Challenges in Providing Industry with Skills for the Green Transition at the Right Pace

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Abstract

The manufacturing industry is undergoing a significant transformation, characterised by a green transition and rapid digitalisation. Technological advances have dominated Industry 4.0, whereas the transition to Industry 5.0 emphasises improving technology from a human-centric lens. This necessitates focusing on digital and green skills development to accelerate the green transition in industry. Within the context of Swedish higher vocational education (HVE), this paper aims to investigate HVE providers' experiences of challenges in providing industry with the skills needed for green transition. Interviews were conducted with 22 representatives of HVE providers collaborating with industry. The analysis is based on a model for analysing overlapping transitioning systems for development of skills for the green transition in industry.

The findings indicate that there was an imbalance in pace between HVE and industry caused by various challenges at three transitional levels. First, at the individual level, there was an imbalance between students', workers', and employers' perspectives on relevant training needs, skills, and engagement in the green transition. Secondly, at the company–HVE provider level, companies needed to keep pace with the programmes and courses offered by the HVE providers and recognise that workers on the shop floor needed to train and learn digital and green skills. Thirdly, the HVE system as a whole was unable to attract and recruit enough students to technical and industrial programmes, whereas the industrial sector did not have sufficient ability to identify emerging jobs which require digital and green skills to accelerate the green transition in industry.

Keywords: Green transition, digital and green skills, higher vocational education, Industry 5.0

Introduction

The manufacturing industry is going through a green transition alongside rapid digitalisation, necessitating strong measures to promote green technologies and innovative solutions in industrial production (Breque et al., 2021). The fourth industrial revolution, known as Industry 4.0 (I 4.0), has significantly impacted the industrial landscape, with emerging technologies like automation, robotics, and artificial intelligence (AI) (Oztemel & Gursev, 2020). While Industry 4.0 has mainly focused on technology advancements, the transition to Industry 5.0 (I 5.0) centres around improving technology through a human-centric lens (Breque et al., 2021; European Commission, 2022; Gupta, 2024). This underscores the critical role of human collaboration with technology in achieving sustainable production processes and accelerating the green transition in industry. Industry 5.0 embraces the twin transitions; emphasising that the digital and green transitions run parallelly and reinforce each other, meaning that digital technology and human skills can be leveraged as catalysts to drive the green transition (Muench et al., 2022; Wang et al., 2024). The green transition is forecasted to create new jobs and employment in sustainable industries such as renewable energy, waste management, and environmental conservation (Bednorz et al., 2022; Oeij et al, 2023). In existing jobs, the impact of the green transition could result in changed work content that will require enhanced skills which are expected to positively affect workers' work (Oeij et al., 2023). However, the concern is that everyone will not be able to benefit from these transition opportunities due to limited access to digital technologies and green innovations (Muench et al., 2022). Therefore, it is argued that it is important to ensure that the digital and green transitions are just and accessible to all (Muench et al., 2022) to mitigate negative employment effects (Sharpe & Martinez-Fernandez, 2021).

It is expected that emerging technologies and a greening approach will lead to unintended consequences that alter workers' work (Bednorz et al., 2022). The risk is that a polarisation may develop between high- and low-skilled green vocations, resulting in both winners and losers. 'Winners' will not only include workers in highly skilled vocations requiring technical and engineering knowledge. Many green vocations may become manual, which could also improve the job market for those with low qualifications (Popp et al., 2021) and for those who have lost their jobs in so-called 'brown industries' (ILO, 2011). There will also be losers—at least temporarily, as low-skilled workers who have more difficulties in taking up training or transitioning to new jobs are at risk (Vandeplas et al., 2022). To mitigate polarisation between workers in low- and high-skilled vocations, there is a consensus in research that transitioning to green jobs will require more extensive on-the-job training efforts in the workplace and more formal vocational education (Consoli et al., 2016).

While the industry's green transition is high on the policy agenda, it is still a quite new theme in vocational education research (Persson Thunqvist et al., 2023). It has been emphasised that vocational education must collaborate with industry to propel digital and green transitions, and vocational education providers have a key role to play in facilitating the provision of required digital and green skills (Persson Thunqvist et al., 2023). A critical problem, however, is that industrial companies' urgent need for digital and green skills does

not align with the vocational education system, as the system has difficulty keeping pace in a time of rapidly increasing green and digital technological advances (Rosenberg et al., 2018). These rapid advances will undoubtedly result in a need for new skills in industry, which is why the topic is at the top of the agenda for vocational education providers. In response to I 4.0 and the shift to I 5.0, vocational education providers have begun to find new ways of attracting students by collaborating with industry and addressing the need to reskill workers (Hong, 2023).

Within the context of Swedish higher vocational education, this paper aims to investigate higher vocational education providers' experiences of challenges in providing industry with the skills needed for the green transition. Although the green transition is prominent in the policy debate, its interpretation and application by different stakeholders remain unclear, and also the pace at which they must provide industry with skills for the green transition. These problems are the starting point of this article from the perspective of higher vocational education providers (henceforth referred to as 'HVE providers'). HVE providers are viewed from their role as contributors to the green transition in industry through education and training. This includes educating students—the workers of tomorrow—as well as training and upskilling workers currently employed in industry to develop the digital and green skills necessary for the green transition in industry.

The paper is organised into four additional sections. The following section outlines the theoretical framework which is based on Rosenberg and Ramsarup's (2020) model for analysing the green transition occurring in both industrial and educational systems, and at different levels within these systems. The next section describes the research method. The subsequent section presents the findings. The last section presents a discussion and thereafter some conclusions.

Theoretical framework

A model presented by Rosenberg and Ramsarup (2020) will be used in the analysis. This model provides a holistic perspective that facilitates the understanding of the complexity surrounding the green transition in industrial companies. This means that industry's green transition is not an isolated occurrence, but is mutually dependent upon, and overlaps with, other green transitions occurring simultaneously and across levels within a larger skill transformation system in which green skills and green jobs are developed (see Figure 1). This implies that the vocational education system itself must undergo a green transition to meet the needs of companies in their transition towards more green jobs (Rosenberg & Ramsarup, 2020). This requires coordination and collaboration between the green transition in industry and the green transition in the vocational education system to address current challenges.
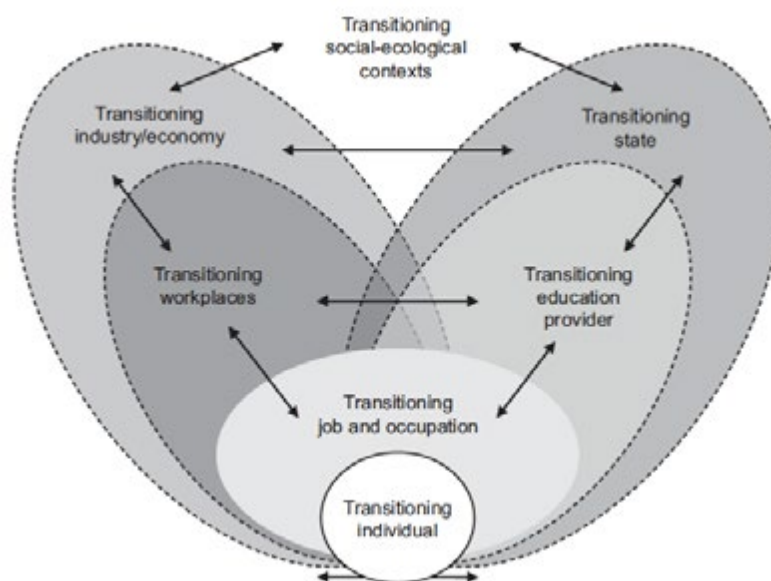
Figure 1. Rosenberg & Ramsarup's (2020, p. 11) model for analysing overlapping transitioning systems for developing green skills. The model is used with the authors' permission.

A criticism raised in the research is, however, that industry and workplaces' green transition and their increasing need for green skills are not aligned with the educational system, creating an imbalance or mismatch in the entire skill transformation ecosystem. While studies, albeit limited, indicate that one explanation for this mismatch is that the vocational education system is unprepared for the emerging demand for green skills development: both within existing vocations and emerging green vocations (Lotz-Sisitka & Ramsarup, 2020). The unpreparedness of the vocational education system can have several causes, but one explanation offered is that many green jobs are still emerging. Therefore, green jobs and tasks are not yet clearly defined or formulated in terms of green skill requirements. Furthermore, the transition from education to work complicates the skill transition, as workplace requirements for green jobs often are new or underdeveloped or even not yet known (Langthaler et al., 2021).

New, underdeveloped, or unknown workplace requirements implies that green jobs are not homogeneous; they vary across industrial branches, companies, and workplaces (ILO, 2011). Therefore, an increasing number of researchers have begun to classify green jobs on a continuum of greenness to demonstrate the variation and diversity of green jobs (Casano, 2019). Casano (2019) argues that the greenness of green jobs determines the type of education and training required, but apart from a few skill-specific exceptions, some green jobs do not differ significantly from non-green jobs. This indicates that most training can take place on-the-job, while other jobs which have a higher level of greenness and digital technology as those emerging alongside the green transition will require more extensive formal education. Formal education measures can be provided as short courses or training programmes on-site or online, but there must also be clear skill development pathways

between formal and informal learning arrangements for the education measures to feel relevant to workers in their daily work (Halvarsson Lundkvist & Gustavsson, 2018).

Other studies (Brown, 2015; ILO, 2011) classify green jobs into the qualifications needed to perform the job, which determines the type of green skills required. These studies divide vocations into the following: (1) existing vocations that will require few or no green skills; (2) transformation of existing vocations in industries that will require green skills; (3) new vocations in industries that will require existing technical skills along with green skills; and (4) emerging new vocations in new and expanding green industries that will require the development of green skills.

Therefore, it is difficult, if not impossible, to identify the need for training without first identifying the types of green jobs, and specifically the green skills workers require. Green jobs require different types of green skills, which has implications for the training efforts industry must undertake to upskill or perhaps reskill their employees to adjust production and work processes to the green transition (Pavlova & Singh, 2022). Despite a plethora of studies that have listed green skills, such as managing water and waste, recycling, conserving energy, and managing raw materials, as well as developing green technologies and solving problems, there is still ambiguity about what should be included, although it is argued that these skills are needed by industry and should be introduced into education (Ibrahim et al., 2020; Mohd Zubir et al., 2021; Nikolajenko-Skarbalė et al., 2021; Sern et al., 2018). A multitude of technical and generic skills have been identified as green skills, and what green skills have in common is that they add value to technical and generic skills by reducing their climate impact (Cledumas et al., 2020; Hamid et al., 2019). Apart from green skills there will be an increased demand for digital skills in the greening of industry. This is because digital solutions, such as automation, robotics, and AI are integral to the acceleration of a greener industry (Muench et al., 2022). There is a wide spectrum of digital skills ranging from basic computer proficiency and the use of technological devices; to aptitude in managing, understanding, and analysing information; to being able to use information proactively; and even expertise in AI, machine learning, and cybersecurity (Fraile et al., 2023; ILO, 2021).

Research context

The research context for this study is postsecondary education known as Higher Vocational Education (HVE). This educational form is publicly funded by the Swedish National Agency for Higher Vocational Education. The agency allocates funds to a range of providers such as municipalities and private companies, which run programmes and courses. Since 2018, HVE has annually expanded their possible intake of students (for description also see Ye et al., 2022) and reached 93,000 available placements in programmes at the beginning of 2023 (MYH, 2024). The programmes (1–2 years in duration) are adapted to the labour market's need for qualified employees, where employability is the main argument for receiving funding for these programmes. The key function of HVE programmes is to prepare students with the

necessary skills for vocations through a combination of theoretical studies and work-based training. HVE in Sweden can serve as an important alternative pathway for individuals seeking to upskill themselves in a vocation or reskill themselves for transition to a new vocation (Ye et al., 2022). Each HVE programme has a steering committee, where employers play a significant role in shaping the content of the programme, but also by providing work-based training. Together with HVE providers, employers bear the responsibility of ensuring that the training aligns with the skills required in working life. In addition to programmes, HVE providers offer shorter-length courses to employers tailored especially for employees to meet employers' specific upskilling and reskilling needs.

Method

Design and selection of participants

The present study is part of a larger research project focussing on skills that matter for workers in Industry 5.0. The article presents a sub-study within this project which employed a qualitative research design based on 20 interviews conducted from May to September 2023 with 22 representatives of HVE providers from different regions in Sweden. Of the 20 HVE providers, 13 were owned by one or more municipalities, 1 university, and 6 private educational companies. Eight of the interviewees were education leaders, meaning that they worked operatively and closely with companies to develop and run one or more HVE programme or courses, 8 were principals or department managers, and 6 interviewees had titles such as strategist, business developer, or were senior managers or owners of educational companies. All selected HVE providers offered programmes in technology and manufacturing. They all had experience collaborating with industrial companies ranging from small and medium-sized enterprises to large companies, in various manufacturing areas.

Data collection

The researchers contacted all 20 HVE providers via email, presented the study's aim, attached an informed consent form, and proposed interview times. If the HVE providers agreed to participate, they chose a time for the interview and provided informed consent by signing the form and returning it. On average, the interviews lasted 60 minutes and were carried out via an online platform but were audio-recorded with a digital recorder which was placed in front of the computer. All researchers carried out interviews, but often an interview was led by one of the researchers while another acted as a listener, asking additional questions as needed. The interview guideline was semi-structured around the following topics: how programmes and courses were adapted to the skills needs of manufacturing companies; the challenges for HVE providers and manufacturing companies in providing the skills needed for industry; skills transitions in manufacturing companies, skills that became less relevant and skills that emerged as a result of technological progress and green transition; the ways and forms in which HVE providers collaborated with representatives of manufacturing companies; the

image and spread of Industry 4.0 and 5.0, and the resulting consequences for future education. When interviewing, the guideline was used as a starting point, but the HVE providers were encouraged to speak freely about their experiences. All interviews were transcribed verbatim.

Data analysis

Data derived from the interviews underwent a thematic analysis inspired by Braun and Clarke (2006), which involved the following stages: identify, discern, and analyse recurring themes. An initial reading of the interview transcripts provided us with an overall picture of the challenges faced by HVE providers. After the reading, an inductively driven coding process was employed to identify recurring themes or patterns of meaning and to discern, categorise, analyse, and ultimately name the challenges identified. The analysis made it apparent that the interviewed HVE providers experienced that they operated under a multitude of challenges stemming from both higher vocational education and manufacturing companies. The challenges identified were divided into three main categories, related to the transitional levels presented in the model in Figure 1.

Findings

This section outlines the main findings of the HVE providers' experiences of challenges in providing the manufacturing industry with the skills needed for digital and green transitions.

Catering different student groups

The HVE providers faced challenges in providing manufacturing companies with skilled workers, both educating students, the workers of the future, and upskilling those already employed in companies with necessary digital and green skills. Therefore, they saw an urgent need to attract more students to technical and industrial education but also provide training to employed workers, in order to supply the industry with the necessary skills. To address this issue, the HVE providers were tasked with designing curricula that would furnish students with the requested skills sought by the labour market while remaining adaptable and responsive to the changing training needs in companies. In developing curricula, the HVE providers found it challenging to reach out to potential students and companies of all sizes, to understand the constantly evolving skills required of workers, which was paramount to be able to offer relevant and flexible programmes and courses.

Another challenge was to attract and cater to the needs of different student groups. The HVE providers emphasised that HVE students are relatively heterogeneous in terms of social background, motivations, life experiences, and motives for applying to and attending HVE, which the HVE providers believed influenced students' decisions to take specific courses, reskill themselves, and to possibly even change jobs. The providers were also required to develop different strategies for lifelong learning with specific skills demanded by employers.

This included guiding students in understanding employers' implicit requirements for social and individual skills that went beyond formal skill requirements for employment. A particular challenge was to increase capacity to broaden recruitment and promote so-called non-traditional vocational paths, especially regarding female students, given that women are still underrepresented in many industrial jobs. Another student group that needed special attention was workers who participated in shorter courses to improve their skills while continuing to work at their current jobs. The HVE providers emphasised that this type of training was dependent on workers' motivation to reskill and employers' willingness to allocate sufficient training time.

> Not everyone who studies in our programmes is unemployed or has nothing to do; many come directly from companies. In the latest round of production technicians, there were probably three or four who were on leave from their companies. This is because they have understood that: "Oh, this is going to be important," or "I need to move on," and they then educate themselves. So, I think that's how it works. Those who can influence change, like the CEO, production manager, and HR manager, understand the challenge in the green transition and in digitalisation. They don't hold off on sending their operators for training because they understand that it is necessary. (IP19)

Sometimes the HVE providers found it difficult to define students' future careers and vocational identities. This issue often arose when the specifics of various vocations were unclear or when new job titles were emerging in the industry. As a result, the HVE providers sometimes had to provide training for vocations not yet fully recognised, resulting in uncertainty about future job roles. They believed that local anchoring in companies of partially new vocational titles, especially in digital and green transitions, could create uncertainty among students as to what vocation they were training for. Even established vocations, such as production technician, were hard to define due to their broad and varied specialisations. The HVE providers recognised that new vocational roles could be perceived differently among students, ranging from practical industrial tasks to high-tech and AI-related duties.

An overall challenge for the HVE providers was to fill courses. Consequently, they could not deliver the skills that the industry demanded, often due to the low attractiveness of industrial jobs. The most common answer by the HVE providers as to why the industry was not considered attractive was that young people had a misguided image of the industry, rooted in notions of factory work as heavy and dirty. Some HVE providers emphasised that manufacturing companies should contribute more to changing this outdated image and develop marketing strategies for this. The HVE providers also had to deal with stereotypes suggesting industrial jobs were mainly for men, making it particularly difficult to recruit female students to technical and industrial programmes. However, they found that efforts towards green and sustainable development in courses could also be a potential strategy for attracting more women to industry by integrating technological development with sustainability and green innovations.

> It is a tremendous opportunity, I would say, for the industry. Integrating technological development with sustainability development will increase equality in these technology-intensive and industrial jobs. (IP4)

These assumptions were also partly based on experiences or hopes among the HVE providers that female students were engaged in sustainability issues to a relatively high degree.

Broad, deep, and innovative education

A prominent challenge for the HVE providers was balancing breadth, depth, and long-term perspectives in technical and industrial programmes, while also being agile enough to quickly address urgent skill needs in companies, as they arise. The analysis shows that sustainability influenced HVE providers' development of programmes and courses. This was partly due to the requirement from the Swedish National Agency for Higher Vocational Education that the programmes and courses should be adapted to the goals outlined in Agenda 2030. The HVE providers revealed various ways of referring to and approaching these formal instructions, sometimes in the form of a mandatory element that had to be incorporated into curricula and courses, and other times as a more deliberate strategy to attract students and improve their learning. The latter was expressed in initiatives aimed at a specific industry or a certain technology such as wind power, solar panels, or green electricity. The HVE providers often tried to combine broad training with new technical skills, which was a challenging endeavour. For instance, they developed innovative titles for their programmes and courses to signal the breadth, but at the same time, employed specific phrases to attract students with the uniqueness of the programmes and courses they were offering, such as 'Automation and digitalisation engineer' and 'Automation and robot engineer within Industry 4.0':

> The title is 'Automation and robot engineer within Industry 4.0' to include the whole name, so with that education we want the students to have a good platform to stand on, we don't want to direct them too narrowly. Even though it could be narrow in some operator educations, we want them to be able to pick the parts they find fun, under the umbrella of automation and robots. So that they can come out and be technicians, they can come out and be automation engineers, it depends a little on their level of ambition. (IP11)

With the development of programmes and courses towards new technology and sustainability, more challenges followed. The rapid pace of technological development required the purchase of expensive machinery and equipment for adequate vocational training. However, it was sometimes not possible to invest in new machines for the HVE providers due to financial constraints, especially for short courses. Finding educators with expertise in new technology and sustainability for courses was also a major challenge, as these courses were at the technological forefront. They also had to consider that some companies were unable to take advantage of cutting-edge technology courses due to

outdated equipment, which meant that the HVE providers also had to keep older equipment on hand. Demands and expectations from companies to rapidly train personnel could entail provisional solutions that were less well-founded. A strategy among the HVE providers was to have a basic concept for a certain type of course and supplement it with training modules that enabled flexibility. The challenge was to act swiftly in providing the courses to employers. Aside from conveying employers' requests for more courses that reskilled workers in digital and green skills, the HVE providers also considered the perspectives of students regarding how the programmes and courses could prepare them for a future vocation.

According to the HVE providers, assigning a few course credits in sustainability could facilitate getting an application for funding approved. One dilemma was, however, that if the integration of new technology and sustainability into courses was only perceived as decorative, rather than substantial, in nature. This was particularly the case when a few credits related to eco-friendly technology were added into a course without substantial changes.

> We've included a sustainability course, a specific sustainability course, in that programme that we didn't have before, and tweaked it a bit to make the credits align more explicitly. (IP26)

In the interviews, different approaches to the climate crisis emerged in the discussion of education focused on green transition. While several HVE providers passionately advocated for climate-smart developments in programmes and courses adapted to industry, it was also noted that some mentioned climate issues more casually, as a trend of the time.

Green transition as investment, duty, and marketing

Industry 5.0 and its focus on the digital and green transitions is very recent, or even still in the development and maturation stage in Swedish manufacturing companies. The HVE providers emphasised that the companies' challenges also became their problems. At a societal and organisational level, the primary challenge for companies was to ensure demand for skills and to increase industry's attractiveness. The HVE providers stated that many companies reported difficulties finding skilled workers. Significant numbers of retirements occurred at the same time that too few young people were attracted to industrial work. Companies demanded programmes and courses that were unique to their needs and students with skills that could directly enter production and fill companies' skill gaps. For example, the need for skills in energy and electricity emerged as particularly critical issues, as there was a significant shortage of expertise in these areas, ranging from electricians to electrical engineers. The issue of inadequate competence supply was also discussed by the HVE providers, as a technological transition required reskilling and upskilling staff on a large scale.

When providing education and allocating students to small businesses, the HVE providers had to consider their financial circumstances. They believed that if smaller companies did not adapt their operations to the green transition, small companies could risk not accessing

suitable courses or losing skilled labour to other companies. Among larger companies, more skills were needed to adjust to the climate crisis, entailing some form of green transition, considered necessary to remain profitable and survive competition. The HVE providers' experiences were that large companies often relied on their own in-house training, while expressing that the educational system did not deliver what skills they needed.

> Time and again, they express disappointment with the educational system for not delivering what they need without being actively involved themselves. Because, in a way, it's about selling and storytelling, making those people, especially young people, curious and eager to be part of their organisation. But I feel they [the companies] have failed miserably at this. It's like expecting someone else to fix it. (IP3)

The intense competition among manufacturing companies for labour, particularly in shortage occupations, also indicated a shift in the balance of power between companies and workers. The HVE providers had noted that when there was a high demand for labour, workers could make greater demands of their employers, but also that students had a wide range of employers and offerings to choose from. This involved not only salary, but also various values such as healthy workplaces, self-fulfilment, and flexible work hours. The HVE providers' experiences were that companies' motives for investing in green transition within production could coincide with external expectations and demands and therefore be seen as a duty but also as part of marketing and self-presentation. Motives could be to invest in the green transition to appear credible to customers and to build up a company's brand, but also, in a broader sense, to demonstrate responsibility based on interest in the climate. Challenges faced by companies could also be seen by the HVE providers in the context of the structural transformation of industry jobs following the movement towards Industry 4.0 and Industry 5.0. The HVE providers emphasised that this transformation required increased awareness among companies that workers had to develop many new digital and green skills. Some HVE providers saw a significant challenge for companies due to a radical shift in which the technological focus had to be balanced more with a social and just transition perspective on workers' jobs on the shop floor in companies. In the future, some HVE providers believed that automation, digitalisation, and artificial intelligence would eliminate many industrial jobs. Other jobs like operators would be transformed and have a broad theoretical foundation, while the need of craft skills would remain strong. At the same time, new occupations were expected to emerge. In response to industry's green transition and digitalisation, the HVE providers mentioned innovative programmes and courses in the making. It was programmes and courses for which funds were sought that dealt with new occupational titles that were not yet known, and whose educational content could sometimes be difficult to determine.

Discussion

The insights gathered from the interviews with the HVE providers unanimously convey that a green transition and rapid digitalisation are regarded as essential for Swedish manufacturing companies. In the transitioning process, the nature of work changes, and students (future workers) and current workers must develop digital and green skills to keep up to date with new technologies and green innovations. This will entail a massive demand for relevant skills within various industries. At the same time, there is uncertainty among HVE providers and companies about what type of programmes and courses would be most relevant for the industry to be able to address present and future skills needs. Additionally, our findings indicate that companies may find it difficult to determine which type of training suits the short and long-term skills requirements that will enable their green transition.

The multi-layered model (Rosenberg & Ramsarup, 2020) presented in Figure 1 serves as an analytical lens to further approach and discern challenges within the overlapping transitioning systems that exist in a larger skill transformation ecosystem aimed at providing industry with appropriate skills for the green transition. The findings illustrate that the green transitioning underway at different levels (Figure 1) is clearly not keeping the same pace and the green transition can thus be seen as unbalanced (Rosenberg & Ramsarup, 2020). The imbalance or difference in pace between the HVE system and industry can be caused by various challenges that manifest themselves differently within the two systems and at different levels.

The transitioning individuals

The HVE providers faced the challenge of managing two distinct groups, students (tomorrows worker) and workers, on parallel training pathways. This required different strategies, adding complexity to the training process. On the one hand, they had to attract and train students in technical and industrial programmes and courses. On the other hand, they provided training to workers based on the employer's terms and circumstances. The training aimed to enhance individuals' chances of gaining a stronger position in the labour market, as well as facilitating the transition to new tasks and jobs for those already employed in industry. This means that the training must be relevant not only for current job roles but also for future ones that may arise in response to the green transition (Casano, 2019).

By offering alternative training paths, the HVE providers demonstrated a high level of awareness about the value digital and green skills could bring for students and workers. However, the HVE providers believed that the success of the green transition at the individual level was largely dependent on the motives and driving forces behind individuals' decisions to take a course or to reskill and possibly even to change jobs. This means that individual willingness and motivation were crucial conditions in the green transition. Nevertheless, the findings showed that the HVE providers' experiences of sometimes unclear skill requirements made it challenging for them to decide which skills individuals should acquire to meet the needs of industry. While some training paths had clear requirements for digital and green

skills, others might not be as clear, because technological advances were driving the emergence of new jobs (Brown, 2015; ILO, 2011). Due to this, the HVE providers faced difficulties in keeping pace in providing training to students and workers for new job titles and roles that were not yet fully developed. Such rapid change required continuous adaptation to industry and flexibility from the HVE providers to navigate these challenges and contribute to the green transition.

Transitioning at company and educational level

The transitioning at company and educational level necessitated delivery of tailored programmes and courses to adapt to evolving job roles and tasks in workplaces and companies. In these tailored offerings, the HVE providers faced pressure to incorporate sustainable and technological solutions. These solutions were pivotal in facilitating the industry's shift toward digitisation and green transition, and in equipping workers with the skills required for change in companies. Notably, digitised and green jobs and skills were not progressing uniformly across all companies. Small, medium, and large companies differed in their requirements for skill development. Therefore, the HVE providers recognised the need to adopt to individual company specific skill development needs. Consequently, when developing programmes and courses, they had to consider the specific conditions of each workplace and company to ensure the transition to digital and green practices.

While HVE providers played a critical role in providing courses adapted to digital and green transitions, they were not the only players who needed to keep pace with the skills needed in industry. According to the HVE providers, companies faced challenges keeping up with evolving skill requirements. The HVE providers experienced that companies needed to recognise that workers on the shop floor had to be prepared to learn and train in a range of digital and green skills that would be required as the green transition accelerated (Oeij et al., 2023). This meant that companies had difficulties keeping pace with the programmes and courses offered by the HVE providers. For example, there could be a mismatch between innovative courses with high-tech and green foci offered by HVE providers, and the skills needed by companies. Due to outdated machinery and insufficient adaptation to the green transition, some companies were unable to benefit from innovative courses offered by the HVE providers.

As the companies had difficulty anticipating skill needs and requesting tailored courses, the HVE providers often found themselves in reactive mode, swiftly training workers when urgent skill development was necessary in companies. Therefore, the HVE providers believed that companies would benefit from adopting a more proactive stance, anticipating skill needs aligned with digital and green trends. This implies that it is not only the HVE providers' responsibility to pick up the pace. To do so they needed help from companies that are searching for skilled workers or looking for opportunities to reskill or maybe upskill their workers, which suggests that both parties need to take on collaborative responsibilities in their green transitions.

Transitioning at industry and HVE system level

The findings indicated that the green transition of the HVE system was not keeping pace with the green transition taking place in industry (Rosenberg & Ramsarup, 2020). The discrepancy was partly due to the HVE system being unable to attract and recruit enough students to technical and industrial programmes, while industry did not have sufficient ability to identify and demand digital and green skills, as many jobs were emerging or not yet recognised. Manufacturing companies struggled to find skilled workers, especially as the number of retirements increased and young people show less interest in industrial work.

As the findings show, the green transition of industry was not an isolated phenomenon but was mutually dependent on the green transition in the HVE system. There was no doubt among the HVE providers that uncertain forecasts about the industry's future high-tech and green skill needs had to be balanced with the current skill needs relevant to the changing nature of industrial work. Intense labour competition between companies could shift the balance of power between workers and employers. As a result, workers could demand more from employers, considering factors beyond salary, like workplace conditions and flexibility. Technological foci had to be balanced with social and just transition perspectives. Additionally, external expectations influenced their decision to invest in digital and green measures to enhance credibility, branding, and climate responsibility. Automation, digitalisation, and AI can eliminate many industrial jobs. Technology megatrends like automation, digitalisation, and robotisation can obscure the fact that many industrial vocations are in short supply.

Conclusion

The article contributes to the ongoing debate about the high demand for digital and green skills among manufacturing companies to accelerate the green transition in industry. It highlights the complexity of this transition by stressing the need for collaborative efforts between stakeholders within overlapping transitioning systems, all part of a larger skill transformation ecosystem, to provide the industry with the necessary skills for the green transition. However, as the findings show, there is a need to understand the reasons for the imbalance or differences in pace between industry and the HVE system, in general, and from a holistic approach. As demonstrated, a holistic approach can take the form of an ecosystem for skill transformation which enables a multidimensional analysis of industry's green transition, where stakeholders are interconnected and co-create knowledge about industry's digital and green jobs and the skills they require. Training and skill-enhancing efforts can become a catalyst for shaping occupations, jobs, and skills, and driving high-tech and green innovations. The way companies engage with HVE providers and other stakeholders in a skill transformation ecosystem can be important for the green transition in the workplace. Despite this, the green transition is still relatively underexplored in the workplace, and more knowledge is needed about workers' everyday learning and work during the green transition in industry. As part of the green transition, students (tomorrow's workers) play an important

role in ensuring digital and green skills. Therefore, companies can benefit from inviting students to contribute to the development of knowledge around the green transition.

However, knowledge about how a skill transformation ecosystem for green transition could be designed is limited. Therefore, further research is needed to develop knowledge that can provide insights into factors contributing to a 'successful' skill transformation ecosystem. This can include an understanding of the specific skills required of industrial workers in the green transition, best practices for stakeholder collaboration, and enablers and barriers within the skill transformation ecosystem. The results of such research could guide policymakers, HVE providers, and industry management by providing valuable insights into collaborative practices that help to create a more cohesive and responsive skill transformation ecosystem. This, in turn, could facilitate a smoother and more effective green transition, and the leverage of advanced technologies to drive the green transition. Ultimately, the research could contribute to the development of policy and educational and training programmes that are better adapted to industry's skills needs in the shift to Industry 5.0.

As with all studies, this study is not without limitations. A limitation is that our findings is based solely on the challenges faced by HVE providers. Incorporating the perspectives of industry representatives (managers and workers), students, and policymakers could have provided a richer understanding of different stakeholders' experiences of collaboration within the skill transformation ecosystem and their challenges in transitioning to a green transition in Industry 5.0.

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