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Charting the path to a sustainable, competitive and green industry in an era of rapid change: proposing a research agenda

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ABSTRACT

Global labor market shifts have spurred the need for innovations and adaptations in workplace norms. This evolution demands a workforce with technical and soft skills to meet sustainability and industry advancements. The paper aims to elucidate the complex challenges related to the ambition to develop a socially sustainable, competitive, and green industry subjected to an accelerating pace of change. It outlines the findings of a Delphi study conducted in Sweden, which integrated workshops, interviews, and surveys with experts from various sectors to identify 14 key challenges. These challenges were synthesized into five themes: innovative competence supply management practices, resilient organizations and production systems, analytics for improvement and learning, socially sustainable work, and green transformation practices. The study provides a set of propositions within these themes, offering a strategic roadmap for future research to foster the growth of industries that are socially responsible, competitive, and committed to environmental sustainability. A practical implication of the study is the recognition of the larger competence ecosystem of which industrial companies are a part. This community must work together to create the knowledge needed to manage the shift to a green, sustainable, and digital working life.

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Introduction

In recent years, unprecedented challenges and disruptions have catalyzed transformative shifts across the global labor market (Mehta et al., 2024; Suciú et al., 2023; Tavella, 2022; Venn et al., 2022; Verick et al., 2022). Industries in every sector are pursuing the green transition, an evolution necessitating technological advancements for fossil-free production, carbon emission reduction, material development, and a strategic shift towards a circular economy (Alcalde-Calonge et al., 2022; Harlin et al., 2022; Sindhvani et al., 2022). The COVID-19 pandemic has turned traditional workplace norms on their heads, as widespread lockdowns and social distancing regulations propelled us into the era of remote and hybrid workplaces (Alshibly & Alzubi, 2022; Delfino & van der Kolk, 2021; Lundqvist et al., 2022; Yarberry & Sims, 2021). Adding to this flux is the advent of commercially accessible AI chat models, such as ChatGPT (Lo, 2023). Such advancements have added another dimension to our understanding of the evolving workplace, marking an exciting yet challenging juncture in the world of work.

In order to stay ahead of these rapid changes, industries must work fast to develop and implement new technologies and environmentally viable solutions. However, this shift requires new knowledge and

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expertise in areas such as renewable energy, green building design, sustainable supply chain management, green human resource management (HRM), quality management, and waste reduction strategies, but also softer skills such as creativity, critical thinking and the ability to foster employee empowerment (Harlin & Berglund, 2021; Martin et al., 2023; Modgil et al., 2023; Rashid et al., 2023; Suciu et al., 2023).

Unfortunately, many organizations do not have the necessary staff to fill these roles, making them less resilient in terms of being able to adapt to complex changes (Florez-Jimenez et al., 2024) by access to expertise in sustainability-related areas. Thus, this leads to a competence gap that can hinder progress towards sustainability goals and Industry 4.0 and 5.0 (Anshari & Hamdan, 2022; Whysall et al., 2019). Therefore, in current research and policy discussions, the need for competence is frequently cast as a central factor driving sustainable development. In Sweden, this need is mirrored in policy initiatives such as the Green Transition Leap (Halvarsson Lundqvist et al., 2022), declaring that competence supply management is one of the most critical issues during the next century. A survey by the Royal Swedish Academy of Engineering Sciences (IVA, 2021) showed that the number of companies considering it difficult to find personnel in research and development is increasing, particularly in growing technology areas such as AI, digitalization, green technology, and electrification. Similarly, a recent interview study with 1300 Swedish industrial small and medium-sized enterprises pointed out that issues concerning employee competence are critical to addressing future development initiatives (Hedman, 2022).

Furthermore, the competence shortage can also have significant social sustainability impacts, i.e. affect individual and collective human behavior in organizations (cf. Faber et al., 2010). Employees who lack the necessary skills and knowledge to implement sustainable practices may face challenges in their work environment that affect their health and well-being (e.g. Tamers et al., 2020). In addition, a lack of opportunities for employee growth and development could lead to job dissatisfaction and high turnover rates, negatively impacting the community (e.g. Kurniawaty et al., 2019; Ruiz-Palomino et al., 2021). Therefore, investing in employee competence development benefits the organization's sustainability goals and contributes to suitable work environments that strengthen health and well-being (e.g. Wikhamn, 2019).

The paper aims to elucidate the complex challenges related to the ambition to develop a socially sustainable, competitive, and green industry subjected to an accelerating pace of change. The paper presents and discusses challenges identified in a Delphi study to arrive at specific priorities and gaps that guide propositions for future research.

Method

The Delphi method was used to identify and explore the challenges for a sustainable industry by reaching a group opinion among a panel of experts (Okoli & Pawlowski, 2004).

The panel in this study was a group of experts within strategic functions that could provide perspectives from industry, labor market organizations, the public sector, and academia. The participants held key management or expert positions in large and medium-sized industrial companies as well as intermediaries such as educational actors and labor market organizations, and governmental agencies. The Delphi method for this study was structured in three steps: An initial workshop, individual interviews, and a survey.

The first step was to arrange an initial workshop to identify what key stakeholders perceive as critical knowledge gaps in relation to the project theme, i.e. to establish a socially sustainable, competitive, and green industry at an accelerating pace of change. The workshop was conducted online via MS Teams by the research team, together with participants representing 14 organizations in Sweden. The research team documented the results from this workshop to form a basis for further inquiry and to develop an interview guide for interviews aimed at further charting the perceived knowledge gaps.

The second step in the Delphi study was to map knowledge gaps, needs, and challenges through individual semi-structured interviews with respondents ($n=24$). Each interview lasted approximately 30–45 minutes and was conducted digitally via MS Teams or physically at the company premises. The interviewees were provided with all the challenges identified in the first step, and the interviews revolved around the question, 'What are the most critical challenges to achieving a socially sustainable, competitive, and green industry (at an accelerating pace of change)?' The interviews were transcribed and analyzed using the QSR NVivo software program for qualitative analysis (Jackson & Bazeley, 2019). The qualitative data analysis was conducted iteratively by a team of two designated researchers who

followed an abductive five-step analytical process: (1) reading and re-reading the transcripts; (2) data reduction by coding; (3) comparing, relating, and integrating codes; (4) thematic analysis; and (5) drawing conclusions by establishing central themes together with illustrative quotes. The coding in NVivo was conducted in an open, data-driven manner, aligning with the principles outlined by Miles and Huberman (1994) regarding attributing specific phenomena to text segments (p. 57). Two researchers independently coded the dataset using the 'Codes' and 'Nodes' tools in NVivo. The separate coding schemes were compared and evaluated before merging into one coherent coding scheme. Following this initial phase, the coded data underwent thematic analysis, wherein variables were organized into overarching thematic codes through clustering. This was also partly done manually, on a physical whiteboard, during several workshop sessions involving several researchers in the team. Based on these workshops, a construct table in NVivo was established, facilitating a comparative examination and critical evaluation of the identified thematic codes.

The results from the NVivo-supported analysis were then validated in a second analysis process conducted by other research group members. Finally, all research members in the team participated in interpretation, where step 2 resulted in 14 identified key challenges along with additional sub-challenges. During this analysis phase, the researchers related the challenges to different research fields, which formed the initial base for clustering and synthesizing the thematic codes into 14 specific challenges. As an illustrative example, Figure 1 features an NVivo-based diagram of the thematic code, which results in challenge no. 5: 'Attracting, developing and retaining employees with the right skills'. The diagram displays the sub-codes linked to this thematic code.

The third step in the Delphi study was a descriptive survey aimed at validating the aggregated findings from the digital workshop and interviews and prioritizing areas for further research. The respondents in the survey study were the interview persons from the interview study together with eight additional key stakeholders from invited organizations (n=32). The survey study was carried out in December 2022 and was designed and structured around the 14 key challenges identified in steps 1 and 2 (the workshop and the interviews). There were 13 experts in the panel that answered the survey. In the survey, the respondents were asked to assess each challenge using a 7-graded Likert scale from two different perspectives: (1) the current ability to address the challenge, and (2) how important it is for the organization to increase knowledge about the challenge. The survey also included an open question where the respondents were asked to add any possible additional challenges and explain why it should be added. In the final question, the respondents were also asked to prioritize what they thought were the five most important challenges out of the 14. The survey data was then analyzed to extract descriptive information on how the different challenges were valued and prioritized concerning the assessment of current organizational abilities and the perceived future importance of each listed challenge.

In parallel with the design phase of the descriptive survey, the 14 challenges were synthesized into themes. Through iterative discussions and mapping of codes, preliminary themes were identified and subsequently refined to ensure they accurately represented the challenges. This review process led to the definition and naming of the final themes: 'Innovative Competence Supply Management Practices', 'Resilient Organizations and Production Systems', 'Analytics for Improvement and Learning', 'Socially Sustainable Work', and 'Green Transformation Practices'. These themes encapsulate the study's findings on necessary innovations in competence management, organizational resilience, data-driven improvement, social sustainability, and green transformation practices within the industry. A complementary theme for 'Future challenges' was included, as the environment is constantly moving, and new challenges may arise.

Concerning research ethics, the Delphi study concentrated on gathering insights about organizations and business environments rather than collecting personal data from the participants. This focus negated the necessity for ethical approval. Nevertheless, we made it a point to obtain informed consent from all participants, ensuring transparency and ethical rigor. The accumulated results have been synthesized at a macro level, making it impossible to trace them back to any participant, thus preserving their anonymity.

Results

In this section, the identified challenges (Table 1) are presented.



Figure 1. NVivo diagram displaying the thematic code, together with sub-codes, forming challenge no. 5: “Attracting, developing and retaining employees with the right skills”.

Organizing and creating conditions for flexible work for all

The first challenge concerns creating flexible work conditions for everyone, including opportunities for flexible working hours, remote and on-site work options, and an organizational culture that supports flexibility. The increased adoption of flexible work models brought on by the COVID-19 pandemic is expected to continue in the future.

One quality of flexible ways of working is combining, to a higher degree, remote and on-site work, which opens possibilities to attract new talents from a wider geographical pool. It also enables employees to design their work process more based on their needs and hence improves conditions for balancing work with private life:

Remote work makes it possible to live a bit further away from the workplace and still make your private life work because you can work from home more days without affecting your work performance, which is positive. This is a change that the pandemic brought.

However, when people work more from home, effort must be put into supporting employees with increased self-leadership and time management to create the optimum workflow. Here, an active

Table 1. 14 challenges identified in the Delphi study.

Challenge
1. To organize and create conditions for flexible work for all
2. To successfully manage crises and drastic external events
3. To successfully drive and contribute to the green industrial transformation
4. To facilitate employee-driven innovation and organizational learning
5. To attract, develop and retain employees with the right skills
6. To take advantage of and exploit the opportunities of digitalization
7. To create inclusive workplaces and utilize diversity
8. To organize competence development
9. To collaborate with external parties to ensure the availability of competence
10. To design for socially sustainable work considering efficiency and good health in a dynamic environment
11. To organize the creation of added value for and together with customers and suppliers
12. To systematically drive continuous improvement work in parallel with long-term development work
13. To develop leadership that creates better opportunities both for a climate-neutral footprint and a competitive industry with good working conditions
14. To transform research- and policy-based knowledge into practice

engagement from the managers is needed to understand the needs of employees and support people to find the right balance:

Employees have a dialogue with their closest manager so that we understand what works well with remote work but also what perceived challenges are so that we can design the work process and conditions based on that understanding. This gives us flexibility which now creates opportunities to combine remote and on-site work in a good way.

Despite many advantages, there are also several challenges with flexible work models. The participants reflect that finding the right balance between individual and team needs is difficult. It has become harder to create a strong culture when colleagues spend less time physically together. There are also differences in expectations between generations when it comes to work flexibility, and there is also a risk of unequal conditions for workers, for example, blue-collar workers who must work on-site to a higher degree and white-collar workers who can work remotely.

Those who work on the factory floor must be on-site. Therefore, tension is created between white and blue color workers, and we will never be able to surpass that. It is what it is.

Managing crises and drastic external events successfully

The second challenge explored in the Delphi study is managing crises and other unexpected external events. Proactively managing uncertainties is increasingly important in a fast-moving and dynamic environment. These events, collectively referred to as ‘critical events’, have a significant impact on working conditions. Additionally, resources, the ability to improvise, the capacity for organizational learning, and the managerial ability to manage potential conflicting interests are needed when facing critical events and still achieving improvements and sustainability over time. Successfully managing crises and extreme external events demands that companies increase their resilient ability related to radical and unexpected changes, or as one of the study participants says:

We have to be able to get back on our feet as quickly as possible.

There are obstacles in how to deal with a crisis and drastic events that bring increased uncertainty. For example, the relationship between resilience and sustainability can be seen in two ways:

It is exciting to explore whether resilient companies are more or less sustainable. The tension between redundancy and efficiency is interesting. Do you choose one or the other? For example, when you build double production lines, you must build also double energy supply systems to be prepared for the worst.

The problem is that companies have tried to become lean and agile to change faster during a more extended period. This trend has removed much of the redundancy needed to build resilience. Another challenge is related to dependence on the global supply chains:

Many industries are very internationalized which means it is dependent on the supply chains that are in different countries.

This has made many companies vulnerable:

Before, one could choose among many different local suppliers in Sweden, but due to consolidation and globalization of supply chains, they have become much more vulnerable, and our choice of suppliers is limited.

Driving and contributing to the green industrial transformation

The third challenge focuses on driving and contributing to the green industrial transformation. This involves managing issues related to preparing the organization for a fast-changing environment, modifying and adapting workplaces and production systems, integrating new or modified products into rebuilt production systems, and incorporating sustainability into daily operations:

So, in an organization, what does electrification mean then? It is something we are building as we go along. It is like building a bridge while we at the same time are walking... no... speedily running on it. It is also not always that simple. And I know what it is like when you attend a course/.../It is often a proven, known competence that you do a course on. However, this new domain requires new knowledge.

One challenge revealed in the study concerning how to drive the green industrial transformation successfully is integrating new environmentally friendly products and a new or rebuilt production system. Another challenge is to find ways to change the mindset of employees and integrate environmental sustainability into everyday work routines and processes for continuous improvement:

I think our capacity to do that is still very low. We are talking about CO2 emissions but what does that mean for each employee? What can each of us do to have an impact in the everyday work? The first step would be to even understand how we can improve our mindset before we can change our behaviors, so we have a long journey to take.

Additionally, working with environmental sustainability calls for new competence:

To work in climate-smart ways creates higher demands and new competence from employees responsible for designing processes and products so that they are not only as cheap as possible but also as sustainable as possible.

This demands that future organizations be prepared for different workplaces and production systems in the design and early development phases of production systems. It also calls for resource-efficient sustainability solutions and a long-term perspective on return on investment (ROI) that enables those solutions. What is often a hindrance is that price is still a decisive factor.

Our customers always talk about sustainability, but when it comes to daily decisions when procurement people call us, the main factor is still the price.

Facilitating employee-driven innovation and organizational learning

The fourth challenge concerns increasing employee-driven innovation, product and production development innovation, and building learning organizations at a rapid pace of change. In the study, employee-driven innovation and a culture for learning were identified as key challenges and priorities for creating a sustainable industry. At the core of these challenges is how companies can build innovation capability that makes them better at continuous learning and harnessing employees' creativity. This will result in increased agility and innovation in products, in production processes, in business models or elsewhere:

One can never be fully prepared for the changes to come. The only way to prepare for them is to develop agility that demands high innovation capability in terms of finding new ways to use innovative technologies, and financial solutions, developing innovative commercial products and services, or finding new business models to overcome and survive future challenges.

So, to get there, the potential of all people in the company is crucial to developing innovation as a core competence distributed across the company. This demands a high level of openness to changes, continuous learning, and innovation. As one of the participants in the study reflects:

It is a lot about the people at our company, they have a key role. We can buy new technology but if people are not on their toes and ready to learn how to use it and run in a completely new direction fast, we will not be able to stay competitive.

Bottom-up innovation driven by employees is closely related to building a learning culture and an organization where companies put conscious effort in developing strategies for learning and continuous development of employees:

I think we have a good structure that enables personal development, including performance and development review and following up on that, but new employees we recruit expect even more support for their development. They want a more concrete development plan, and they are asking us: how will you help me develop?

These expectations are not hard to understand when one knows there is a need for a significant shift towards the new competence demanded stimulated by the pace of change the industry is facing. For example, the shift from the production of automobile vehicles driven by fossil fuels to electric vehicles demands a lot of new knowledge and innovation:

I think our biggest challenge is systematically creating space for learning and reflection as a culture for learning. This way, we would have time to reflect on what we did, what is happening around us, and what we are learning from it. This is hard when we have so much pressure in the organization and much to do.

Attracting, developing, and retaining employees with the right skills

The fifth challenge is attracting, recruiting, and retaining employees with the necessary competence. This challenge encompasses addressing the lack of core competence in emerging domains, streamlining recruitment and onboarding processes, leveraging innovative technologies in HR practices, and developing existing staff.

The interviews show that the industry experiences problems with finding the right people. One contributor is that many people have started working as low-skilled operators and stayed in the company, hence not possessing the skills needed for the future, e.g. related to green or digital transformation. And the highly skilled people with the right skills are hard to attract and retain:

Almost all of us used to be machine operators and came in straight from the high school. We stayed at the company and developed internally. This is why I tried to recruit more engineers, but they come and question, change some things, and then leave. We have not succeeded to attract and retain them.

Therefore, it is essential to retain and develop existing employees by offering continuous learning opportunities so that employees feel they have development opportunities and do not have to go to another employer. Employee retention and development needs to be adjusted to the different needs of people from various generations, cultures and backgrounds. Organizations need to become better at developing new skills among existing employees and transforming and transferring skills within and between organizations. This will be more likely through global recruiting, which is enabled by digitalization and remote working. Another solution will be shared competence pools that will require more flexible forms of employment:

For example, maintenance work will probably be done remotely in the future because everything will be super connected and digitalized. We will not need maintenance people for every single department. Maybe we can have a pool of maintenance experts supporting several parts of the organization. And we can buy this expertise from outside, for example, from gig workers. Whenever we have a problem, we can connect to them and pay them for solving a specific problem, not on a monthly salary base. But how do we build the compensation policy for this new working method? We are not ready for that yet.

In general, a more strategic approach to attracting talent with future skills will be needed to be at the forefront of upcoming technology development:

We need to work from a strategy the whole time and it is important to identify talented workforce, having a special program for talents so we can find ways to create conditions for competence development that allows us to stay at the forefront of new market and technology trends.

Taking advantage of the opportunities of digitalization

The sixth challenge focuses on taking advantage of the opportunities of digitalization. This need includes utilizing the possibilities of digitalization for advanced decision-making, innovative competence supply management practices, big data analysis and other forms of AI, data security, and managing ownership of data and data ethics.

A key challenge in industrial organizations is being able to keep up with the pace of the transformation of technology and new ways of working. One of the participants in the Delphi study formulated this challenge in the following way:

The current transformation is fast. We don't keep up with the pace.

A foundation for any industrial organization in digitalization lies in its ability to cope with implementing current and emerging Industry 4.0 technologies, such as the Internet of Things (IoT), AI, robotization and machine learning. Developing such capabilities is crucial for industrial organizations to improve their operations by enabling real-time monitoring and analysis of data from various sources. However, technology is necessary but not sufficient. Adopting agile methodologies is also vital for industrial organizations that quickly want to adapt to changing customer needs and market conditions.

Digitalization, robotics, and automation are perceived and listed by different reports as key opportunities for developing next-generation industries and improving sustainability. Unfortunately, the study participants reflect that the industry is still relatively traditional and lagging with robotization and automation:

Almost nothing is robotized in the cable industry. It is mainly hand-labor. We have started to look at robotization, and there is a big potential because we have many production processes that look alike. A bigger challenge will be processes from customer to supplier because they vary a lot. But production processes are relatively standardized, so there is potential there.

Another challenge identified by industry participants in this area is a better utilization of digitalization for advanced decision-making:

In 10 years, we will not be able to recognize our operations anymore because of digital transformation. To give the right information to people that need it in real-time to make smart decisions is the key.

Creating inclusive workplaces and utilizing diversity

The seventh challenge relates to creating inclusive workplaces that utilize diversity. This includes issues related to managing a global company culture, increasing diversity and gender equality and creating autonomy in teams (distributed decision-making to take responsibilities and proactive actions). It also relates to creating conditions for more work in interdisciplinary teams and managing the eventual adverse effects of digitalization on inclusion.

Challenges connected to creating more inclusive and diverse workplaces include difficulties in forming a global company culture, including people at the risk of marginalization, increasing diversity and gender equality, and becoming better at working against silos, strengthening the work in interdisciplinary teams. Inclusion efforts targeting risks of marginalization, for example, because of age, lack of skills, gender, and cultural background, are critical. Digitalization can also create feelings of exclusion for those lacking digital technology skills. More support in areas where discrimination happens is therefore needed. One such area is gender equality:

I'm working on a program for women mentorship which will hopefully help us attract and retain more women. We have hard times retaining women because they often feel a bit alone and still experience a macho culture in some parts of the organization. Understandably, if one is part of minority, one feels excluded.

Increasing diversity and gender equality demands proactive work to attract and retain a more diverse and gender-balanced workforce. Another future challenge related to the inclusion of co-workers who are not traditionally employed but work on demand, like gig workers:

When you will need to work with people that are not part of your team, and you have no responsibility for. How do you create inclusion for gig workers that will come and go? How do you build trust when working with people you have never worked with before? It will be part of the challenge. We will have to work with different people for shorter periods much more.

Organizing competence development

The eighth challenge pertains to organizing competence development. This includes managing issues related to long-term strategies for competence supply and preparing for new reskilling or upskilling needs and strengthening multi-competence within areas such as electrification, circularity, sustainability, digitalization, AI, energy, and transformation ability. An overall aspect of this challenge is the need for both more specialization and broader generic knowledge.

A more structured and strategic approach is needed to organize future competence development, but this can be difficult since things are changing fast, and companies often feel they cannot predict what skills will be needed for the future:

There are a lot of new technologies and skills around data analytics, machine learning, and other types of AI. But it's a very blurry picture of the future and what skills we will need; maybe it will be clearer in some years.

Thinking about the future can also be hard when one is stuck in everyday routines and habitual ways of thinking:

We are so trapped in the daily operations that we lack time for future thinking.

Since what companies are doing today might be different in ten years, this will demand a fast transformation in terms of competence shift, and there is currently a need for a long-term strategy for competence supply management:

Transformation is happening fast now, both in terms of automation and digital ways of working, and we are not up to speed, competence-wise. We have not built an organization and, in general, a structure in our society that would help us manage the challenge of continuous competence development we need to do. There is a big need for transformation.

There is also a need to balance the specialization and general knowledge of employees, which demands an expansion of their roles from narrow job descriptions towards multiple roles and contributions to developing other areas in the company. On top of that, due to the shortage of competence, there is a need for the ability to develop multi-competence among employees by moving between different departments and functions in the organization, filling in the gaps when needed:

I know that in several places, it is expected to be able to move between departments and perform different jobs even if one didn't apply for that specific job. The employees are expected to know several things, which I think is quite demanding because we have very different departments. Even the office workers are expected to do that less often, but anyway, sometimes they must change departments even if they don't want to because we are missing competence.

Collaborating externally to ensure availability of competence

The ninth challenge relates to collaborating with external parties to ensure competence availability. This includes managing issues related to the long lead-time for the educational system to understand and adapt to industrial needs of new skills and collaboration with municipalities, universities, schools, professional education actors, trade unions, and labor market intermediaries.

Collaboration with external parties is seen as important by the participants in the Delphi study. In the interviews, the participants stressed the importance of collaboration with various external parties in ways that supported the companies they represent. One participant formulated it like this:

We want to connect with actors who can help us.

One of the challenges when it comes to collaboration with external partners is to ensure the availability of the right competence:

It is hard to work with high schools if there are such long processes to adjust the competence developed in the educational system to the needs of the industry where things are changing fast. This gap and how you fill it to stay competitive is challenging.

Other challenges and opportunities are seen in closer collaboration with universities and research institutes, mainly where they are closely located to the company sites, but tight collaboration is often missing:

The university has a part of its operations in the same facilities as we do. There are many possibilities for collaboration that we don't take advantage of. We don't have an organization that would be responsible for working with them, which makes it very fragmented and uncoordinated without having an overview of all the shared activities. This is what we want to improve. For example, we co-own a high school and a science park where the university is also present, and we have a formal partnership with the research institutes.

Designing socially sustainable work considering efficiency and good health in a dynamic environment

The tenth challenge relates to designing socially sustainable work that considers efficiency and good health in a dynamic environment. This includes managing issues related to rapid changes and their impact on working conditions (health and safety). Furthermore, there are challenges in creating seamless and cross-functional collaboration across traditional borders, managing structural barriers and achieving working-life balance in a dynamic work environment with increasing pressure. Increased attention to social sustainability dimensions related to work is needed regarding how to support leadership for increased health in new work environments, such creating good conditions for remote working and self-leadership.

A strong culture in which there are enabling structures that encourage employees to help each other and collaborate across functions is perceived as important to create sustainable work conditions:

Having a structure and forums to support each other and create a strong culture is key for sustainability. We cannot get the right balance if we work in silos, so we need more resources to strengthen cross-functional collaboration. It is about creating a feeling that one is not alone, but rather that we are doing things together as a team.

Creating good conditions for remote working and increasing flexible work opportunities were also identified as key factors for socially sustainable work:

The possibility to have the flexibility and work from home creates more calmness among employees and a more sustainable human-centric culture which improves employee performance. It is a win-win situation, and an extra benefit of remote working is less impact on the climate.

Organizing the creation of added value for and with customers and suppliers

The eleventh challenge concerns creating new forms of collaboration with customers and suppliers, including organizational conditions for developing sustainable solutions with partners in the value chain related to balancing cost and quality, localizing production, etc. The challenge is also associated with increased transparency and trustful relations with customers, suppliers, partners, and stakeholders.

To build closer collaboration with customers, one of the participants lifts the importance of yearly strategic meetings with the key customers that have been put aside during the pandemic:

Strategy meetings that we should have with all our bigger customers to understand their future direction haven't happened for almost 2,5 years. This is one of the activities we haven't done that creates the anxiety of just about thinking what happens if we stop doing it. It is a key part of our company's success to meet bigger customers at least once a year for a day or two.

The understanding of and dependence on customers is lifted as a vital issue to consider also when it comes to transitioning to new technological and more sustainable solutions:

We are very dependent on our customers. Therefore, it is very important that we choose the right customers who make the right choices when it comes to sustainability. The question is whether we should phase out those customers that are not meeting our sustainability requirements. We haven't had this discussion yet, but in the future, there might be a shift in customers which will also depend on the pressure from those customers that have higher expectations when it comes to sustainability.

A similar issue comes into play when it comes to the choice of suppliers, which might change based on different future technology and sustainability-related requirements:

It is unclear which will be the best suppliers for us when it comes to new battery solutions, for example. It is not obvious that our current key suppliers will remain that in the future. It is a challenge, trying to understand how to make the best choices today.

The increased importance of local production, both from environmental and social sustainability perspectives, is perceived both as a challenge and as a priority, and larger companies are identified as those who should take most of the responsibility to work towards it:

The big companies should take more responsibility for developing local supply chains. I believe in local production, both thinking of sustainability and social aspects. Taking more responsibility for the development on the local and regional levels demands more resources to enable subsidized life-long learning and competence development for smaller companies.

Systematically driving continuous improvement in parallel with long term development

The twelfth challenge includes managing issues related to increasing autonomy within teams, driving short – and long-term development work in parallel, and persevering despite time pressure. New forms of cooperation for development work across functional and traditional borders are needed, where the collaboration among parties is solution-oriented towards mutual long-term purposes. Furthermore, there is a need to operationalize and integrate environmental aspects in continuous improvement work.

One of the challenges in strengthening systematic continuous improvement is to increase autonomy within the teams and move towards a less hierarchical organization that raises a broad involvement in improvement and development work. Alongside digitalization, this increases the possibility of well-grounded decisions, information transparency and sharing, and avoidance of suboptimization:

Decisions must be made where things happen by those who know the operations, machines and processes, without losing the time to go up in the hierarchy. Teams need to have higher autonomy, the competence and mandate to take decisions. This is a big question for us, and it is connected to digitalization which has created an opportunity to share information more. This can speed up our processes and support our continuous improvement.

Another challenge is to increase the sharing of knowledge, learning and improvements across different parts of a company:

In our improvement work we always have revisions about how we work with different improvements and then there is a question of how have other parts of organization done it? Have we shared this knowledge across organization to scale up the learnings?/.../Often people say: 'of course we should share what we have learned' but in the end we don't do it.

Due to the high speed of change, study participants see considerable importance in bringing more 'environmental and green issues' into continuous improvement work to keep developing and improving in parallel with the more long-term development:

We can't stop, we have to keep getting better.

Developing leadership that create better opportunities for a climate-neutral footprint and competitive industry with good working conditions

The thirteenth challenge includes issues related to developing new leadership, such as leading in a fast-changing pace of transformation and remotely in hybrid workplaces. Strengthening leadership support for long-term development work and adapting leadership to different individual needs is necessary.

Developing leadership to adjust to future needs is a critical challenge highlighted in the interviews. It involves training leaders to lead in a fast-changing environment and to integrate sustainability issues into their leadership. One of the problems is that managers are often stuck in the 'here and now' state and old habits, focusing on short-term deliveries. This makes it hard to have a more long-term sustainability perspective and allow it to influence leadership practices:

Many leaders in our organization do not feel confident engaging with uncertainty – things unknown to them. Because they are used to know and have the answers. There is the fear of uncertainty and this feeling of 'I have worked like this for 20 years, so I know how things should be done.' It is hard to admit that everything we know is not valid anymore. Furthermore, there is also a low willingness to take risks, especially because we've been so focused on deliveries and results. Everything here is very much controlled and measured because we need to deliver the right products to the customers at the right time, in quantity and quality. So more daring leadership is a challenge for us.

Another challenge is moving away from the idea that managers need to be experts towards leadership focused on enabling people:

We are coming to a point where employees are getting new knowledge that the managers have no clue about. This demands a very different kind of leadership style. As a leader, you will no longer be on top of everything. You will really need to be a leader of people and not a process leader. I think that is a challenge in a traditional organization where many managers used to be the experts and can block our growth because of their fear of not knowing.

A part of this people-focused leadership is the need for leaders to develop dialogue competence with their colleagues on a deeper level, encouraging people to bring their whole selves to work:

One key leadership competence we need to develop is dialogue. To move from directing towards leaders having a dialogue with their colleagues to really reach them and listen to them. To make them feel safe so they can share their feelings, ideas, and how their role will change. Understand their needs and what you can do as a manager to support them in developing their potential. This is the only way we can change something in our organization.

A big question is also what kind of leadership is needed to ensure social sustainability and prevent people from wearing out when there is high stress and workload:

We need to prioritize the well-being of workers and a work-life balance. It is not ok to press people to work more and more, which happened during the pandemic. Leadership is very important here, helping colleagues prioritize, have time for development and find long-term sustainability in their roles.

Another aspect is adapting leadership to different needs, which also vary between generations, stages of life or career positions:

Younger generations expect another type of leadership which can create tensions since we who are older have another view of how one should behave in the workplace. It is a challenge for managers to meet and balance the needs of different generations.

Moreover, a significant change that creates new demands from managers is leading remote workers and leading in hybrid workplaces where part of the team is on-site, and part of the team works remotely:

We will have more demand for remote working, which craves another type of leadership. If you work in IT support, for example, you don't have to be on-site. You can sit elsewhere, so how do we adjust leadership to that?

Transforming research- and policy-based knowledge into practice

The fourteenth challenge includes managing issues related to utilizing research results in workplace practice and overcoming the knowledge transfer problem, i.e. the 'knowing versus doing' gap. Furthermore, challenges are related to developing consensus and a shared understanding of elements/terms/concepts related to sustainability. The challenges that need to be addressed here are to become better at transforming theory and policy into practice and thereby bridging the knowing-doing gap:

There is a lot of knowledge that we don't use in practice.

The question is also when the technology transfer from research to industry should take place, as one of the interviewees exemplifies:

There is a lot of exciting research within 3D-printing technology. Therefore, professional education institutions say: 'Let's train 3D-technicians', which is completely right, and there is also interest from young people. But then we get

the question of where the 3D printers in the industry are today where we could do the on-job training. And there aren't many yet, apart from some for prototyping. So, when should we start educating people in this area? That's the tough question of innovating production. It's easy to do small-scale experiments but hard to take a proper step forward early enough.

Regarding sustainability, companies experience a lack of collective understanding and consensus around key concepts and terminology:

I think the green transformation, environmental and social sustainability, etcetera, there is a lot of buzzwords and concepts around them, so I think the first step is to define what we mean by all those terms and concepts.

Another challenge is that even though sustainability concepts might have reached strategies and policies, in practice, sustainability work is still more often reactive than proactive:

The word sustainable is very trendy now, and we use it in many contexts. I think we have become better at it, but I don't think we always really do it in practice. I think we often forget about the sustainability perspective in practice, and our work is often very reactive.

Priorities and gaps

In the survey study, the Delphi study's panel prioritized the 14 thematic areas in two dimensions: importance and ability. Importance is related to how important a particular area is for the panel member's organization to increase knowledge to better contribute to a sustainable industry within ten years. Ability refers to the panel members' view of their organization's current ability to address this challenge. The data set was combined into a priority matrix (Figure 2).

The priority matrix shows that all except one challenge ('Research and policy-based knowledge') are grouped in a broad cluster. The range of importance for challenges is from 'Research and policy-based knowledge' (mean value = 5.15) to 'Employee-driven innovation and organizational learning' (mean value = 6.46). The ability concerning various challenges ranges from 'Attract, develop, and retain employees' (mean value = 3.84) to 'Manage crisis' (mean value = 4.92).

Further, the matrix also shows that the challenges at the upper and left parts are the ones that have the most considerable potential if abilities in the organizations are improved, as they are considered highly important. Still the organizations have a lower ability to address them. The panel members were further asked to prioritize the five most important challenges. This procedure forced them to judge the relative difference between challenges (as compared to the individual judgement of challenges on a scale from 1 to 7). This analysis shows that half of the panel (7 out of 13) had 'Green industrial transformation' on their priority list. Almost half of the panel (6 out of 13) prioritize 'Attract, develop, and retain employees' together with 'Organize for competence development'. Generally, the analysis shows that

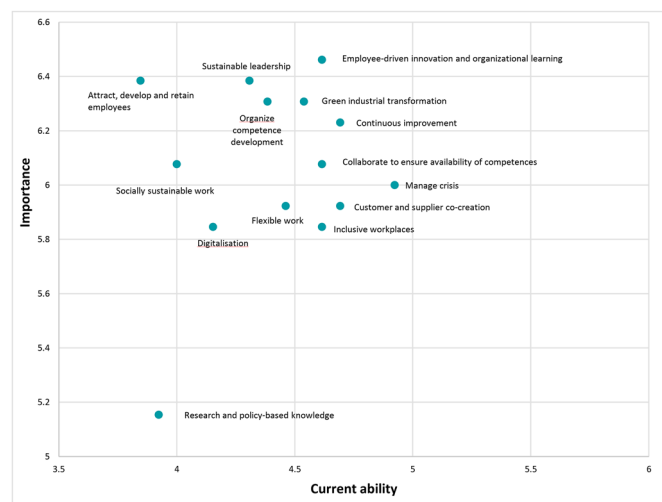


Figure 2. Priority matrix for ability and importance of the 14 challenges.

there is not one challenge the panel members believe is the most important. Instead, it points to the fact that many identified challenges are intrinsic and essential for creating a sustainable industry, where some challenges are also perceived as intertwined.

Synthesis and discussion

In this section, we will synthesize the findings to suggest an agenda for future research to address these challenges and support the growth and development of a socially responsible, competitive, and environmentally friendly industry. The challenges can be related to five themes to give a better overview; however, some challenges are related more than one theme (Figure 3).

These themes serve as a base for ten suggested research propositions. In the agenda, we also recognize the potential for currently unknown challenges to arise. Therefore, in Figure 3, there is an opening for ‘future challenges’.

Theme A: innovative competence supply management practices

Theme A comprises innovative ways of working with organizational competence supply management. Competence supply management refers to activities that aim to satisfy an organization with competence in a long-term perspective, including attracting, recruiting, onboarding, retaining, and developing employees who possess the right competence based on the organization’s current and future needs (Wallo et al., 2016). The Delphi study showed that competence supply management is one of the most critical issues and the area that the representatives of participating organizations feel is most difficult to address. How can organizations work innovatively with competence supply management to combat the skills shortage standing in the way of a resilient and sustainable industry? There is currently access to tools based on AI, robot process automation, and machine learning, which potentially can change the daily competence supply management practices in organizations. Areas potentially suitable for automation include staffing, recruitment, introduction, employee engagement, payroll management, administration and systematic work environment management (Anagnoste, 2017; Balasundaram & Venkatagiri, 2020; Burnett & Lisk, 2019).

Moreover, given that external recruitment may not adequately meet future competence demands, it is essential to allocate internal resources towards competence development and continuous learning initiatives. These efforts aim to reskill and upskill existing employees, enhancing employee-driven innovation opportunities. In this context, the role of learning-oriented leadership by managers within organizations becomes crucial. Such leadership directly and indirectly supports an adaptive and developmental environment for workplace learning (Wallo et al., 2024).

By the above arguments, we propose the following:

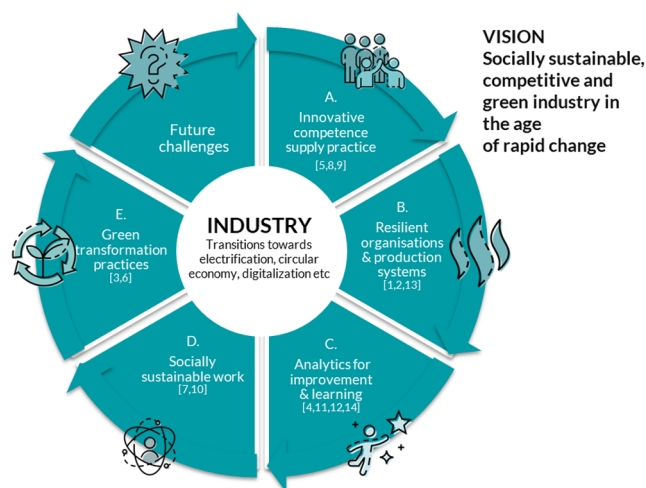


Figure 3. Gaps between importance and current abilities (numbers in parentheses refers to the challenges clustered under each theme).

Proposition 1: To maintain sustainability in competence supply management, the industry needs to continuously monitor and review the supply and demand of competence and adjust their strategies accordingly. It also requires long-term thinking and investment rather than short-term solutions that can lead to a lack of stability.

Proposition 2: The transformation to sustainable industry requires the utilization of new technology that can streamline and improve the efficiency of competence supply management practices.

Proposition 3: Internal competence development and continuous learning initiatives significantly impact the reskilling and upskilling of existing employees, thereby enhancing their capacity for innovation within the organization.

Future research is required on how HR specialists' and operations managers' work and competence are affected by the increased presence of digital technology in competence supply management practices. Future studies should also address what factors drive effective and sustainable competence supply management that meets the needs of green transition in an increasingly digitalized world. Future research investigating the impact of managers' leadership is also required.

Theme B: resilient organizations and production systems

Theme B focuses on successfully managing crises and drastic external events by building resilient performance (Degerman, 2021), and production systems consistent with the Industry 5.0 paradigm, which emphasizes sustainability, resilience, and human-centricity in industrial development processes. Manufacturing companies must include resilience and sustainability perspectives in their agendas, where production innovations, integrated work processes, and new competence are essential (Säfsten et al., 2022).

To address challenges related to needed resilience, a holistic understanding and cross-collaboration are essential to avoid locked structures and rigid solutions that counteract the possibility of developing resilient and sustainable production systems. Moreover, to address the different aspects of sustainability (including both environmental, economic, and social factors), a system perspective that includes technology, people, and organization is necessary (Alayón et al., 2022), especially focusing on the shared purpose of the organization as this 'positively impacts organizational resilience, [and] the latter brings the organizational ability to continue to deliver competitive sustainability performance' (Florez-Jimenez et al., 2024, p. 30).

Following the above reasoning, we propose the following propositions:

Proposition 4: The ability to perform resiliently, i.e. absorb disruption and recover with minimal effort, requires an organizational ability to adopt a system perspective and develop a comprehensive understanding of enablers and barriers for sustainability.

Proposition 5: Increased resilience capability and sustainability in organizations and production systems depend on integrating technological aspects such as digitalization and automated work processes with a human-centered approach and sustainable resource usage.

Additional research is needed to understand what characterizes resilient and sustainable systems in different industrial contexts and levels. Furthermore, further research is needed to understand the challenges organizations face in developing resilience and supporting sustainability while effectively managing eventual contradicting demands, competence development, and organizational learning in change and development processes.

Theme C: analytics for improvement and learning

Theme C focuses on building organization for learning, continuous improvement, and innovation. Analytics for improvement and learning refers systematically using data and statistical analysis to gain insights and drive continuous improvements in an organization (Davenport, 2013). The goal is to make data-driven decisions that lead to enhanced performance, increased efficiency, and continuous learning (Elg, 2022). This approach typically involves defining performance metrics and key performance

indicators (KPIs) (Neely et al., 1995). Data is collected and analyzed to monitor the performance of these KPIs and, through the application of quality management, identify trends and opportunities for improvement (Gremyr et al., 2020).

Building on this rationale and the challenges outlined by organizational representatives in the Delphi study, we suggest the following propositions:

Proposition 6: Effective use of analytics requires a systematic approach, including the use of quality management techniques, to continuously improve performance and drive growth.

Proposition 7: When organizing analytics for improvement and learning in organizations, the distinction between measurements and data used for control and follow-up purposes and those used to support improvement and learning is crucial.

Further research is needed to understand how organizations can effectively involve employees in continuous improvements and learning when integrating analytics into business processes and decision-making systems. A particular area is to explore how organizations use predictive analytics in competence supply management, especially in attracting and retaining employees. Furthermore, there is a need to understand how organizations can utilize machine learning and AI to automate processes, improve operational efficiency, and understand the social consequences of this development.

Theme D: socially sustainable work

Theme D concerns creating an inclusive and sustainable place of work in a fast-moving environment, which is crucial for success in the Industry 4.0 and 5.0 paradigms (European Commission, 2021a; Pinzone et al., 2020). The green transition will require a workplace where employees can handle increased complexity, parallel changes, and uncertainties (Harlin et al., 2022). As raised in the so-called Operator 4.0 vision, future smart factories are increasingly suited for workers with different skills, capabilities, and preferences (Kaasinen et al., 2020). Utilizing diversity by creating teams and development projects with representatives from different backgrounds, functions, disciplines, ages, genders can provide possibilities for an increased holistic understanding of the assigned tasks and performance areas. If adequately managed, diversity can potentially improve organizational productivity and competitiveness (Sharma, 2016). Thus, managerial development is required to support renewal ability and create conditions for workplace innovations in parallel with daily operations.

One of the priorities in the EU Strategic Framework on Health and Safety at Work for 2021–2027 is anticipating and managing change, given the green and digital transition, demographic challenges, and incipient competence shortage (European Commission, 2021b).

Proposition 8: Systematic occupational health and safety management (SOHSM) needs to focus not only on a preventive health perspective (i.e. avoiding risks and hazards at work) but also on promotive aspects such as how work is organized, the type of job demands and job resources available, and opportunities for learning and competence development.

Research is needed to develop managerial support to strengthen and integrate diverse perspectives, create autonomy in teams and cross-disciplinary teamwork, bridge barriers, and utilize emerging technologies beneficial for individual work and organizational flexibility. Additionally, studies must address the impact of green and digital transitions on competence supply management and employee health maintenance.

Theme E: green transformation practices

Theme E relates to successfully driving and contributing to the green industrial transformation and leveraging technology opportunities. Moving towards a sustainable industry requires an integrated focus on ecological, economic, and social sustainability. In creating such focus, it is critical to integrate sustainability considerations into a firm's daily operations and practices (Luttrupp & Lagerstedt, 2006; Maxwell & van der Vorst, 2003). Such integration prevents it from being a separate consideration exposed to the chance of being down-prioritized, e.g. in decision-making (Waage, 2007) involving trade-offs between performance and sustainability.

With the support of technology (Philbeck & Davis, 2018), organizations need to develop capabilities and practices that support green transformation. Besides coping with the technology and the output data per se, the vast amount of data generated also requires new roles, practices and processes to enable an organization to respond to and create value from the data (Gremyr et al., 2022).

Regarding green transformation practices, two propositions are offered:

Proposition 9: Technology, in particular digitalization, is a key to enabling green transformation practices and a more sustainable industry. Therefore, capabilities and abilities to support Industry 4.0 technologies are crucial for organizations to exploit technical possibilities.

Proposition 10: To exploit the technical possibilities and realize their potential support of sustainable development, organizations must also create trustful, innovative, structured collaborations and organize continuous integration of green transformation practices.

Additional research is required to understand the role of *integration* of green transformation practices in organizations. For instance, it is important to consider how actors can collaborate with each other to support green transformation practices in the supply chain. It is also crucial to integrate green transformation practices into management processes. Moreover, we need to understand the requirements for integrating Industry 4.0 technologies into industrial practices that support a green transformation.

Conclusions and implications for practice

The results of the Delphi study have pinpointed critical areas of concern and priority for future research through a systematic and iterative process. The themes presented in the paper provide a roadmap for future research areas that will support the growth and development of a socially responsible, competitive, and environmentally friendly industry. The move towards sustainable and green business models and increased digital integration necessitates workforce resilience, competence, and socially sustainable working conditions. Entrepreneurial spirit, strong relationships, solution-oriented development, and transparency across the value network are vital in a circular economy. Key enablers to achieve a sustainable industry in this environment include organizational resilience, knowledge management, and a socially sustainable working environment, securing a competent workforce.

Concerning practical implications, a critical prerequisite for successfully fostering the competence supply essential for the sustainable transformation of the industry lies in the collaborative ecosystem of organizations within the labor market (cf. Singh & Rahman, 2021). This ecosystem encompasses diverse sectors, including industry, public sector organizations, trade unions, and universities, which are imperative for developing the knowledge and expertise required to drive this transformation. As companies are integral to a broader community, a collective responsibility is to forge the knowledge base necessary for transitioning to a green, sustainable, and digitally advanced working life. This collaborative approach aligns with the triple helix model, emphasizing the synergistic partnership between these sectors to cultivate a dynamic and sustainable innovation system that promotes economic growth alongside social development.

To further strengthen the practical implications of our research, we recommend that policymakers introduce and support initiatives designed to facilitate cross-sector collaboration. This may include financial incentives for sustainable innovation projects, regulatory frameworks encouraging green practices, and platforms enhancing knowledge sharing between academia, industry, and public entities. By implementing such measures, policymakers can significantly accelerate the industry's shift towards sustainability and digitalization.

An implication for organizations within the collaborative ecosystem is to monitor the ongoing shifts in global labor markets and breakthroughs in green technology to anticipate changes and adapt their strategies to meet the challenges and opportunities that lie ahead.

Authors' contributions

This article represents a collaborative effort among all listed authors, each of whom has significantly contributed to the successful completion of this work. The conception and design of the study were led by Wallo, Martin, Elg, Harlin, Bozic, Williamsson, and Skagert. Martin, Elg, Wallo, Harlin, and Bozic handled the analysis and interpretation

of data. The manuscript was drafted by Wallo, Martin, Elg, Gremyr, Harlin, Bozic, Williamsson, and Skagert. Every author has critically revised the manuscript for important intellectual content, ensuring the integrity and accuracy of the work. Additionally, all authors have given their final approval of the version to be published, signifying their collective responsibility and endorsement of the content presented.

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There are no financial or non-financial competing interests to report.

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Data available on request from the authors.

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