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Article

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The Role of VET in a Green Transition of Industry: A Literature Review

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Abstract

Purpose: This article examines the role of Vocational Education and Training (VET) in a green transition of industry. In the world of industry, battling climate change is often treated as a technical issue, but recent research on VET has tried to balance the technological paradigm with more human-centric approaches. The literature review addresses emergent VET research that presents various and partially competing perspectives on the purpose of VET in relation to climate change.

Methods: We use an integrative literature review to investigate this complex topic. This technique is particularly useful for making sense of emergent research concepts, as well as various, and partially competing, theoretical and methodological approaches. It also allows us to incorporate literature from different countries and VET systems. The main search was performed in Scopus during March 2023, and included studies published within a timespan of eight years (2016–2023).

Findings: Through a qualitative content analysis, we have identified five cross-cutting themes in the literature: Conceptualising ill-defined concepts of green jobs and skills; high-tech solutions in the movement towards a fourth industrial revolution versus inclusive growth for VET greening; towards sustainable work-based learning for green skills in VET; radical transformative approaches to a just green transition; and the co-creation of skill-formation

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ecosystems. The analysis has highlighted the ways in which VET can take on different roles in the green transition, and that these roles can be developed successively in parallel with a green transition in industry. In the development of the role of VET, it is also relevant to consider the contrast between *transitional* approaches and *transformative* approaches in VET research. While transitional approaches are recurrently marked by empirical research in specialised areas and subsystems within society, transformative approaches are characterised by a stronger focus on societal transformation (large-scale changes), power dynamics, and social justice.

Conclusion: In conclusion, we suggest an analytical model that synthesises research on what role VET can play in a green transition of industry. The development model highlights that VET can take on different roles in a green transition and can gradually develop in parallel with a green transition in industry.

Keywords: Climate Crisis, Green Transition, Industry 4.0, Vocational Education and Training, VET

1 Introduction

Although high on the political agenda, battling climate change is quite a recent theme in VET research. The role of VET can be situated within a broader societal context. It includes questions about technological change and the rapid expansion of green jobs and skills, requiring the reskilling and upskilling of many industrial workers, as a response to climate change. To put it somewhat incisively, industrial revolutions can both strain the ecological environment and be a source of hope that new eco-friendly technologies will contribute to greener societies and industries. The vision of a fourth industrial revolution (Industry 4.0) is predominantly associated with a multitude of new digital technologies (Avis, 2020) (e.g., 3D printing, the Internet of Things, robots, artificial intelligence), new materials (e.g., bio- or nano-based) and new production processes (e.g., data-driven production, synthetic biology). Such technological innovations are expected to fundamentally transform industry, its structure and organisation, business models, products, production and distribution chains. Consequently, requirements to develop workers' skills and competencies through education and skill-formation systems will follow.

The fourth industrial revolution is usually framed as a linear, technical, and inevitable logical progression, in which the first industrial revolution is followed by the second, third, and so on (Avis, 2020). Some researchers (Demir & Cicibas, 2017) even claim that we are already moving from Industry 4.0 towards the fifth industrial revolution (Industry 5.0), where the focus is on collaboration between people and machines, as well as sustainable production, green jobs and skills, and resilience, which includes endurance

and the ability to deal with change. The movement towards green industries is also strongly supported by several international organisations, such as the United Nations, the International Labour Organisation (ILO), The Organisation for Economic Co-operation and Development (OECD), and the European Commission (EC). Within these organisations, there is an overarching consensus that a green transition means counteracting climate change and environmental destruction, manifested in common agreements and objectives set out in, for example, Agenda 2030, the Paris Agreement, and the EU's Green Grant.

Within these policy contexts, VET is regarded as an important aspect of skill-formation systems, which promotes green skills and jobs (Avis, 2020). Knowledge about different types of VET and skill-formation systems is essential in order to understand current research on a green transition in VET. Given the heterogeneous nature of vocational education internationally, it is relevant to pay attention to comparative and holistic approaches to VET (e.g., Busemeyer & Trampusch, 2012; Jørgensen et al., 2018; Thelen, 2014). Until quite recently, however, very few research overviews have focused on the role of VET in connection with a green transition (Avis, 2020).

This article examines the role of VET in a green transition of industry. The main research question is: What role can VET have in making the move towards a green transition of industry? The next section presents the integrative literature review method. Thereafter, the findings of the literature review are presented. It is followed by a discussion that aims to contribute to a synthesis by providing a conceptual understanding of this relatively new research area and a reflection upon further research directions in VET.

2 Literature Review Method

An integrative literature review is used to investigate the complex topic of the role of VET in a green transition of industry (Torraco, 2016; see also Gessler & Siemer, 2020). This literature review technique is particularly useful for making sense of emergent research concepts, as well as various, and partially competing, theoretical and methodological approaches. It also allows us to incorporate literature from different countries and VET systems (see Appendix 1). The main search was performed in Scopus during March 2023, and included studies published within a timespan of eight years (2016–2023). The choice to limit the search to eight years was based on the increase in studies about VET and green transitions that we observed during this time period. The literature review limited the main source of data to peer-reviewed articles. However, four studies (three peer-reviewed articles and one conference paper) were manually selected (using Google Scholar) because we assessed them as being central to the topic of the article. In a three-step selection and assessment process (by title, abstract, and full-text analysis), any re-

cords that did not focus on both VET and climate change were excluded. Based on the quality assessment, 36 full publications (30 peer-reviewed articles and six peer-reviewed conference papers) were included in the literature review (see Figure 1).

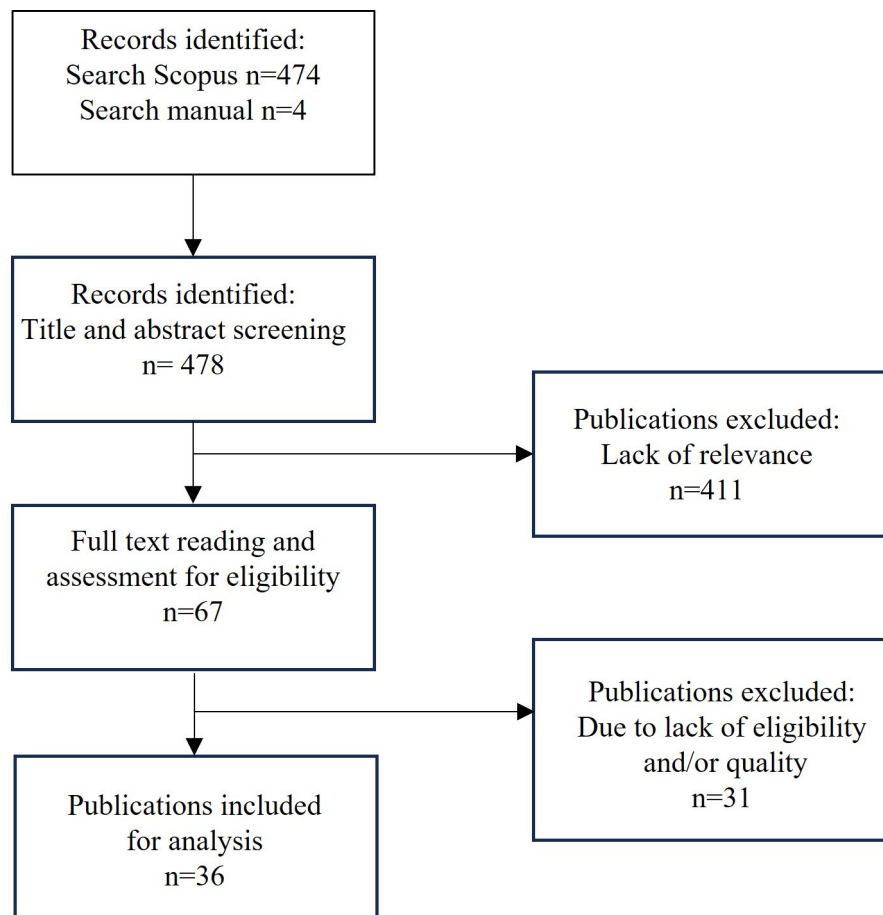


Figure 1: Flowchart Over the Publication Selection and Assessment Process

The 36 selected publications were analysed by using an inductively driven thematic content analysis (Braun & Clarke, 2006). Through the analysis, we identified five cross-cutting themes in the literature, involving different types of research contributions: 1) A conceptualisation of green jobs and skills in VET; 2) high-tech innovations and inclusive growth for VET greening; 3) towards sustainable work-based learning for green skills in VET; 4) a radical green transformative approach in VET; 5) the co-creation of skill-formation ecosystems. By introducing these themes, we also analyse the role of VET in making the move towards a green transition in industry.

3 Findings of the Literature Review

The following section presents the five cross-cutting themes identified in the literature.

3.1 Conceptualisation of Green Jobs and Skills in VET

The first section addresses research that has made substantial contributions to conceptualising the most common (and ill-defined) keywords in the VET literature: Green jobs and green skills. Indeed, the studies are quite diverse. Taken together, the literature on green skills covers multiple perspectives representing the voices of policymakers, employers, unions, industry and firms, VET teachers, and VET students.

VET and Policy Discourses on Green Jobs

Policy-oriented research on green jobs has focused on the tension between international commitments and national policy priorities. Based on document analysis and surveys involving stakeholders in different labour-market sectors in ten Asian countries, Sharpe and Martinez-Fernandez (2021) conclude that all Asian member states have developed national strategies to implement the ILO's (2018) vision for green jobs in prioritised labour-market sectors (building and construction, manufacturing industries, agriculture, and tourism). All of these countries have also made inroads into defining and counting (approximately 12 million) green jobs. Despite these national commitments, the level of collaboration and dialogue between different national and international policy arenas and stakeholders is weak. In addition, supportive policy ecosystems, such as active labour-market policies and social insurance, are not sufficiently in place (Sharpe & Martinez-Fernandez, 2021). This lack, it is argued, has serious consequences for VET, which is supposed to manage a multitude of partially conflicting challenges, such as supporting skill formation, employment, social inclusion, and simultaneously fighting unemployment and climate change. It is unlikely that this can be achieved without economic and political support systems. Therefore, a holistic approach to the "policy-readiness" for a green transition is key (Sharpe & Martinez-Fernandez, 2021). However, a weakness of this study is that it is largely based on the narratives of dominant official actors in various labour-market sectors and only covers the employment dimension of green jobs, which risks leaving aside other partners in the field of VET.

Other policy-oriented studies problematise the 'orthodox' perspectives on VET and green jobs that centre on dominant western discourses of economic growth driven by corporate and political interests. In the context of South Africa, Lotz-Sisitka et al. (2023) argue for the importance of establishing an ecosystem approach to VET, including boundary-crossing social learning networks that link formal and informal VET. In a similar vein, Langthaler et al. (2021) argue that green jobs must be anchored in a social justice approach to VET, in which economic growth is a means rather than an end. This human-centric approach highlights

neglected *social green skills* that are considered relevant to VET, including: multi-stakeholder learning involving diverse voices; embodied and empathic learning that encompasses inner reflection and listening as well as an ethic of care and empathy; and learning that identifies and confronts contradictions, framing new solutions and trying them out.

Conceptualising Green Skills

Green jobs and green skills seem to be everywhere and nowhere. Technological green skills are considered most important in the VET literature. However, studies (Nikolajenko-Skarbalé et al., 2021; Sern et al., 2021; Stanef-Puica et al., 2022) based on document analysis and interviews with experts present a multitude of different green technological, generic, and soft skills that industry requires to be implemented in VET. Rosenberg et al. (2018) have tried to develop a holistic analytical model focusing on the learning needs and competencies that are necessary to drive a green transition in various sectors. Three overall and overlapping skill areas are identified: (1) Technical skills, (2) relational skills, and (3) transformative skills to support social and organisational changes. In VET, there is often a great learning need for technical skills, but relational and transformative skills (collaborating, communicating, leadership skills, imagining change, integrating development goals, and applying policy) also emerged as significant in Rosenberg et al.'s (2018) data concerning different firms and workplace settings. These areas of competence influenced how technical skills were developed and applied. Technical skills were tied to particular industrial contexts and workplace settings, while relational and transformative skills were more generic. Not all of these skills necessarily have to be present in all employees, but different competencies could be distributed across a team involving different professional roles and tasks. For VET, this implies that educational curricula must build capacity to involve such a variety of skills and competencies.

A Pedagogical Framework for Green Skills in VET

Research has also contributed to a pedagogical framework for green skills based on surveys and interviews with VET teachers and trainee teachers (Nurdianshyah, 2019; Ramli et al., 2019; Setiawan et al., 2017). To become a highly qualified VET teacher, it is argued, teachers are expected to master: 1) Teaching in 'hard' (technological) skills, 2) imparting technical skills combined with the knowledge, values, and attributes necessary for green job preparation by Technical VET (TVET) graduates, and 3) soft skills (e.g., communicative and relational skills).

These studies also problematise the fact that green skills are overwhelmingly conceptualised by experts in jobs that require higher education, neglecting the perspectives of most industrial workers and students in initial VET. Ramli et al. (2019) argue that green industries need a mixture of 'traditional' and new green skills. For example, construction companies that carry out building and housing projects will require skilled workers who are also up to date with energy efficiency.

Only two of the studies found in Europe conceptualise green skills in initial VET. A longitudinal study (Barbosa et al., 2020) in Portugal tracks how the perceptions of VET teachers and former VET students of green skills and sustainable development evolve over time due to different learning experiences in education and work. This provides a dynamic perspective on green skills learning trajectories, in contrast to merely listing preferred skills. Finally, a Swedish study (Gustavsson et al., 2018) describes a pedagogical innovation in vocational teacher education where an assignment for VET student teachers was to design, conduct, and evaluate an interdisciplinary course for initial VET students about sustainable development. Extra-curricular courses and lectures in sustainable development are very common in the Swedish educational system, from primary school to higher education, but they are not yet established in vocational teacher programmes. A survey of the VET students' experiences of the course showed that they were very positive and inspired to learn more about green skills and jobs.

3.2 High-Tech Innovations and Inclusive Growth for VET Greening

A recurring theme in the Asian VET literature is high-tech innovations to battle climate change, which is severely affecting the living conditions and health of many people in the region. Through the analysis, we can identify a field of tension between two strands of research: High-tech innovations supported in higher vocational education and envisioned by a fourth industrial revolution, versus inclusive growth for VET greening that includes initial VET.

High-Tech Innovations and the Green Transition

The first strand of research focuses on the attitudes and preparedness among students in higher vocational education and vocational colleges to contribute to a green transition (Liu et al., 2022; Mahmud et al., 2023; Nurdianshyah et al., 2019; Zubir et al., 2021). Based on a survey covering 363 Chinese students at a vocational college, Liu et al. (2022) show that female students had a more favourable attitude towards the educational dimension of sustainable development than male students. The study concludes that TVET fosters generic and critical abilities, and a questioning mind, that result in a positive attitude towards learning green skills. Comparable results were reported among Malaysian students at technical vocational colleges (Mahmud et al., 2023; Nurdianshyah et al., 2019) regarding their readiness for Industry 4.0 and attitudes towards green jobs and skills. Recommendations put forward in the above studies are the implementation of innovations in curricula, including the *green campus* (to reduce the carbon footprint of students, teachers, and human-resource management) and *green research*, that is, programmes in sustainable development.

However, research also acknowledges skills gaps between education curricula and high-tech industries. As a pedagogical innovation in Indonesia (Saputri & Ediyono, 2022), researchers and teachers invited experts to vocational colleges and TVET institutions to hold

lectures about green jobs and skills. The above study was based on an analysis of 332 engineering lectures concerning electrical and mechanical green skills. A common message in these lectures is that green jobs are becoming more important for VET students' employment and further careers. That is, the students must prepare for emerging green jobs, and future green jobs that do not yet exist.

The research on high-tech green skills also includes pedagogical innovations relating to how learning and teaching is best organised (Moldovan, 2017; Nandiyanto et al., 2022). These studies acknowledge a field of tension between engineers' technical approaches and teaching methods. Questions about how learning and teaching is best organised are considered important for students to gain a deeper understanding of how products can become climate-friendly and environmentally sustainable. The studies also conclude that technical expertise should be supplemented by interdisciplinary approaches to a green transition. For example, in the fields of advanced bio-nanotechnology (da Silvia et al., 2019; Nandiyanto et al., 2022) the studies suggest that course curricula could combine specialised high-tech skills with humanistic and ethical perspectives on sustainable development.

The Appreciation of Initial VET

In contrast to the first strand of research, the second strand places great emphasis on including the masses of young people and workers to make the move towards a green transition. More specifically, questions about the quality and efficiency of initial VET are addressed (Monavvarifard & Alibaygi, 2023; Napathorn, 2021; Salem & Najihah, 2023; Saputri & Ediyono, 2022). Hence, it is acknowledged that initial VET has a significant role to play in the green transition. Investments in green jobs can potentially proceed hand in hand with investments in initial VET, and, in effect, improve the status, attractiveness, and appreciation of VET.

On the other hand, it is recognised that such changes will not be a quick fix. The problem is that initial VET in Asia is associated with low-paid work, poor working conditions, and brown industrial jobs (Napathorn, 2022). Research on initial VET systems in Malaysia and Palestine (Salem & Najihah, 2023) reveals a contrast between policy and social experience. Surveys on the opinions of experts and vocational teachers in the Palestinian VET sector have concluded that there is no significant relationship between sustainable growth and quality improvement in initial VET (Salem & Najihah, 2023). While investments in green technologies are being made in higher TVET programmes (universities), mainstream VET suffers from the lack of a comprehensive system in practice. Other studies have highlighted the limitations of systematic updates on green jobs and green skills in both industries and VET (Napathorn, 2021). The dominant focus on industrial technological revolutions (Industry 4.0) in the literature on a green transition in VET is also problematised in research about VET in the large agricultural sector in Middle Eastern countries. For example, Monavvarifard and Alibaygi (2023) argue that modern technologies must be in tune with key social learning goals, such as learning by doing and learning to live together.

3.3 Towards Sustainable Work-Based Learning for Green Skills in VET

Most pedagogical research on VET deals with the challenge of integrating green skills (based on experts' opinions) into school curricula. Another strand of research covers training and learning in workplace settings. The latter literature acknowledges that vocational education, along with positive attitudes to green skills, are not a sufficient condition for industries to introduce green innovations into workplaces: Firms must also be innovative in collaborative processes and spend more time on training VET students, apprentices, and employees (Keshminder & Cheng, 2020; Napathorn, 2021, 2022).

In the context of VET in the European construction industry, the tension between a purely technical approach to promoting low-energy construction and a more human-centric view on work-based learning is examined. Ramioul et al. (2016) argue for an employee-centric approach to work-based learning in VET, which includes worker participation, empowered teamwork, investment in developing apprentices' and workers' capabilities, and improving job quality. Another comparative study (Barsotti, 2023) on the manufacturing industries that are envisioned by Industry 4.0 in five European countries concludes that VET providers, in cooperation with companies, should support workers better in becoming more digitally aware, and better prepared to undertake non-routine work tasks.

Comparative research (Clarke et al., 2020) on VET for low-energy construction in ten EU countries also refers to an employee-centric approach. In this comparative study, Belgium and Germany come closest to travelling 'the high road', which means that low-energy construction is closely integrated into VET programmes in the curricula and exam regulations for each occupation. In both countries' VET systems, students are taught building physics and knowledge of materials as well as the general skills, such as communication, coordination, and teamwork, that are relevant to the low-energy construction sector. In addition, in both countries, the construction industry's labour market is regulated and less fragmented than in many other European countries. This provides an infrastructure for work-based learning in close cooperation between companies and education providers. Bulgaria, Hungary, and Slovenia are categorised as countries that conform to a 'low road' to green construction (Clarke et al., 2020). In these 'low-road' countries, the fragmented nature of the construction sector, lack of labour-market regulation, and limited governmental investment in VET do not allow for the broad expertise and learning opportunities necessary for a green transition. Other countries are on the way to 'the high road'. Ireland, Italy, Poland, and Spain have developed a coordinated and comprehensive approach to integrating sustainable development elements into VET programmes, but they are still under-resourced and need improvement. The study by Clarke et al. (2020) concludes with the presentation of a toolset within the European Qualifications Framework, against which different VET programmes for low-energy construc-

tion can be assessed. However, they also concluded that quantitative and output-driven policy conceptions of green skills could potentially undermine qualitative aspects of the climate literacy needed by construction workers.

3.4 Radical Green Transformative Approach to VET

Critical research suggests the need for a radical transformative approach to VET in relation to climate change. In terms of methodology, these studies are guided by critical realism, sociology, feminism, and colonial studies, and have a strong theoretical and societal orientation. Based on the nature of this literature, the studies referred to below can be conceptualised as related to the vision of Industry 5.0 in terms of social and humanistic values. By contrast to the vision of Industry 4.0, the critics adopt a conflict perspective on society and VET. Leading research in the field (McGrath & Powell, 2016; Paryono, 2017) questions the hegemony of western notions of productivity and technocratic perspectives on a green economy. The vision of Industry 4.0 may imply that there is a global political consensus about the importance of reuniting productivity, high technology, and the greening of world economies. Instead, these authors argue that a consensus perspective conceals the fact that social realities for most people in Asian countries are structured within political economies that have emerged out of contestations and compromises in specific historical and geographical spaces. Thus, labour markets and education and training are characterised by inequalities and exclusions, profoundly influencing individuals' and communities' views on the value of different forms of education and training. However, inequalities do not fully define young people's aspirations, hopes, or actions. Therefore, the argument runs, structural changes in VET and society must provide hope that an alternative future is possible for the masses of VET students.

The conflict perspective is also based on studies focusing on capitalism and power struggles between different stakeholders in VET (see the introduction section). It is argued that progressive trade unions (Paryono, 2017) are credited with a central role in fighting for a green transition to proceed hand in hand with the pursuit of socio-economic equality. The role of trade unions as active players in relation to VET is essential to balance the dominant employers' perspective on VET. However, a double challenge for unions is the poor status of VET and to collaborate with social-ecological movements for sustainable development in order to balance green goals with decent working conditions in industry (Paryono, 2017). The low status of initial VET can create a vicious circle leading to the will to invest in green industrial jobs becoming a secondary issue.

Transformative VET in African Countries

In the context of research on African VET, the critical approach includes a vision of 'transformative VET', a term that was originally discussed at the Third International Congress on Technical and Vocational Education and Training (Powell, 2012). The crucial question is how

VET can contribute to the human development and societal changes needed to battle climate change and poverty (Powell, 2012). However, VET can support development but cannot generate it on its own. Therefore, Powell argues, VET must be approached from within a holistic theoretical framework with the capacity to link critical theories and empirical knowledge about the historical and actual development of skill-formation systems, and colonialist experiences of marginalisation. The segregation between African industry-focused VET systems and a separate skill system focused on agricultural and natural-resource management, which Powell traces back to the colonial era, reflects the unequal access to and ownership of land.

A systematic literature review (McGrath et al., 2020) reveals that vocational training in African countries is mostly associated with economic research on western-governed interventions (labelled 'vocational training') designed to tackle unemployment in settings where there is an employment crisis. However, this research neglects mainstream VET systems in Africa. The literature review also investigates the growing practice-focused research on learning, teaching, and pedagogy published in African VET journals. However, according to the (nine) authors, the main problem is that both western-oriented economic research and practice-oriented research is locked into a narrow individualistic perspective on human progress. In addition, the human capital theory is based on economic dynamics in the most advanced economies and downplays broader structural issues. The societal transformation of VET must be balanced with social and humanistic dimensions covering *community development* (youth inclusion and local labour-market experiences) and critical abilities based on agency (aspirations and decent work for human flourishing).

3.5 Co-Creation of Skill-Formation Ecosystems

Research on the role of VET in a green transition has focused on building new arenas for skills formation in collaboration between VET and working life. This includes the co-creation of: 1) Cross-disciplinary networks; 2) regional skills ecosystems; 3) digital infrastructures for mass education; and 4) intermediary institutions. Such initiatives can be seen as examples of a larger movement to reconstruct existing school-based VET systems and transgress the boundaries between different stakeholders involved in VET.

Building Capacity in VET Through Networks and Skills Ecosystems

The first research theme addresses two related key challenges: Skills gaps due to weak cooperation between education providers and working life, and radically increasing the numbers of skilled people involved in green skills formation. Thus, it is not only restricted to the existing workforce.

Two studies in Finland focus on 'green innovation ecosystems'. In the first case, the purpose of the research (Holm et al., 2017) was to improve the cooperation between in-

initial vocational education, higher education, and universities of applied science (higher TVET). In addition, the study examined knowledge supply chains by surveying stakeholders' views regarding green skills in different companies and trade associations, which was followed by workshops with the participants. All these exchanges resulted in the setting up of a cross-disciplinary network aiming to reach a holistic understanding of each partner's role and obligations within the knowledge supply chain. Reported challenges for the sustainability of the network was that financiers only provided funding for specific fields, and there was no common understanding of the green economy.

The second study (Shamzzuzoha et al., 2022) surveyed the skills necessary to establish several 'centres of excellence' in VET for green innovations supported by the European-Union-funded project GREENOVET. The overall aim of these centres of excellence is to strengthen regional skill ecosystems, namely Styria in Austria, Leiria in Portugal, Skopje in Macedonia, and Vaasa in Finland. The focus on regional skills ecosystems can be seen partly against the background of the international VET literature based on typologies of green skills, which is broad and not specific to different countries or regions. The future-oriented goals for these strands of research are to establish new arenas for collaboration between researchers and stakeholders in VET and industries. This entails new missions and roles for VET.

Digital Solutions for Mass Education in Green Skills

Swedish research has provided innovative digital platforms to support mass education in the form of online courses of short duration (Leire et al., 2016; Pavlova et al., 2020). In contrast to online university courses about sustainable development, vocational online courses are more oriented towards developing specific green skills. In general, two challenges for massive online courses are low throughput among students and that they are time-consuming for teachers (e.g., answering hundreds of emails daily). To overcome these challenges, Leire et al. (2016) developed a model for online courses involving a set of different learning activities that create opportunities for students to choose different degrees of participation and progression. The model consists of: 1) Access to video and training materials and literature (non-graded level); 2) participation in discussion forums and written assignments (graded participation); and 3) completing course assignments and examinations (graded demonstration of competences). Such a model is also intended to facilitate education providers' planning of their own work, as different learning activities require different work efforts and perhaps even resulting in an increased workload. Interestingly, the massive online courses commonly involve students from a multitude of countries around the globe, not least from Asia and the Americas.

Another large collaborative research project (Pavlova et al., 2020) has developed digital platforms for mass education to promote resource efficiency in the Baltic Sea region (Sweden, Finland, Russia, and the three Baltic countries of Lithuania, Latvia, and Esto-

nia). In this project, courses and training materials for a green transition were developed in cooperation between VET and companies, along with channels for the dissemination of educational materials. Twelve teachers and 64 VET students from across the region collaborated with companies to develop course materials. The core of the extensive results is that the research team succeeded in getting companies and educational institutions to cooperate based on an interdisciplinary approach to the circular economy. What stands out in the study is that the students took the roles of 'training providers' for entrepreneurs. The students were also successful in generating ideas that business owners judged as possible to implement in their companies quite soon (Pavlova et al., 2020).

Intermediary Institutions for Mobilising Change in School-Based VET

A third strand of research addresses a recent, industry-driven 'innovation' to improve sustainability in the Swedish school-based VET system (Persson & Hermelin, 2018). The initiative, the 'Technical College Scheme' (TCS), is unusual in the Nordic context of universal, state-governed VET, which is largely oriented towards social inclusion, lifelong learning, and progression through the national education systems. The TCS is a certification scheme in technology for upper-secondary schools, which includes most of the technical and industrial VET programmes in Sweden. The scheme was initiated by stakeholders from industry, including trade unions. These cross-collaborations between different partners represent an intermediary institution in-between education and industrial companies. The aim of the TCS is to improve the quality, and industrial relevance, of VET. The criteria for certification include strong industrial involvement in school-based VET, requirements for high-quality, work-based learning, and the influence of regional actors in the planning of education. Quite recently, sustainable development and green industrial skills have been added as important goals. Yet, large Swedish industrial companies, which dominate the Swedish economy, continue to demand that upper-secondary school VET should prioritise broad general and vocational knowledge, and not focus primarily on specific skills. Indeed, this also reflects a neglected issue in the research on a green transition in VET and the world of industry; namely, the different conditions for small, medium-sized, and large companies, for example in providing comprehensive in-house training.

4 Discussion

A wide variety of research across many countries has contributed to our understanding of the role of VET in a green transition of industry. Therefore, there is a need to synthesise this research to determine what role VET can play in a green transition. The literature review indicates rapidly growing research on VET and a green transition in the so-called Global south, and European countries. As industry undergoes a green transition, while embracing

Industry 4.0 and Industry 5.0, the role of VET and its impact on developing ways to accomplish a green transition must be considered. The literature review shows that the role of VET develops successively, ranging from identifying green skills and jobs to co-creating skill-formation ecosystems that train a workforce equipped with the right skills (green, technical, and generic) in an ever-evolving industry (see Figure 2).

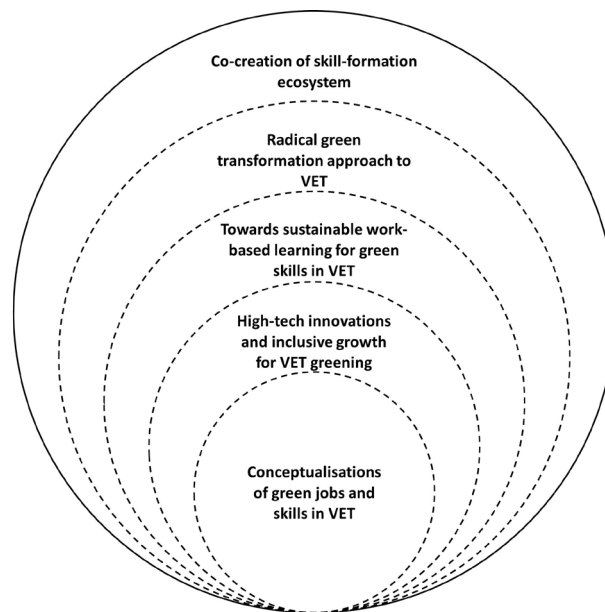


Figure 2: The Role of VET in a Green Transition, Ranging From the Conceptualisation of Green Jobs and Skills to the Co-Creation of a Skill-Formation Ecosystem

The implication of these conceptual studies on green jobs and skills is that green skills must be developed in collaboration between VET institutions and working life. This statement may seem trivial, but the concept of green skills in the literature reflects either the employers' views or the education providers' perspectives, seldom a combination of the two. In addition, the establishment of vocational teacher-training programmes at the university level can also be seen as an education-driven innovation that can potentially reduce the gap between the teaching professions and vocational teachers. This may also bridge the gap between academic and vocational skills. Collaborations between education providers at different levels within education systems are also key to recontextualising university-based typologies of green skills into educational practices.

The conceptualisation of green skills and jobs in VET also involves a policy dimension. An important stage in VET development is to realise its enormous potential to influence the global movement towards a green transition. In line with green transitional policies (e.g., those of the OECD, ILO, EC, and United Nations Educational, Scientific and Cultural Organization [UNESCO]), TVET is considered a driving force in the transition due to its close connection to industry. Industrial companies need green skills in order to adhere to both regulations and customer requirements related to a green transition. The (potential) synergistic effects of the unification of a policy-driven movement for a green industry driven by international organisations, and an industry-driven movement towards Industry 4.0, create a 'window of opportunity' for a green transition.

The literature review reveals two quite diverse lines of thought regarding green technical innovations in VET: High-tech innovations that engage a technological elite (e.g., engineers, vocational colleges, and universities) versus a bottom-up perspective that includes most VET students, apprentices, and employees in the world of work. A key challenge is the segregation between different socio-economic groups and educational sectors, which works against socially inclusive approaches to a just green transition.

As the literature review shows, sustainable work-based learning in VET deals with the pedagogical challenge of integrating green skills (based on experts' opinions) into school curricula. From a transitional development perspective, the first critical step is to develop a positive mindset about environmental issues as a basic requirement for engaging in transition processes towards a greener industry and society. The development of work-based learning in terms of educational curricula and massive online courses on green skills are examples of initiatives in this direction. The second step concerns the development of generic skills that consider climate impact and generic technical skills and industrial processes. Generic skills and lifelong learning are also a key prerequisite for the preparedness for future green jobs that do not yet exist. The third step is the development of new, specialised eco-friendly technologies and green jobs that can replace old jobs and old technologies. The latter may be perceived as threatening, but the alternative – i.e., preserving old jobs and old technologies – may also result in the loss of new jobs. Ultimately, at the highest level, most industrial workers are highly skilled in eco-friendly technologies. Given that this scenario on a large scale belongs to an imaginary future, the stepwise model implies that learning trajectories in green skills can move forward progressively at different stages. That is, people need to get started at the basic and general levels before they can reach the top. In terms of theory, we also acknowledge the need for a holistic understanding of green skills, ranging from a narrow, individualised conception of 'skills' up to VET approaches to *collective* skill formation that integrate different forms of knowledge and participation.

The literature on a green transition in industry can also benefit from well-established research on work-based learning. The roll-out of new industrial technologies, including me-

ga-trends such as automatisisation, digitalisation, and AI, must also follow the principles of worker participation and sustainable work in workplace settings. That is, high-tech industries must also be innovative in supporting extensive learning among workers (Brockmann et al., 2010; Clarke et al., 2020). These tendencies are exacerbated in countries where there is as yet no comprehensive (introductory) collective formation VET system in place. The role of VET is then reduced to that of an instrumental technical approach to vocational training. We recognise that several Asian studies on a green transition also focus on the school-to-work transition. The logic of this is that a green transition must go hand in hand with the vast research on VET students' transitions into employment and skilled jobs, including opportunities for social mobility. These parallel transitions require large-scale changes in VET that link transitional approaches to societal transformative approaches.

The notion of a radical green transformation approach to VET is based more on critical and radical future visions than on the status quo. The critical approach raises further questions about how VET can contribute to a development that is human, in solidarity, and sustainable, and at the same time responds to the conventional concerns about employment, income, production, and technological development raised by representatives of the Industry 4.0 paradigm. In line with the vision of Industry 5.0, the critical literature clearly contributes to a human-centric approach to VET and industry. This means that the radical transition stage is generated by the contradictions between a technocratic paradigm versus human-centric approaches to inclusive growth. The latter can be illustrated by the vision of Industry 5.0, which is characterised by socially inclusive approaches to human development, not only for an elite but for industrial workers as well.

There is increasing interest in research on VET and the co-creation of green skill-formation ecosystems. This is partly a response to shortcomings in collaboration between different policy areas, support systems, and industry. New and dynamic partnerships and networks are emerging, creating a range of new relationships between stakeholders representing VET and industry, as well as intermediary institutions, and local and regional alliances. The impetus to collaborate comes from the need to build up ecosystems for skills supply and strengthen industry's need to upskill and reskill workers for a green transition. Innovative investments in digital solutions for mass education and online courses in green skills will require new roles for VET providers.

5 Conclusion

This article has highlighted the ways in which VET can take on different roles in the green transition, and that these roles develop successively in parallel with a green transition in industry. In the development of the role of VET, it is also relevant to consider the contrast between *transitional* approaches and *transformative* approaches in VET research. These two

concepts can be understood as a duality (not a dualism), as they are not mutually exclusive. All differences aside, we argue that both transitional and transformative dimensions are important for a holistic developmental perspective on VET and climate change. In the reviewed literature, both concepts provide nuanced perspectives on how to describe, interpret, and support desirable changes in VET to battle climate change. We suggest that the main difference stems from different research communities, which are concerned with either transition or transformation. Our literature review shows that transitional approaches are recurrently marked by empirical research in specialised areas and subsystems within society, such as different forms of VET, high-tech innovations in industries and firms, and the educational dimension of green skills. In contrast, transformative approaches are characterised by a stronger focus on societal transformation (large-scale changes), power dynamics, and social justice.

Based on the literature review, we can discern at least two different but partially overlapping transformative approaches to the role of VET in society. The first is a social-justice approach, which is marked by a conflict perspective on society. The transformative role of VET is argued to extend beyond the needs of the labour market by including the interests of people who are marginalised in both education and working life. The purpose of VET is thus redefined. That is, the multifaceted nature of different forms of VET must be more fully recognised in order to better support the needs of those who live in poor and precarious conditions.

The second transformative approach draws upon comparative studies on path dependencies and institutional change in VET (e.g., Thelen, 2014). Following this research tradition, the scope of radical changes in the field of VET is circumscribed by struggles between multiple stakeholders in VET. The research on collective skill formation provides a conceptualisation of the combined effects of state commitment and employer involvement in the development of VET. Comparative studies on collective skill-formation systems in VET have usually been defined in relation to industry and craft (i.e., the labour market). In the present literature review, we have expanded the object of inquiry by focusing on the role of VET in contributing to battling the climate crisis, which also involves other international organisations and stakeholders, as well as socio-ecological concerns.

6 Limitations and Further Research

The integrative literature review has been useful to investigate the complex topic of the role of VET in a green transition of industry. However, one limitation is that the completed literature review cannot claim to provide a representative picture of all ongoing research that focus on green transition in relation to VET. This is partly because the selection is mainly based on English-language studies, partly because a significant number of studies have been published

in the field over a short period of time. Undoubtedly, it is a rapidly growing field of research, which makes it difficult to obtain a complete overview of the role of VET in the green transition of industry.

Despite the limitation, the present literature review has enough value to contribute to the body of research in the field of VET. The literature review suggests a further direction for research on transformative approaches, which is a need not only to continue to focus on stakeholders in industry, in VET, or in socio-ecological movements, but also to focus on the links between these stakeholders. The increasing interest in research for co-creating green skill-formation ecosystems is partly a response to shortcomings in the collaboration between different policy areas and support systems as well as industry. A possible role for VET to take on is to coordinate skill-formation ecosystems and facilitate their co-creation with other stakeholders. However, further research is needed before VET can take on such a role because, as studies in the field of VET indicate, bringing stakeholders together to collaborate will require them to solve many difficult issues. Therefore, studies of the collaborative efforts to establish a skill-formation ecosystem involving stakeholders from national organisations, educational institutions and industry would be welcome. A closer collaboration between stakeholders could pave the way for VET to battle climate change more effectively.

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Ethics Statement

This integrative literature review did not require approval by an ethics committee. Nevertheless, the ethical principles in accordance with the IJRVET Ethics Statement have been implemented in the reporting of our review so that the entire research process is available to the reader.

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