ledger technology) & Blockchain technologies Artificial Intelligence technologies
Research and innovation (1)	**Innovation and change** Management and development of research **Knowledge Transfer: From LAB to Industry** Fundamental research Analytical capacity
Basic scientific knowledge (8)	Maths Information and Communication Technologies. Physics Chemistry Biotechnology Biology Chemical Engineering Nanotechnology
Rules and regulation (9)	Local legal regulations Patent regulations IPR - Intellectual Property Rights

	Common EU regulations Quality, safety and security regulations Waste regulations Bio-based products legal framework Digital Compliance
Social responsibility (16)	Economic responsibilities Legal responsibilities Ethical responsibilities Philanthropic responsibilities Environmental responsibility Green engineering awareness Health Responsibilities Self-consumption energies
Sales and marketing (7)	Market globalization Adapting the products to new targets Openness of the industrial processes and products Marketing online and Social Media Increasing consumer/society awareness on bio-based products Packaging solutions derived from bio-based materials.
Competence (specific competences)	**Sub-competence (specific skills)**
Specialists in bio-based sector business/market development. (5)	**Bio-based-market knowledge & techno-economic expertise** To raise society's awareness on circular bio-based economy **Identify and create market applications for new bio-based products** New Blue-Bio-based Business models and Value chains New Bio-based Business Models based on technological surveillance, competitive intelligence and funding attraction
Technical expertise in sustainable biomass production (14)	Advanced pre-treatments at harvest-storage stage Precision farming Feedstock-specific & market driven cascade valorisation Precision equipment for biomass harvest/collection Advance ICT applications to logistic/storage (IoT, industry 4.0 ...) Techno-economic assessment of processes, bio-refineries and bio-based value chains Life Cycle assessment of processes, bio-refineries and bio-based value chains New varieties of macro- micro- organisms for cost-effective bio-products.
Technical expertise in primary conversion processes (11)	Methods for efficient and cost-effective biomass' production Advanced technologies to mildly extract or separate functional components Market flexible and feedstock adaptable multiproduct integrated bio-refineries New processes to improve bio-products yield from bio-waste Implementation of cascade biomass valorisation approach in integrated bio-refineries New Industrial symbiosis designs and implementation in integrated bio-refineries Biotechnologies to convert C02 effluents to bio-chemicals.
Technical expertise in secondary conversion processes (13)	Chemo-catalysis & Thermo-chemical processes to obtain functionalised chemicals and products Hybridization of processes for different feedstock valorisation New more efficient methods to recover/convert bio-based chemicals including cascade valorisation and circular economy approaches Design of control systems for robust, stable and sustainable production, quality and contaminants monitoring Advanced methods to preserve and generate functional natural macromolecular polymers' Biopolymer processing to obtain different materials (films, fibres, structural composites) for automotive, agriculture, building, etc... Polymerisation processes based on new bio-based monomers Oleo-chemistry (fatty acids conversion technologies) including chemistry and biotechnology.
Technical expertise in materials, products and functionalization (12)	Materials based on lignin (and bio-aromatic) chemistry Materials based on oils and fats from plants and animals (bio-based lubricants, surfactants, solvents Bio-based alternatives for existing polymers and innovative polymers from new bio-based monomers.

	Extraction techniques to obtain High added-value biomolecules from marine, agri-food or forest biomass for pharmaceutical, nutraceutical and cosmetic sectors New (chemical) building blocks from renewable resources. New functional bio-based materials and products: plastics, composites, based on lignin, starch, (nano-) cellulose or carbon fibres. New packaging solutions derived from bio-based materials New products design from bio-waste.

Figure 54: **Detail of general and specific competences and its sub-competences.**

The importance of these competences is not and cannot be the same in each one of the education stages addressed. The level of complexity should be developed along the curricula. At VET level, for instance, we can expect the introduction of some specific concepts and some practical examples to illustrate them, whereas at higher education levels we should expect an increase in the degree of development to conclude with a creative an innovative approach at Master and PhD level. Therefore, we can talk about specific competences in some cases and, in other cases, training itineraries that are expanding their scope with new competence units.

The completion of educational programs that respond to the training needs identified require maximum collaboration between the educational, industrial and business sectors, in order to achieve the best results for bio-industrial development. Moreover, joint social objectives must be defined in order to seek to achieve more aware citizens of a more sustainable reality and respect for the environment.

Additional aspects to consider from the evidence of our study, are backed up from reports[3] and documents related to this subject matter and from which we return some significant ideas with the purpose of generating positive responses to the relationship job market needs-educational responses.

The following contributions are drawn from this perspective:

a.- On bio-economy

There is not yet a common understanding of the concept of bio-economy. Fragmented knowledge represents a barrier for stakeholders to find their role is and how they can contribute. Education systems seem to have difficulties in managing change in a fast-paced environment and rigid academic structures do not favour this change that is required to successfully meet the needs of the European bio-economy. The complexity and highly dynamic panorama does not help identify, understand and prioritize the innovation opportunities and translate them in a long-term vision for the development of the sector. The need for awareness raising activities across different stakeholders is still prominent. Better university networks and alliances are necessary to improve cooperation in developing integrated approaches to provide better answers to the bio-economy challenges.

Bio-economy and particularly bio-based innovation systems bring in a new comprehensive and cross-sectorial context. Education as well as the new generation of experts, that should fulfil the needs of stakeholders and industry, need to adapt to it.
There is also a lack of knowledge and awareness of bio-economy from the general public which is also a barrier for development. Growing awareness and interest would contribute to the implementation of the required educational and business measures to empower the bio-economy sector.

[3] From: "*Workshop on promoting education, training and skills across the bioeconomy*", EC, Brussels, Oct. 15, 2019.

b.- On the different educational levels

Some competences become very relevant at PhD level and they are explicitly taught to doctorate candidates. However, it is interesting to point out that most soft skills are (or should be) taught at all educational levels adjusted to the different students' maturity stages and with different degrees of deepening and awareness.

There should be a dialogue between the different education suppliers, amongst universities and VET. Curricular paths based on skills needs should be developed together in order to complement each other and be more efficient in developing skilled professional for the bio-economy.

Universities offer a number of degrees with different disciplines that may address some industrial sectors within the bio-economy. However, there is no link or lead programme between the different degrees. There are no clear itineraries designed for specific bio-industrial sectors. Students may develop an interest in bio-economy at a Master's or PhD level almost by chance because there are no previous roadmaps that would clearly target this fast growing sectorial niche. Bio-economy must be integrated at all educational levels, starting at primary schools.

At present, the educational system is producing heterogeneous cohorts of students with different backgrounds: biologist, chemists, engineers, etc. and the university is debating on the type of students they need to be training: generalists vs. specialists, for example, and also to the extent the university is responsible of catering for all training needs of the new professionals. Alternative educational methods must be complementary to official degree education: continuous education, e-learning, specialisation courses provided by industry, etc. If the sector cannot anticipate a clear long-term roadmap for their development, official degrees are unlikely to change drastically.

c.- Technical skills and soft skills

Technical skills will remain relevant in 2030. In the bio-based sector, the technical skills of today are the same as the skills of the future and they include basic science and technical skills. Transversal skills are identified by industrial stake holders as relevant, which does not necessarily mean they should be incorporated into bio-economy degrees as core expertise. For example, "data science" can hardly be the core expertise by those studying forestry, but maybe instead, they need to acquire some minimum skills (how the data is treated, stored, retrieved, used, ownership, etc) to understand digitalisation to be able to work with data scientists. The following complementary skills are recurrently identified:

- Artificial intelligence and digital compliance
- New technologies
- Ethics
- Environmental impacts
- Expertise in social media and innovative communication tools to influence and generate awareness
- Knowledge transfer
- Openness for technological innovations and readiness to use them.

The soft skills are getting increasingly important and include:

- Capability to connect and learn
- Team-working
- Capability to manage highly-dynamic and complex systems
- Multi-disciplinarity
- Social skills: resilience, flexibility

As the bio-economy is conceptually wide, interdisciplinarity, curiosity, critical and systemic thinking is required. Problem solving and collaboration become crucial. The current problems cannot be solved alone, but multi-actor approach skills are relevant. There is a need to work together with different groups of stakeholders that have different viewpoints as well as different educational and professional backgrounds. Promoting mutual learning and multi-stakeholder approach to education. Raising awareness in all groups of stakeholders and sharing best practices:

- Pro-active attitude
- Creativity
- Understanding the value-nets
- Entrepreneurship and start-up
- Communication

Knowledge on Economy and Social Sciences becomes prominent in bio-economy as there is a need to understand new business models, new products and markets as well as new end-users and customer targets (behavioural approach):

- Business skills in a more innovative market
- Calculating and handling risks
- Globalisation, climate change, circularity and sustainability are key concepts in any bio-economy degree.
- Gender gap awareness, particularly in primary producers

d.- Methodologies and educational processes

VET seems to provide more hands-on experience for students, innovative training methods and more interaction with industry. Ideally, VET's best practices in their collaboration with industry should also be implemented at higher education levels for a better alignment of graduates to the demands of the job market.

As observed in UrBIOfuture's results, current educational programmes mostly use master class/lecture based methodologies. Making use of new technologies is key for more efficient teaching: sharing best practices and materials, e-learning, interactive materials.

It is important to share educational modules across European institutions as well as to foster diploma systems that are recognised by all EU countries. It seems obvious that this action requires a great degree of commitment to international mobility by all institutions: internships, exchange programmes among students, etc. and also the development of European degrees or pan-European educational programmes.

Furthermore, the development of current educational programmes must provide an answer to the language barrier particularly at lower education levels and among bio-industrial professionals who perform their activity in a very local context. Likewise, it seems very relevant to provide specific trainings for unemployed and primary seasonal

workers or to promote any other career development opportunities for bio-economy professionals.

e.- From the perspective of university accreditation agencies.

Since the mid 1990's (Bologna Treaty), a lot of discussion has been on the table about employability of university graduates, the need for soft skills training and the extent to which the university should or would be able to address those needs. Particular emphasis on this discussions has been placed on how to tackle specific vs. transversal contents in the academic curricula at the different educational levels. Moreover, the concept of multidisciplinary teams to address problems from different points of view. Some academic answers to this discussion currently are: double degrees, end of degree projects in groups with students from different disciplines, industrial doctorates, etc.

A study carried out by AQU (Catalan Higher Education Quality Agency) on biosciences[4], conclude that the main competences required by the job market for bioscience graduates are:

- Decision taking
- Problem solving
- Practical training: how to apply knowledge
- Independent work
- Creativity
- Leadership and Project management (planning and implementing projects)

Furthermore, at PhD level, in addition to the above mentioned skills, it is highly valued the focus on research and innovation.

Current and prospective employers also agree on the following:

- English Proficiency level
- Communication skill (oral and written)
- Public presentations (mastering support presentation tools)
- Work by objectives
- International mobility
- Social skills and emotional intelligence
- Knowledge of business models: generating value-delivering value-cost-effectiveness.
- Social impact awareness
- Adaptability to change
- Continuous education
- Broader view of STEM disciplines
- Capacity to develop and contrast arguments
- Teamwork

f.- Contextualising education

There seems to be a good presence of soft skills in educational programmes. However, industry keeps insisting on the need for soft skills on recent graduates. This may be a result of the way these skills are taught/used in academia and the adaptability of them to each particular industrial context. The system/context training seems to be lacking and

[4] JORNADA AQU: "*Reptes en la formació universitària en l'àmbit de les Biociències*", UAB, November 8, 2019.

extremely necessary to foster the transferability of the soft skills. Students do not seem to be taught about the relevance of the contents they are learning, the global challenges they are supposed to address.

Trust networks must be developed between bio-industrial employers and academic counterparts, scientists and professors. This strong collaboration is crucial for the development of future professionals, especially because of the ever-changing environment of innovation and new business models in the bio-based economy sector. Adaptability and lifelong learning are a must.

For the successful development of a bio-economy curricula, institutions must reach an agreement on continuously monitoring skills mapping at all levels: workers, engineers, theoretical academics, etc. from industry and academia. This exercise should count on the subsequent support of national and European authorities.

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