

Testing and validation of the prototype Industry 5.0 Learning and Assessment Tool

Greta Braun & Daniela Angione

November 2024

Disclaimer: This document has been prepared for the European Commission, however, it reflects the views only of the authors, and the European Commission is not liable for any consequence stemming from the reuse of this publication. More information on the European Union is available on the internet (<http://www.europa.eu>).

1. Introduction

An ongoing twin (green and digital) transition and the need to attract the best talent bring new challenges and put additional burden on business and organisational models at company level. As mentioned in the recently published report on Future of EU competitiveness by former European Central Bank President M. Draghi “Companies, and in particular SMEs in Europe are facing significant skills shortage and cannot find or fail to attract necessary skills.... Skills shortages and talent misallocation are also pervasive in the managerial layers of organisations.”¹

Combination of human-centric approach required to tackle the skills gap, sustainable practices and resilient methods in company processes require shift in thinking at company level (system thinking) and change in behaviours and decision-making process. Adoption of Industry 5.0 principles and methods in business practice could result in enabling companies to tackle the skills gap, attract and retain the best talents and maximise the benefits from the collective experience and know-how of its employees. It could help reducing the vulnerability to costly disruptions of supply chains and the lack of critical skills.

The prototype Industry 5.0 learning and assessment tool co-developed by Industry 5.0 Community of Practice members between November 2023 – May 2024 could help in achieving these goals. The prototype tool aims to:

- Encourage companies/organisations to check their performance against human-centricity, sustainability, and resilience at various stages of the production process;
- Inspire organisations (in particular, start-ups) to design impact-driven organisational models aligned with green, digital, and social transformation;
- Provide an overview of company’s impact-driven performance for policy-makers and investors.

In addition, the tool could serve as an integral part of education and training schemes (capacity building) for local businesses provided by respective regional and local entities (such as business support agencies etc.)

¹ https://commission.europa.eu/topics/strengthening-european-competitiveness/eu-competitiveness-looking-ahead_en#paragraph_47059

The prototype tool is composed of two parts: qualitative (“learning”) and visual (“assessment”). The qualitative part zooms-in on individual pillars of Industry 5.0 (human-centricity, sustainability, and resilience) and their key dimensions. It is structured in a matrix combining the three Industry 5.0 pillars with individual phases of production process (inputs-processes-outcomes).

The visual part "regenerative tree" provides a visualisation of a company's Industry 5.0 performance and enables the identification of advanced areas and those which require further attention. It helps us better understand interlinkages between different components.

More detailed information about the matrix structure of the prototype tool and its components is included in the CoP 5.0 final report adopted by CoP 5.0 Members at the plenary session on 16 October 2024² (footnote to the Industry 5.0 website where the final report as well as summary report from the plenary are published). The testing and validation of the prototype tool – its qualitative/learning component - with industrial stakeholders aims to: a) check the proposed structure of the prototype with industrial practitioners in order to make it as user-friendly as possible; b) collect ideas on how to further improve the prototype tool; c) collect input/ideas from industrial stakeholders on Industry 5.0 in general and its application in practice.

2. Testing methodology

2.1 Conceptual background

The testing and validation of the qualitative/learning component of the Learning and Assessment tool was carried out by interviewing 160 stakeholders (representing managers, employees, and organisations as a whole) across 20 Member States of the EU. The very first version of the Prototype Industry 5.0 Learning and Assessment Tool was developed by Industry 5.0 and AI in Science Unit of DG RTD at the European Commission. It was inspired by several existing impact-driven EU concepts and frameworks targeting human-centricity, sustainability, and resilience as presented in the following.

The core of the conceptual approach on which the EC has based the Industry 5.0 Learning and Assessment tool is represented by the Social Economic Canvas developed by the Joint Research Centre of the European Commission as a visual sense-making framework inspired by design and complex-adaptive systems. The context in which the Social Economic Canvas has been conceived is the emergence of new economic theories integrating social and environmental values as opposed to traditional self-interest and profit-based dimensions. People-centred practical and actional methods reflect a bottom-up approach to addressing the current environmental emergencies and increased social inequalities³ and constitute the essence of the Human-centricity pillar within the I5.0 Learning and Assessment tool.

² https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/industry-50_en#industry-50-community-of-practice-cop-50

³ https://policy-lab.ec.europa.eu/news/canvas-social-economy-design-method-regenerative-economies-2020-03-13_en

The Corporate Sustainability Reporting⁴ represents a major step from the EU into regulating large and listed companies' reports on social and environmental risks they face and on how their activities impact people and the environment. The new rules help investors, civil organisations, and all stakeholders evaluate the sustainability performance of companies, as part of the European Green Deal⁵, and constitute a substantial background for the I5.0 Learning and Assessment tool especially related to the Sustainability and Resilience pillars.

In addition, the EU Taxonomy⁶, which entered into force in July 2020, provides a list of EU-wide classification systems for sustainable activities, and it represents a cornerstone of the EU's sustainable finance framework and an important market transparency tool. The taxonomy is a classification system that defines criteria for economic activities that are aligned with a net zero trajectory by 2050 and broader environmental goals other than climate. This classification is specifically called out in the Industry 5.0 Learning and Assessment tool within the Sustainability pillar in the process dimension.

The Fit for 55 Package [a multi-sectoral overhaul involving expanding existing laws and the introduction of new directives that touch upon climate, energy, transport, buildings, and land use: Completion of key 'Fit for 55' legislation⁷] and the EU Eco-design for sustainable products⁸ represents the foundations of the regulations developed to respond to the requirements in the EU Climate Law⁹ [to reduce Europe's net greenhouse gas emissions by at least 55% by 2030] and in the updated REPowerEU¹⁰ plan. Both sets of regulations are embedded across the whole Industry 5.0 Learning and Assessment tool, indicating directions for achieving the digital and green transition.

The interviews carried out during the testing and validation study were based on a questionnaire conceived by Industry 5.0 and AI in Science Unit of DG RTD at the European Commission which was further developed via co-creation and collaboration during the Industry 5.0 Community of Practice (CoP) with inputs from the CoP members. The questionnaire has close reference to the outcomes of the study carried out by an expert group and published in the European Commission DG RTD policy document on human-centric industrial technologies roadmap¹¹.

⁴https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en

⁵ https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

⁶ https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en

⁷ https://ec.europa.eu/commission/presscorner/detail/en/ip_23_4754

⁸https://commission.europa.eu/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/ecodesign-sustainable-products-regulation_en#:~:text=Overview,can%20significantly%20impact%20the%20environment.

⁹ https://climate.ec.europa.eu/eu-action/european-climate-law_en#:~:text=The%20Climate%20Law%20includes%3A,of%20emission%20reductions%20and%20removals

¹⁰ https://ec.europa.eu/commission/presscorner/detail/en/ip_22_3131

¹¹ European Commission: Directorate-General for Research and Innovation, *ERA industrial technologies roadmap on human-centric research and innovation for the manufacturing sector*, Publications Office of the European Union, 2024, <https://data.europa.eu/doi/10.2777/0266>

2.2 Practical approach

The interviews were conducted by two experts who approached the interviews in two phases; during the first phase, the experts guided the interviewee through the Industry 5.0 Learning and Assessment tool, question by question. During the process, the researchers shared their screen, read each question to the interviewee, and selected the multiple-choice answer the interviewee provided as a response, with the option of elaborating their answer in a comment box for each of the questions. The second phase of the methodology consisted of discussing and validating the tool and asking for feedback or ways of improving it.

The questionnaire consisted of 119 questions and was divided into the three main pillars of Human-Centricity, Sustainability and Resilience, with 52 questions allocated for the Human-centricity pillar, 28 for the Sustainability pillar and 39 for the Resilience pillar. In addition, each pillar was investigated through the lens of the input, process, and outcome dimensions to address each stage of the industrial production process and organizational structure aspects.

The organizations were recruited by the experts on an individual basis and connections and pooled within the following:

- SME
- start-up
- public research organisation
- private research organisation
- national authority
- regional/local authority
- big industry
- university
- civil society organisation
- investor
- umbrella industrial/business organisation
- other

Although the focus was on recruiting for-profit start-ups and SMEs in the interviewees pool, a significant number of Large and Mid-cap organisations were included.

The interview process was fully anonymous, and the only information collected at the beginning of the session was the geographical distribution and size of the organisation,

- Micro business (max 10 employees)
- Small business (10-50 employees)
- Medium-sized business (50-250 employees)
- Mid-cap business (250-3000 employees)
- Large business (min 3000 employees)

the role of the interviewee (individual/employee, manager, or whole organisation), and the industrial ecosystem:

- aerospace and defence

- agri-food
- construction
- cultural and creative industries
- digital
- electronics
- energy-intensive industries
- energy-renewables
- health
- mobility-transport-automotive
- proximity-social economy-civil security
- retail
- textile
- tourism
- other

The interview was conducted by setting up a video call with the interviewee, by sharing the EC webpage where the survey was located and reading the questions to the interviewee. The answers were submitted by the expert on the portal with the possibility to include for each question a more detailed elaboration of the context of the answer chosen. In addition, at the end of the interview, the expert asked the interviewee feedback on:

- General impression on the tool
- Helpfulness of the tool
- Suggestions for improvement.

Those final comments were then included in the submission form and informed the final recommendations added in this report in section 5 of the report.

3. Collected data: analysis

3.1 Sample

The study's results provide a detailed picture of how users perceive the prototype Industry 5.0 Learning and Assessment tool and how it could be adapted or improved to suit different industries' needs. A diverse sample was assembled for that purpose.

The 160 participants in the study have either managerial roles or are employed at companies across Europe. They are part of various industrial ecosystems and differ in terms of company type and size.

As illustrated in Figure 1, the interviewed participants provide a very good EU geographical coverage (among them Sweden, Germany, France, Netherlands, Italy, Estonia, Slovenia, Ireland, Spain, Belgium, Denmark, Lithuania, Bulgaria, Portugal, Denmark, Finland, Czechia, Greece, Latvia, Lithuania, Poland and Austria).

Participants' Workplace Countries

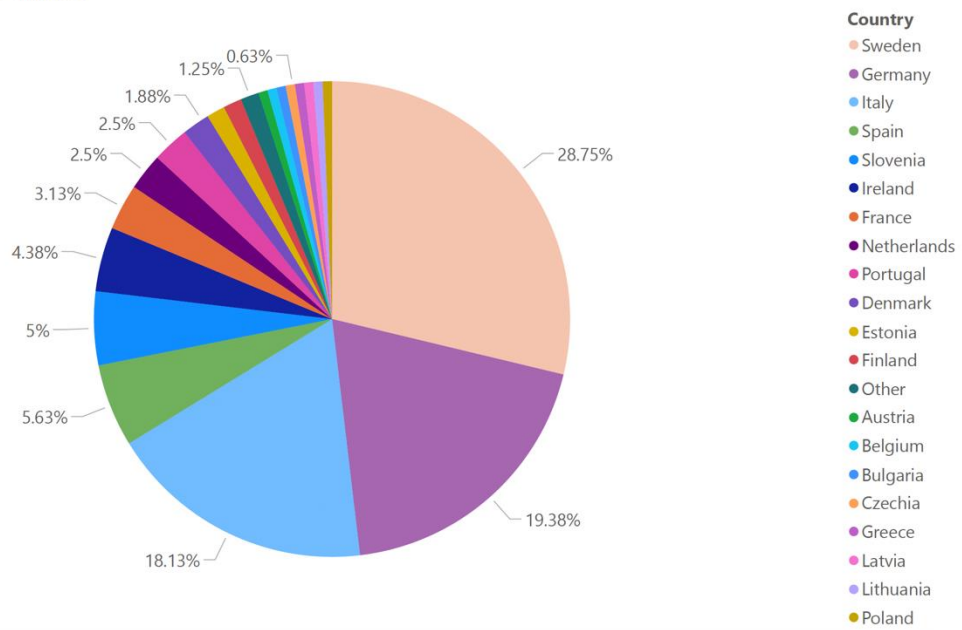


Figure 1 - Countries in which participants work

45% of participants in the study have managerial roles in their company, while 41% replied to the questions from an employee or individual's perspective. Only a few participants (14%) took the perspective of organization, which, for instance, means that they are on the board of the company (see Figure 2).

Participants' Roles

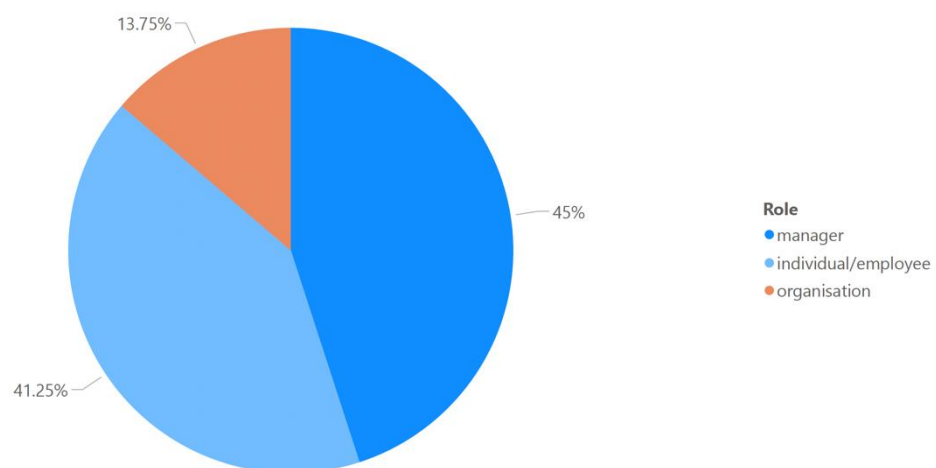


Figure 2 - Participant's role

In terms of company size, more than half of the participants work at SME's or startups and the sample shows a spread over different sizes of organisations. 38% of participants work in a big industry. This aligns well with the size of their organisation. 14% of participants work at a micro business, 24% at a small business, 16% at a medium-sized business, 26% at a mid-cap business, and 20% work at a large business (see Figure 3 and Figure 4).

Type of Organisations

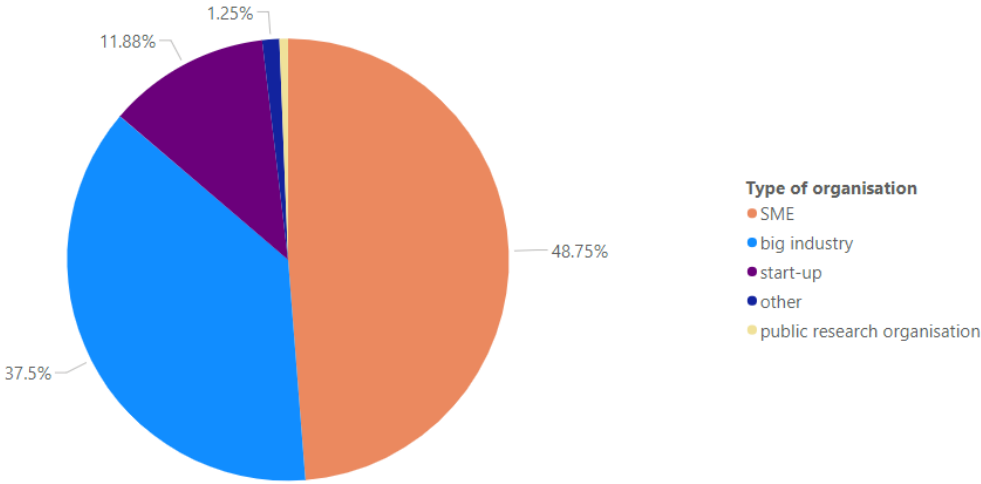


Figure 3 - Type of organisation

Participating Organisations' Size

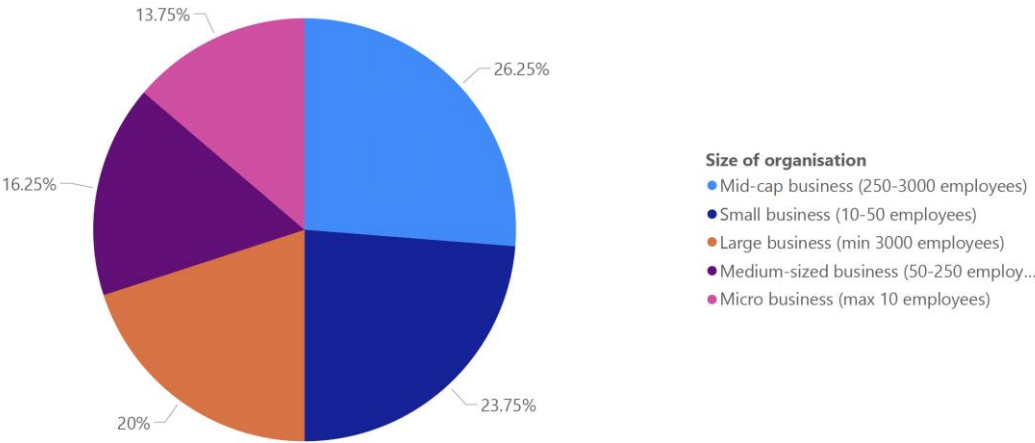


Figure 4 - Organisation size

The participants work in companies from different industrial ecosystems (see Figure 5). 40% of participants didn't identify their company within one of the suggested industrial ecosystems and specified their organisation with other descriptions. These were bundled and can be read in Annex I.

Industrial ecosystems of participating organisations

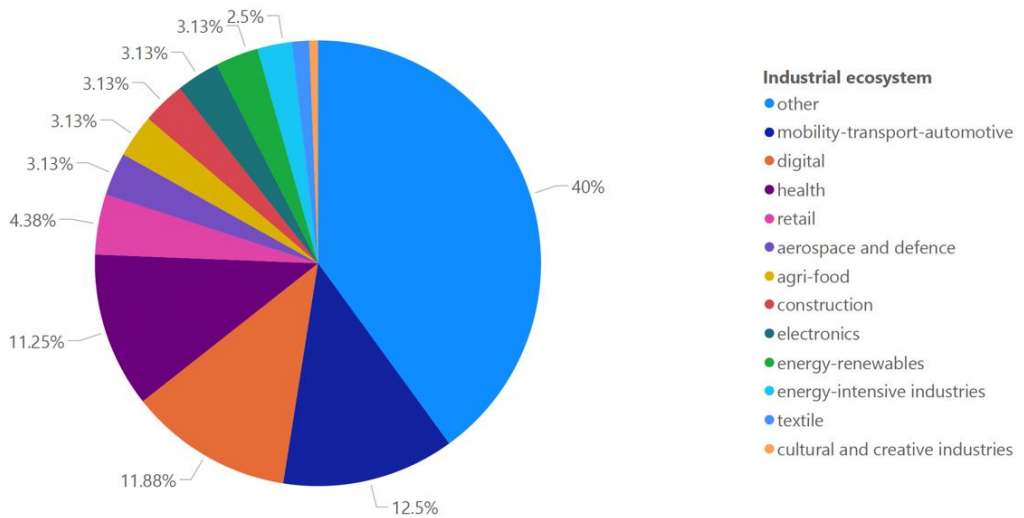


Figure 5 - Industrial ecosystems of participating organisations

3.2 Quantitative data

As described above, the Industry 5.0 Learning and Assessment tool aims to assess the company’s progress towards Industry 5.0 and support their learning on and shift towards impact-driven methods and organisation models based on Industry 5.0 principles. Therefore, the results from the respondent’s answers to the survey questions are analysed partly from an assessment and benchmarking perspective and partly from a learning perspective. Figure 6 gives a broad overview of answers for the questions in each Industry 5.0 pillar. The percentage of “Yes”-answers is highest in the questions about

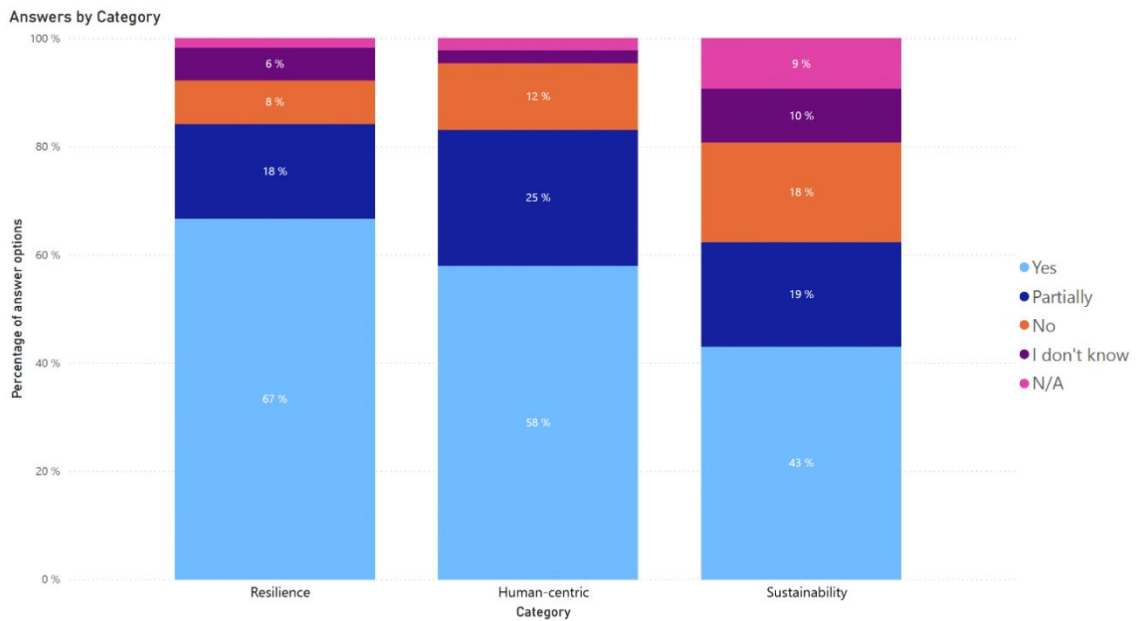


Figure 6 - Answers by Industry 5.0 category

resilience, while the highest percentage on “No”-answers is within the sustainability questions. All questions are asked in a way that “Yes” is the desired answer, since the questions indicate the desired state to achieve Industry 5.0.

Benchmarking

Large businesses are on the top and have the most “Yes” on the different pillars Figure 7. However, small businesses are right after large businesses, and in terms of the Human-centric category, they are actually doing better than large businesses. This means the tested small businesses are performing better in the human-centric and resilience pillar, in comparison to mid-cap businesses. The result can be attributed to the increased agility of small businesses as opposed to larger organisations, and the prevalence of horizontal rather than vertical hierarchy in small business enabling a more workforce-empowered organisational model.

Resilience is the strongest pillar in all organization sizes, except in micro businesses.

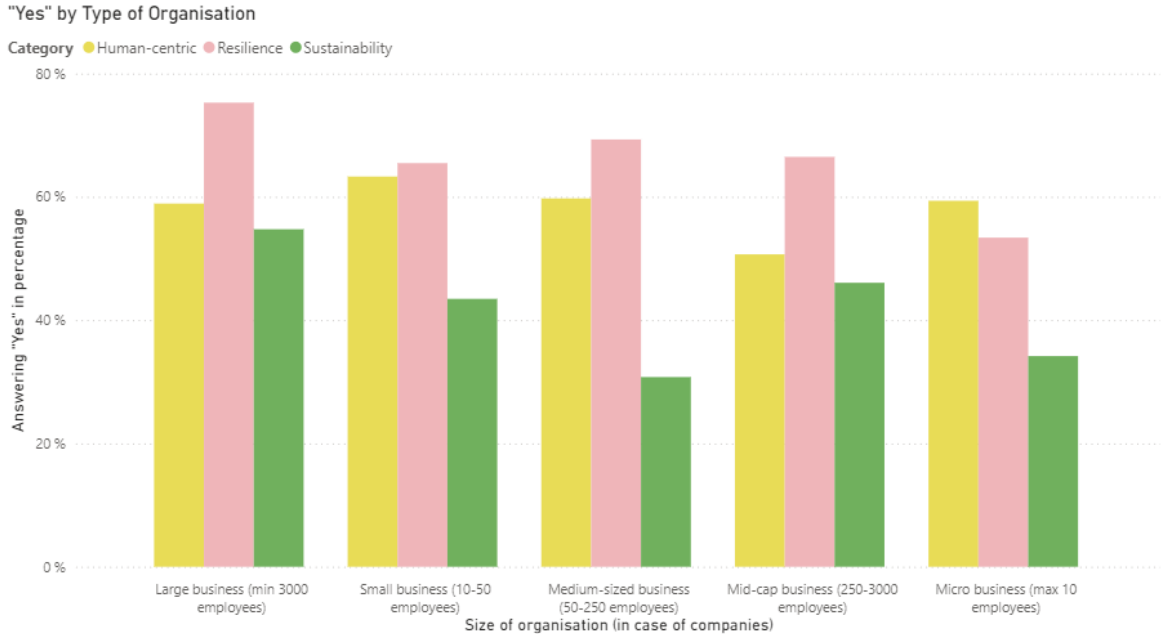


Figure 7 - Answering "Yes" by size of organisation and category

Disclaimer: Figure 8 needs to be interpreted on a case-by-case basis since the distribution of the tested sample is not uniform across the 20 member states in terms of the number of companies interviewed and in terms of the size of companies interviewed. For example, in the case of Lithuania, which scored

"Yes" by Country and Industry 5.0 pillar

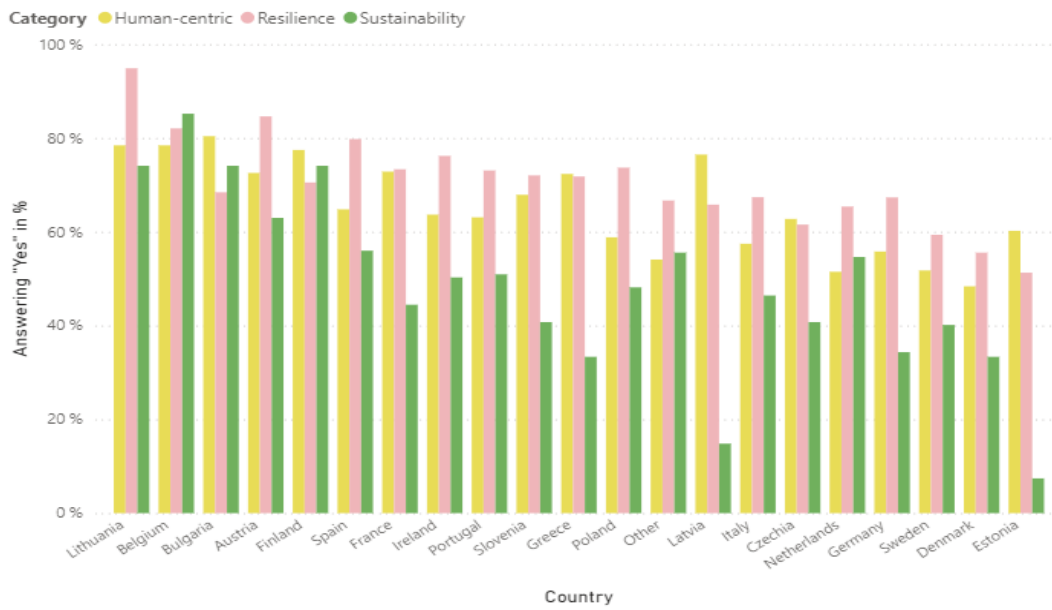


Figure 8 - Answering "Yes" by country and Industry 5.0 category

quite high across the three pillars, it needs to be clear that the number of companies in this country is only three.

The results obtained when analysing the number of "Yes" answers across the industrial ecosystems show higher performance of energy-intensive industries, followed by the energy renewables, compared to the rest of them. The data has to be interpreted carefully since the category 'other', which represents the biggest group (see Figure 9), includes a variety of sub-ecosystems, see Annex I, that are not fully visible in the graph but embedded in the group.

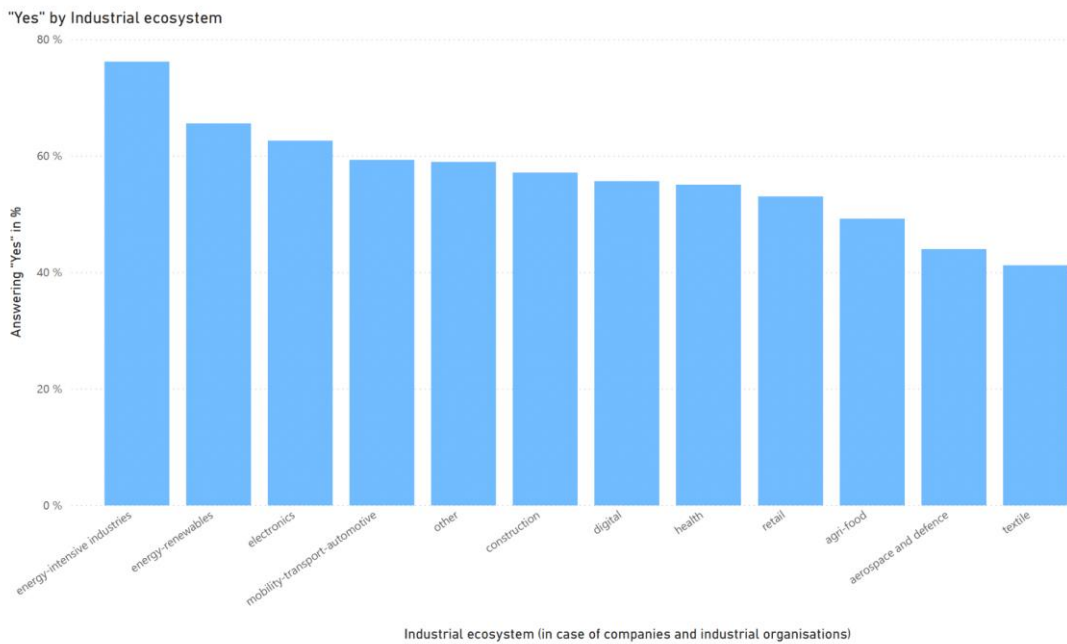


Figure 9 - Answering "Yes" by industrial ecosystem

Participants' Industry 5.0 Framework awareness

In this part, we showcase the participant's overall knowledge and awareness about the Industry 5.0 framework and its key pillars – human-centricity, sustainability, and resilience. This component is visualised against the interviewee's role (see Figure 10).

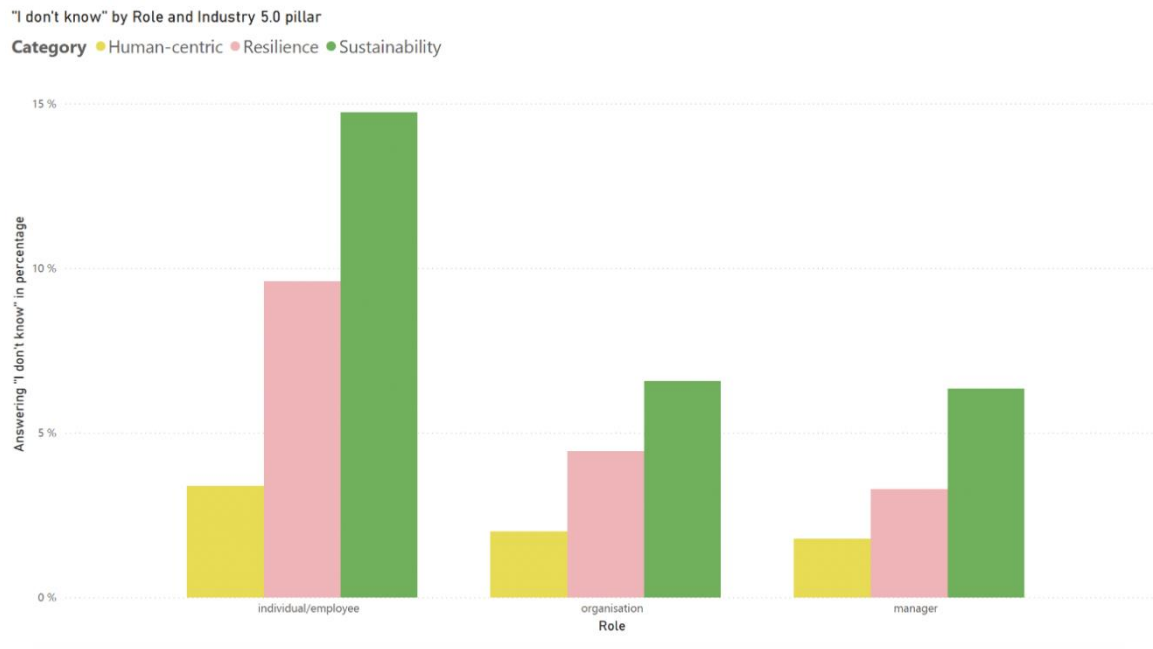


Figure 10 - Answering "I don't know" by role and Industry 5.0 pillar

In some cases, interviewees asked for an explanation about a given question to understand it better (especially during the question, "Do you somehow preserve the cognitive dimension of work and autonomy in cognitive tasks?"). There was also a pattern in which questions were difficult for participants to give a clear answer to, and they had to reply, "I don't know". These questions with the most "I don't know" answers are shown in Figure 11.

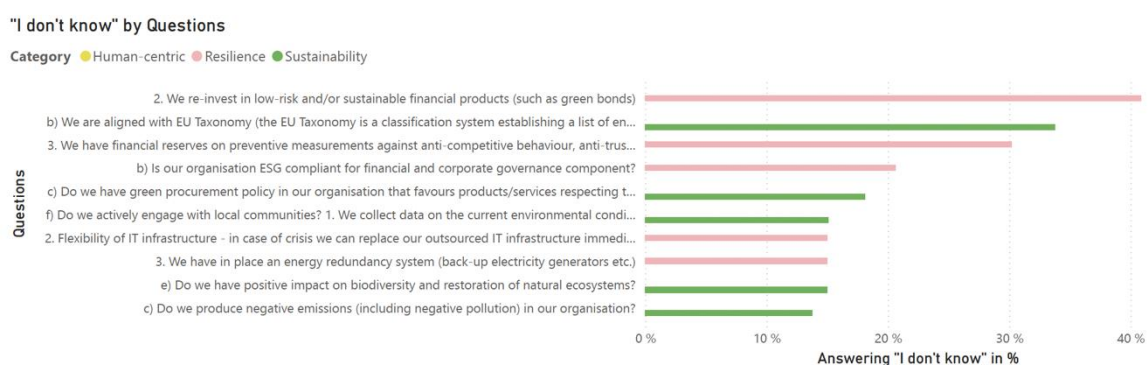


Figure 11 - Questions with most "I don't know" answers

Relevance of questions to industrial ecosystem

Further, the collected data is analysed regarding the applicability of the prototype tool to different industries, company types and sizes, and countries.

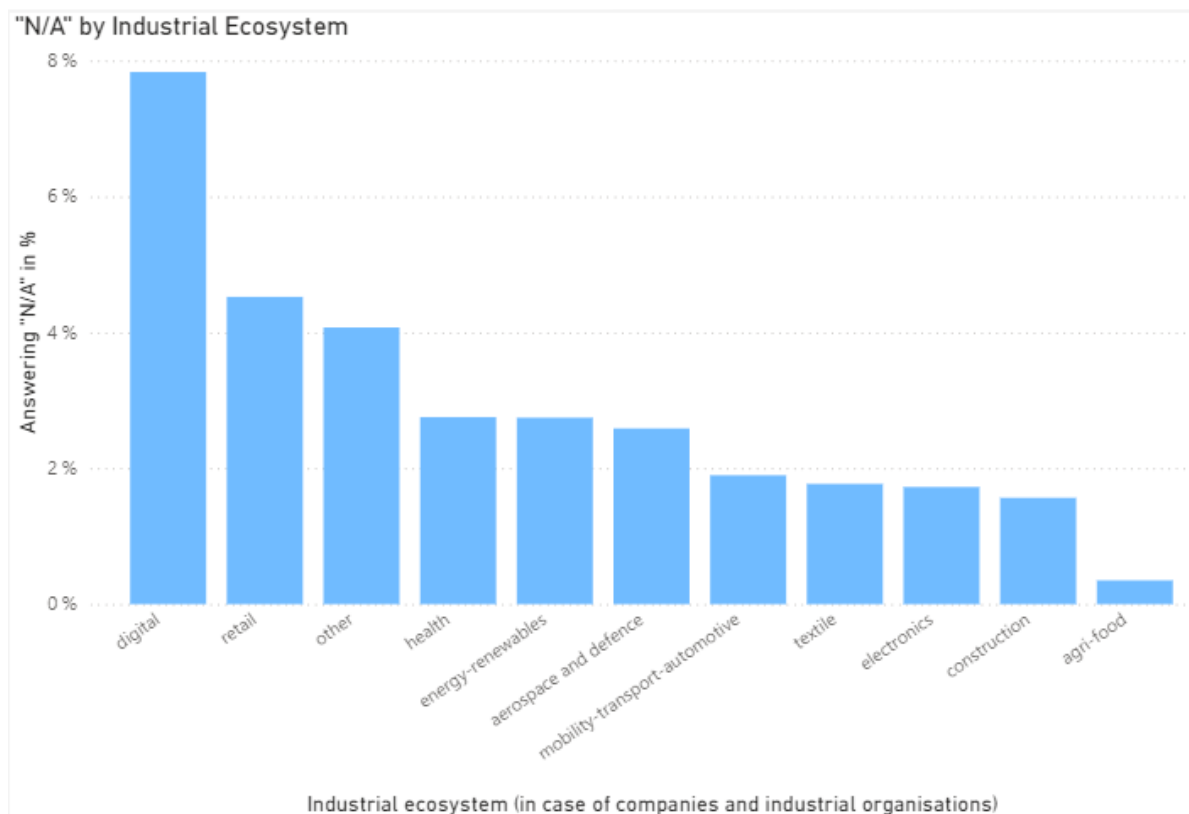


Figure 12 - Answering "N/A" by industrial ecosystem

3.3 Feedback from the interviewees on the prototype tool

Following the Learning and Assessment prototype tool questionnaire, the participants were asked to provide their feedback about the tool, i.e., in what way it was helpful, and how they would improve it. Their responses were encoded and thematically analysed.

Most of the respondents consider the prototype tool **Useful**. They gave very positive feedback, confirming that the tool “helps to reflect”, makes you “more aware of things that you need to be aware of”, is “very important for the world we are living in right now”, can help to “see the value of the tool in understanding how to be an attractive employer” that this tool is “Great! Feels like a good step forward for the world”, and that they get better clarity of the framework “understand what Industry 5.0 is about.”.

Secondly, the tool raised **Interest and Engagement**. This statement is underpinned by comments like “very interesting,” “challenging,” “Good questions - it was worth it to go through all of them,” and “this was way more thought-through compared to Industry 4.0 - not just “cool technology”, and “very good type of tool.”

Many respondents commented on the **Tool Complexity**, criticizing the “overwhelming” feeling the tool could cause due to its granularity (high number of questions and the time and effort it takes from the participants). At the same time, some respondents evaluated the complexity of the tool as something positive since it gives a broad overview and covers all the important topics. Some participants mentioned it would be necessary to include “a group of people from the company to reply correctly.”

Further, some respondents noted the need to increase the **Clarity of Questions and Instructions**. Respondents highlighted issues with understanding the questions properly, saying that “some words/phrases need more clarity,” and “what do you mean with new technologies?” “some questions are hard to understand” and that “some questions seem similar.” In addition, the answer options didn’t always seem clear to participants, who proposed to replace the current range of answers with alternative ranking such as, e.g. from 1 to 5 or in percentage, instead of only “yes”, “partially”, and “no” answer option. In addition, respondents asked for a possibility to express that they are working towards a certain question but are not there yet. So, adding a response option “to express an aspiration, like ‘in the process’ might be useful. “. Respondents also commented that it should be clear from the beginning whether an interviewee responds as representative “ – of the whole company or a team as well as blue/white collar.” The collected feedback also confirmed that further improvement of the prototype tool regarding its relevance for different sizes/company roles might be useful. Comments like “not sure how suitable this is for us as a smaller company,” “questions should be oriented to shop-floor workers,” and “questions should be adapted to individuals depending on their role” indicate the need to further fine-tune the relevance part of the tool (distinguish better the use of the tool for different categories of workforce/stakeholders). Some respondents signalled the tool did not cover all the relevant aspects their company’s sustainability approach, highlighted in comments like “tool should include how the product creates a positive impact on the environment.” At the same time, some small companies/startups see this rather as an opportunity stating that the topics brought up in the tool will become necessary for them to deal with in the future: "When we become bigger, we have to look at these questions. Right now, it is about surviving but, in the future, we will have to". Following the testing exercise, it is clear that in particular for SMEs a long-term impact-driven company vision/perspective is rather missing – comments like “right now the main concern is to make it out until the next month.”

Some participants pointed out the need to **Sharpen the content of Human-centricity and Sustainability** parts. These aspects were highlighted by comments like “human-centricity part should be sharper,” “more deep dive into company policies,”, “missing area of ‘health and safety’ and ‘mental health’”, and "to understand better human-centric technologies - so far we don't have so much focus on this because we have focused on the technologies - we should work more on creating a better work environment for our workers".

Some respondents linked the qualitative part of the prototype tool with **Benchmarking and Comparisons**, as seen in comments like “would be nice to get a benchmark with other companies from the same industry”, “would like to use this as a follow-up tool to see progress towards industry 5.0”, and “would like to get recommendations after using the tool” and understand “which areas of improvements” they have.

4. Collected data: interesting cases/examples

In this section, some specific cases are highlighted as examples, to bring up some best practices and challenges in the implementation of Industry 5.0.

German Bionic

German Bionic develops active and fully connected wearable robotic systems/exoskeletons for preventive occupational safety at the workplace. The use of AI/ML makes the technology highly customisable to the individual and the respective workplace situation. Sensor-generated data analyses enable a data protection compliant ergonomic evaluation of the workplace, to protect the health of employees in addition to aiding and to significantly reduce the risk of occupational accidents and injuries in times of a shortage of skilled workers and an ageing society.

German Bionic develops and produces the active and fully connected exoskeleton Apogee in Germany. It combines strategically relevant technologies such as robotics, connectivity, and AI/ML. It combines human intelligence with machine power to improve workplace safety and the health of workers. The technology offers support for repetitive lifting and holding operations of up to 36 kg to protect the lower back and active walking support to reduce fatigue to prevent the risk of stumbling.

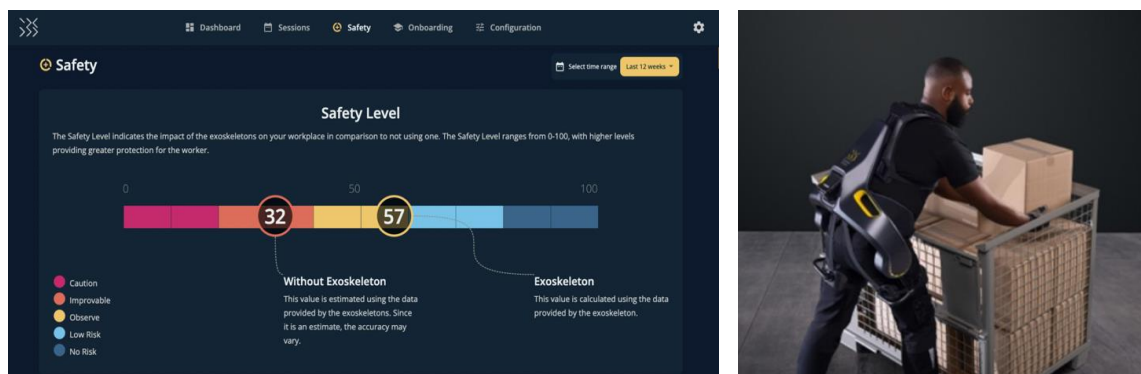


Figure 13 - Screenshot from German Bionic dashboard of worker safety software and worker using Exoskeleton

With real-time safety analyses based on sensor data, German Bionic offers a new level of data empowerment. Meaningful evaluations and reports provide insights into ergonomics, task performance and device usage in relation to specific workplace situations. This makes specific work environments. The German Bionic IO data insight platform stores the core of all bio-telematic data generated by the devices used in a data protection-compliant manner. It provides insights into ergonomics and safety in the workplace. Optimizing occupational safety based on data and checking it for practicality and effectiveness not only revolutionizes today's preventive occupational safety, but also closely follows the approach of human centrality with its claim to use technology to overcome social challenges. Supplemented by the smartphone application 'German Bionic Connect', the technology promotes transparency, trust and, last but not least, data literacy, i.e. an understanding of value-adding data. This naturally leads to more openness and acceptance of technologies as a cornerstone of digital and technological transformation.

Helios Innovations

Helios Innovations, a Swedish startup, exemplifies the innovations needed to achieve Industry 5.0 with their sustainable technology designed to address environmental challenges connected to process industries. This startup has developed an evaporation technology that cleans process fluids using waste heat. Despite their forward-thinking approach, the startup faces the common struggle of balancing

immediate survival with the broader Industry 5.0 pillars, i.e. human-centricity, resilience, and sustainability.



Figure 14 - Helios innovations' evaporation technology

LabService

Lab Service Analytica srl (LabService) is an innovative Italian SME company active in the field of production and distribution of analytical instrumentation essential to perform analysis, measurement campaigns, quality control and research in the fields of analytical chemistry, food safety, environmental monitoring and polymer characterization since 1984.

Thanks to constant collaboration with leading public and private laboratories, it holds important experiences in the analysis of pesticide residues and micro-persistent organic contaminants and provides solutions according to the main reference methods.

All the company's sampling (OdorPrep) and monitoring systems (NetPID, Electronic Nose, Odor Source Monitoring System) arise from the socio-economic need to assess the negative impact generated by industrial activities that, consciously or unconsciously, emit unpleasant substances (among the main reasons for complaints from the European population) and to significantly reduce the risk of occurrences, as well as to offer assistance in resolving them. The technologies comply with the main international reference standards and respond to the challenges of a society increasingly aware of environmental pollution and accustomed to living in contexts where urbanisation levels are conflicting.

The technologies and software solutions, all based on Artificial Intelligence for food safety and quality control, ensure that companies which do not always have adequate internal laboratories can: (i) carry out a greater number of quality analytical tests without the need for highly qualified personnel and (ii) significantly reduce lead times during the food processing phase.

The company demonstrates best practice in both designing and developing advanced digital solutions for environmental management, and in working with local administration and environmental agencies to ensure a co-creation approach. The ultimate company's impact is addressing social benefits through improved health and quality of life, and enhanced community resilience.

5. Recommendations on how to further improve the prototype tool

Synthesising the results from the quantitative and qualitative feedback analysis leads to some first recommendations on how to improve the tool and its usability further.

Policy level

Support for learning

- Provide clear guidance and motivation for companies on how to use the tool effectively. Welcome companies to learn about Industry 5.0 by using the tool.
- Provide a continuous support (one-stop-shop/platform) contact and an online community where users can share their experiences and share best practices, connected to the tool.
- Connect recommendations to funding opportunities. It would especially help startups to get links to suitable funding related to their recommended actions.

Continuous feedback loop

- Establish a continuous improvement loop for regularly updating the tool based on users' feedback, technological development, and requirements on sustainability, human-centricity, and resilience.
- Track the usage of the tool and follow-up with users on how they took their results further in their company.

Awareness raising

- Campaign for the tool to make industrial practitioners aware of the opportunity.
- Highlight best practices from companies who do well in human-centricity, sustainability, and resilience and use the tool to establish an Industry 5.0 benchmarking.
- Link the awareness about the tool and Industry 5.0 framework in general with addressing one of the key challenges companies face during industrial transition: how to tackle the skill gap and attract/retain the best talent.

Technical level

User Interface/User Experience

- Make the tool user-friendly and less overwhelming by adding a progress bar so users see how many questions are left.
- Add a feature to allow users to save a draft and return later, to avoid overwhelming feelings.
- Include more information or examples for complex questions, through pop-ups or a glossary.
- Implement a tutorial or short introductory video to get users started with the tool.
- Simplify the words and formulations in the questions to ensure they are understood correctly by all users. Also, make some questions more specific and clearer to avoid misunderstandings.
- Paragraphs should have short captions instead of questions.

Adaptations

- Provide the tool in native languages.
- Implement a feature that adapts the tool to users' input regarding company size and industrial ecosystem, i.e., provide different sets of questions depending on company size and industrial ecosystem.

- Add a feature that allows multiple users from the same organization to answer different sections of the tool (depending on their expertise), and then aggregate the responses.
- Add questions for smaller companies that address their specific challenges, such as resource constraints and prioritization conflicts.

Answer options

- The “partially” answer option needs to be adapted depending on the question and must account for different implementation or fulfilment stages. Expand the range of answer options, e.g., using a scale from 1-5, or more descriptive answer options like “Totally agree”, “Agree”, “Not agree nor disagree”, “Disagree”, and “Totally disagree”, or a scale from “Yes”, “Partially yes”, “Partially no”, and “No”.
- Expand the number of industrial ecosystems to include, e.g., chemicals.

Usable for follow-up

- Companies are keen on getting concrete recommendations for follow-up actions after their assessment. Provide immediate feedback or recommendations based on their responses, including benchmarking within different areas of the tool against other companies in the same industry, same country, and same size.
- Include a summary or report after users finish the questions in the tool, highlighting strengths and areas for improvement.
- Implement the opportunity to have a profile login to save results and use the tool regularly as a follow-up tool and track progress.
- If possible, add recommendations for startups to suitable funding related to their follow-up actions.

Content

- Include more aspects of human-centricity, like mental health, safety, and well-being.
- Provide more examples to show how other companies have successfully implemented Industry 5.0 principles.

Annex I

List of specified industrial ecosystems, if respondent replied with “Other”.

1. Manufacturing, Production

- Manufacturing
- Manufacturing, white goods, electronics
- Manufacturing, healthcare, electronics, energy, telecommunication, space, and defence
- Manufacturing for several industry fields
- Advanced manufacturing
- Mechanical and plant engineering
- Mechanical engineering for machines, maritime, models (3D-printing)
- Manufacturing valves for building technology
- Integrated and automated machinery for defence, automotive, energy
- Manufacturing - CNC automation solutions for several industries
- High tech industry

- Developing miniaturized technologies for several industrial applications - health, agri-food, electronics, aerospace, and defence
- Mechatronic solutions
- Steel and metal distribution, eventual pre-production, machining of components and parts
- Robotics
- Energy generating products
- Materials for health and climate
- Ceramics
- Production of rubber, silicon, and fluorosilicon products for several industrial ecosystems
- Plastic manufacturing (LEGO company, customer owns the tools)

2. Chemicals and Biotechnology

- Chemical industry - cleaning (hand sanitiser, cleaning for cars, cleaning for machines)
- Biotechnology and chemicals
- Chemical industry
- Automation/digital for chemical
- Technologies for environmental monitoring of volatile chemicals

3. Energy, Automation, and Electrical Systems

- Energy management, industrial automation, electrical component production
- Tools for energy industry, manufacturing, agri-food, finance
- Digital and energy solutions
- Equipment for environmental and food safety
- Engineering/process automation
- Production of building safety components

4. Digital Solutions, Technology

- Software to developing organizations in the automotive industry
- AI solutions Software-as-a-service for various industries
- Simulation/digital solutions for production planning
- Digital for health
- Digital products and services for manufacturing
- Digital, EU regional and innovation projects
- Services for digital transformation of SME and public sector - sector agnostic
- Technology provider

5. Environmental Sustainability and Resource Management

- Machines/water cleaning service for wastewater management
- Reusing waste from construction and agri-food, sustainable concrete
- Systems engineering (for construction)
- Developing and manufacturing smart air ventilation systems
- Materials for health and climate

6. Food and Beverages

- Trade organic food
- Food and beverages
- Pet food
- Machines for agri-food sector

7. Construction and Infrastructure

- Products and systems for construction sites
- Systems engineering (for construction)
- Reusing waste from construction and agri-food, sustainable concrete

8. Mining and Material Handling

- Mining and minerals
- Material handling solutions, manufacturing
- Steel and metal distribution, eventual pre-production, machining of components and parts

9. Research, Consulting, and Innovation

- Consulting
- Research about production systems
- Digital, EU regional and innovation projects
- Services for digital transformation of SME and public sector - sector agnostic

10. Healthcare and Life Sciences

- Digital - health app
- Life science
- Biotechnology and chemicals
- Materials for health and climate
- Developing miniaturized technologies for several industrial applications - health, agri-food, electronics, aerospace, and defence