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Article — Published Version

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International Journal of Training and Development

Provided in Cooperation with:

John Wiley & Sons

Suggested Citation: Chen, Pujun (2025) : Green Skills in Logistics Vocational Education: A Comparative Study of Curriculum Integration in China and Germany, International Journal of Training and Development, ISSN 1468-2419, Wiley, Hoboken, NJ, Vol. 29, Iss. 2, pp. 124-139, <https://doi.org/10.1111/ijtd.12348>

This Version is available at:

<https://hdl.handle.net/10419/323866>

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RESEARCH ARTICLE OPEN ACCESS

Green Skills in Logistics Vocational Education: A Comparative Study of Curriculum Integration in China and Germany

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Received: 24 July 2024 | **Revised:** 9 January 2025 | **Accepted:** 13 January 2025

Keywords: comparative analysis | curriculum integration | green skills | logistics vocational education and training

ABSTRACT

The logistics sector plays a pivotal role in driving economic growth while addressing environmental sustainability challenges. As the industry transitions towards greener practices, the integration of 'green skills' into logistics vocational education and training becomes crucial for equipping the workforce with the competencies needed for sustainable growth. This study explores the integration of green skills into logistics vocational curricula in China and Germany, aiming to gain the current state and challenges in greening the VET curricula for equipping logistics professionals to address the transition towards a green logistics. Using a qualitative curriculum analysis framework inspired by Sterling's model of educational responses to sustainability, this study examines national, regional and school-level curricula to identify the embedded green skills and their integration approaches in both national contexts. The findings reveal both similarities and differences in green skills integration across the two countries. Both contexts exhibit a stronger emphasis on general green skills over logistics-specific and cross-sectoral green skills, reflecting a shared priority for transferable competencies. However, the Chinese curricula demonstrate a fragmented, bottom-up approach with inconsistent alignment between national and school-level curricula. In contrast, the German curricula adopt a more structured, top-down integration strategy, yet inconsistencies at the school level hinder deeper systemic reform. This study concludes that although both countries exhibit evidence of green skills integration, the efforts predominantly remain at the stage of 'cosmetic reform'. Greater efforts are needed to strengthen the role of VET in supporting the global green transition, with a particular emphasis on adopting systemic approaches from a transformative perspective to embed sustainability into logistics vocational education.

1 | Introduction

In the dynamically changing landscape of international trade and commerce, the logistics sector is emerging as a critical driver of economic efficiency and ecological sustainability (Jumadi and Zailani 2010; Baidur 2022). With the growing awareness of environmental challenges, coupled with the persistent emphasis on its

economic performance, the logistics industry is facing an urgent need to embrace more sustainable practices to facilitate its green transition (Agyabeng-Mensah and Tang 2021). A crucial aspect in this transformation lies in the upskilling and retraining of the workforce towards the green transition, particularly in the development and application of 'green skills' (Thai, Cahoon, and Tran 2011; McKinnon et al. 2017; CEDEFOP 2023a, 46–48). This

Special Issue: Skills for Local Sustainability Transformations and Development.

[Correction added on 27 June 2025, after first online publication: Author's first and last name were swapped in the initial publication. They have been corrected in this version.]

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necessity arises because, beyond the nascent green occupations still being established, the majority of the workforce in the logistics industry is experiencing changes in existing occupations due to increased green demands and the need for enhanced green skills (International Labour Organisation 2019, 91). Although these occupations may retain their core purposes and processes, their contexts, specific tasks, and required skills are being adapted to align with the shift towards a green economy (Tsironis 2023). According to the skill foresights of the European Centre for the Development of Vocational Training (CEDEFOP), this shift is especially evident in those positions with managerial functions, such as logistics managers, who are expected to 'guide companies towards circular production goals through the design and implementation of more sustainable products and services' (CEDEFOP 2023b, 2). Therefore, these managerial roles are seen as one of the key occupations for the green transition of the logistics industry (CEDEFOP 2023b, 2; Vona et al. 2015). In this context, cultivating requisite green skills in logistics vocational education and training (VET) is essential for these key occupations (McKinnon 2015; Baidur 2022), because this step could ensure that current and future logistics professionals in managerial roles are well-equipped to effectively implement and manage eco-friendly logistics solutions, thereby supporting the transition to green growth (cf. CEDEFOP 2023b, 3; European Commission 2020, 58–59; McKinnon et al. 2017; Thai, Cahoon, and Tran 2011; Tsironis 2023; UNESCO-UNEVOC 2017).

In the field of logistics vocational education, considerably more studies have been dedicated to investigating general skills requirements and gaps for logistics professionals (Al Harrasi et al. 2023; Dwiyantri, Ana, and Okitasari 2021; McKinnon et al. 2017; Thai, Cahoon, and Tran 2011) than to addressing the skill needs associated with the green transition. Research projects such as InnoLA and Pro-DEENLA¹ are among the few that have developed and piloted learning modules and tasks related to sustainable development within logistics vocational education. A notable research gap exists in the in-depth analysis of whether and how green skills are incorporated into the curricula of logistics vocational education. This gap implies the need for a deeper understanding of the extent to which green skills are embedded into curriculum framework of logistics training programmes across various VET systems. By examining which green skills are embedded in or missing from logistics vocational curricula, gaps in curriculum development and potential areas for revision could be identified, ultimately aiming to better facilitate the development of green skills for future logistics professionals in vocational education.

Building on this context, this article delivers a comparative-analytical exploration of the integration of green skills into the vocational curricula of logistics training programmes in China and Germany. The aim of this article is to uncover the current state of curriculum integration concerning green skills and the broader transition to sustainability, offering insights into potential opportunities for further advancing the greening of curricula within the VET systems of both countries. As key players in the logistics sectors of Asia and Europe, respectively, China and Germany are proactively pursuing sustainable practices and promoting a green transition within their logistics industries (cf. State Council of the People's Republic of China 2022; Federal Government of the Federal Republic of

Germany 2021). Both nations are dedicated to advancing green initiatives in logistics workforce development and professional training, aiming to enhance the green skills of logistics professionals to support sustainable development (cf. China Federation of Logistics and Purchasing 2018; Gregori and Wimmer 2011). Furthermore, bilateral cooperation between various stakeholders from both countries is being fostered to establish green logistics personnel training systems and develop green logistics standards (cf. China Federation of Logistics and Purchasing 2021; GIZ 2021). Against this background, a comparative analysis of how green skills have been integrated into the logistics vocational curricula in both countries is of significant interest. This analysis will provide valuable evidence for future directions of curriculum revision and cooperation efforts to better prepare logistics professionals for the global green transition. To investigate the integration of green skills into the Chinese and German logistics vocational curricula, the research question is divided into three sub-questions:

1. Which green skills have been integrated into the logistics vocational curricular?
2. In which parts of the curricula are these green skills integrated?
3. What are the similarities and differences in the integration of green skills between the curricula of both countries?

The subsequent section provides the theoretical foundation of this study, beginning with a concise literature review on the role of education and its responses to the sustainability transition, as well as the integration of green skills in VET through curriculum practices. Drawing on Sterling's model of educational responses to sustainability challenges, a theoretical framework is constructed for this study. Following this, the conceptualisation of green skills in the field of logistics is explored. The research design is outlined briefly in the fourth section. The fifth section presents the analysis results for the first two sub-questions, structured by national context. Subsequently, the sixth section offers a discussion of the comparative results related to the third sub-question, interpreting these findings within their respective national contexts. Finally, this article concludes with a brief summary that addresses the study's limitations and proposes directions for future research.

2 | Theoretical Backgrounds

The role of education in addressing the challenges of sustainable development and facilitating the green transition has been a central theme in both public debates and academic discourses. International organisations have consistently underscored the critical role of education in equipping individuals and societies with the knowledge, skills, attitudes, and values necessary to contribute to a sustainable future (UNESCO 2017; OECD 2018). Education for Sustainable Development has been recognised as a global strategic priority for fostering the transformative changes required in both individual mindsets and collective behaviours to respond effectively to the societal shifts and demands of sustainable development (ibid.). Here, the objectives of education extend beyond aligning workforce development with labour market needs to prepare young people for

employment. Education also aims to empower individuals with the competencies required to become active, responsible and engaged citizens (OECD 2018; CEDEFOP 2023a). Similarly, many scholars also contend that education's role should not be limited to addressing unsustainable practices or encouraging participation in sustainability initiatives. Moreover, education should serve as a transformative force—one that reshapes societal values, drives innovation and strengthens adaptive capacities to address the complex environmental and social challenges of our time (Bonal and Fontdevila 2017; Kopnina 2020; O'Flaherty and Liddy 2018; Tikly 2019; Wals and Benavot 2017). Through this lens, education transcends its instrumental function as a means of achieving sustainability goals. More importantly, in the context of transition, it should be envisioned as a foundational process for reimagining and redefining the relationship between society and its ecological and economic systems, thereby driving systemic change (cf. Bonal and Fontdevila 2017; Kioupi and Voulvoulis 2022).

Building on the broader perspective of education's role in addressing sustainability challenges, Sterling (2004) proposed a tiered model of educational responses to sustainability. This model is inspired by O'Riordan and Voisey's four-stage framework of the 'sustainability transition', which progresses from 'very weak' to 'very strong' sustainability (O'Riordan and Voisey 1998, 15–17). Central to Sterling's model is the assertion that sustainability should not be seen as an 'add-on' to existing educational frameworks but as a fundamental rethinking of education itself. This reorientation involves shifting from transmissive learning, which focuses on the passive transfer of knowledge, to transformative learning, which prioritises critical thinking, systemic understanding and active participatory engagement (Sterling 2004, 57–59). Sterling's model delineates four levels of educational responses to sustainability challenges. The first level represents minimal or no response, where sustainability-related changes are absent or negligible within the educational system. The second level, described as 'accommodation', involves a superficial integration of sustainability concepts into the existing system, often described as a 'bolt-on' response. Here, sustainability efforts result in 'cosmetic reform', as the underlying educational system remains largely unaltered. The third level, referred to as 'reformation', marks a shift towards a more integrated 'build-in' approach. At this stage, sustainability is incorporated not only into educational content but also into values and skills associated with sustainable development. This approach drives notable changes in educational policies and practices, resulting in what Sterling calls 'serious greening', achieved through critically reflective and adaptive processes. The fourth and final level is transformative, where education fosters a conscious re-design of existing structures, values and methodologies within the system and facilitates a paradigm shift that deeply aligns with sustainability principles (Sterling 2004, 57–60).

Although Sterling's model was primarily conceived with a focus on higher education, its conceptual framework for understanding educational responses to sustainability transitions provides a compelling theoretical foundation for exploring the integration of green skills and broader sustainability principles into curricula in the context of VET as well. This applicability arises from the recognition that curriculum is typically

perceived as an outcome of a process that embodies political and societal consensus regarding the objectives, content, and methodologies of education necessary for shaping a desired future society (Tedesco, Opertti, and Amadio 2014, 528). Meanwhile, curricula establish a fundamental framework of principles and guidelines, ensuring alignment with educational policies and coherence in content orientation for training programme (Tedesco, Opertti, and Amadio 2014, 542; Jonnaert et al. 2007, 189). In practice, the critical role of curriculum in integrating sustainability into educational practice is further underscored in numerous international VET policies. For instance, one of the key approaches for bolstering the development of green skills in VET is the incorporation of sustainability into educational practice through 'Greening the Curriculum and Training', as initiated in the practical guide *Greening Technical and Vocational Education and Training* by the UNESCO International Centre for Technical and Vocational Education and Training (UNESCO-UNEVOC 2017, 35–38). In a similar vein, the CEDEFOP stresses that the skills needed for the green transition must be 'embedded across the board in "green" education and training programmes and curricula' (CEDEFOP 2023a, 16–21). Consequently, the curricula emerging from such greening processes can provide a clear indication of whether and to what extent green skills and sustainability principles have been integrated, and thus can be regarded as a tangible representation of how VET responds to the sustainability transitions.

Broadly, the embedding of greening aspects and green skills into curricula can be structurally approached in two common ways. One approach involves developing new curricula specifically for the Green New and Emerging Occupations,² incorporating the necessary green skills identified for these roles. The other approach entails adapting existing curricula for current occupations to embed the new skill demands arising from green employment (CEDEFOP 2019, 37). From a broader perspective on content and purpose, the embedding of green aspects and skills into curricula can be aligned with two overarching approaches to sustainability transitions, as identified by Wals and Benavot (2017). The first, an *instrumental approach*, emphasises the development of knowledge, awareness, skills, and technical solutions aimed at fostering changes in specific sustainable behaviours. This approach is characterised by instruction-oriented, expert-led and policy-driven learning processes, with a primary focus on equipping learners with the green skills needed to achieve predefined sustainability goals (Wals and Benavot 2017, 4). The second, an *emancipatory approach*, aims to facilitate a deeper, systemic transition towards sustainability. This approach seeks to cultivate capacities, literacies, and forms of citizenship grounded in sustainable values and principles. This approach promotes action-oriented, collaborative, participatory and transformative learning. Learners are encouraged to become self-reflective agents who critically evaluate their values and behaviours while developing their own solutions to sustainability challenges (ibid.).

In the field of VET research, numerous studies address the greening of VET curriculum across various vocational education settings for both emerging and existing occupations within country-specific contexts, such as Canada (Knibb and Paci 2016), Indonesia (Setiawan 2017), Thailand

(Napathorn 2022), Finland (Shamzzuzoha et al. 2022), etc. Many of these studies have concentrated on identifying the green skills or elements that should be integrated into VET curricula through literature reviews and expert interviews with different stakeholders (Hasan, Hassan, and Fauzi 2017; Shamzzuzoha et al. 2022; Setiawan 2017; Sern et al. 2021; Zolkifli et al. 2016). Additionally, several qualitative studies have been conducted using questionnaires and interviews with schoolteachers to explore their perceptions of green skills and their views on integrating and implementing these skills within existing curricula (Handayani et al. 2020; Hamid et al. 2019). Further discussions in the literature have focused on the patterns and approaches to curriculum design or redesign concerning the development of green skills (Lee 2013; Baghbanpourasl et al. 2017). The primary findings of these studies empirically confirmed the necessity of incorporating green skills into vocational curricula within their respective national contexts.

However, despite the years since the launch of UNESCO-UNEVOC's Greening Curriculum Initiative (2017), there have been limited studies that use curriculum analysis to discuss and examine the practical implementation of greening VET curricula and the integration of green skills into them. More research has instead focused on the greening of curricula in higher education, targeting the development of green skills related to particular occupational fields (Chakraborty, Singh, and Roy 2018; Xiong et al. 2013). Comparative analyses in curriculum study on this topic are even scarcer. Existing research tends to focus more on comparative policy studies, analysing educational policies and initiatives aimed at developing green skills in VET across different regions or countries (Pavlova 2019). This has left a notable research gap in the detailed, comparative analysis on the integration of green skills into VET curricula. Addressing this gap is essential for gaining a deeper understanding of how VET is currently responding to the challenges of sustainability and identifying exemplary practices in diverse contexts to support the sustainability transition.

Above all, a theoretical framework for analysing the integration of green skills into VET curricula can be constructed by adapting Sterling's model of educational responses to sustainability for this study. This framework links the level of sustainability transition with corresponding actions in VET, the

state of curriculum integration and the approach to curriculum development, as outlined in Table 1.

3 | Conceptualisation of Green Skills in the Logistics Field

Although green skills have been widely discussed in numerous reports and studies over the past few years, their definition can vary depending on the application context (Kwauk and Casey 2022). As early as 2009, the Council of Australian Governments formally approved the *Green Skills Agreement*, which established guiding principles to incorporate green skills (also referred to as *skills for sustainability*) into their VET system (McDonald, Condon, and Riordan 2012). They defined green skills as 'the technical skills, knowledge, values and attitudes needed in the workforce to develop and support sustainable social, economic and environmental outcomes in business, industry and the community' (Ministerial Council for Tertiary Education and Employment 2010, 3). Clearly, this definition is more oriented towards the VET context and primarily reflects a technical, occupational understanding of green skills. In the context of the United Kingdom, green skills are referred to, following CEDEFOP (2010), as 'the knowledge, abilities, values and attitudes needed to live in, develop and support a society which reduces the impact of human activity on the environment'. However, these skills are typically associated with 'green jobs', which either directly contribute to or indirectly support the achievement of the United Kingdom's net-zero emissions target and other environmental goals (Simmonds and Lally 2024, 2). In this sense, this also reflects a narrow interpretation of green skills.

In contrast, green skills are defined more broadly in the European context. For instance, the CEDEFOP defines green skills as 'knowledge, abilities, values and attitudes needed to live, work and act in economies and societies seeking to reduce the impact of human activity on the environment' (CEDEFOP 2024, 356). These green skills, also regarded as 'skills for the green economy', are categorised into three sub-sections: *generic green skills*, *specific green skills* and *highly specialised green skills* (ibid.). Similarly, European Training Foundation categorises green skills into two main areas: (1) technical knowledge and skills that enable professionals to

TABLE 1 | Theoretical framework for analysing the integration of green skills in VET curricula (based on Sterling 2004; Wals and Benavot 2017).

Level of sustainability transition	Responding action in VET curricula	Concrete approach to curriculum integration	Resultant change in VET curricula
Very weak	No or minimal integration	No integration of existing curricula	No change
Weak	'Bolt-on' integration	Instrumental approach in existing curricula	Cosmetic reform
strong	'Build-in' integration	Instrumental approach in new curricula	Serious greening
Very strong	Rebuild or redesign	Emancipatory approach in new curricula	Wholly integrative

effectively use green technologies and processes; (2) transversal skills, along with knowledge, values and attitudes that help professionals make pro-environmental decisions in their work and daily lives (European Training Foundation 2023, 5). These classifications underscore the multifaceted nature of green skills. Here, the concept of green skills shares certain overlapping elements with sustainability competences,³ yet they differ significantly in both scope and purpose. Green skills primarily focus on the technical and operational competencies required to meet the demands of a green economy within specific occupational contexts. In contrast, sustainability competences encompass broader, value-driven capacities aimed at fostering systemic transformation towards sustainability (cf. Wals and Kieft 2010, 23–25). This distinction highlights a key critique of green skills: their emphasis on employability and workforce adaptation may risk marginalising the broader transformative dimensions of sustainability education (cf. McGrath and Powell 2016). Nevertheless, within the context of VET, green skills remain crucial as they address the specific labour market demands arising from the transition to sustainable economies. Hence, to mitigate the risk of narrowing the focus solely on technical aspects, the OECD and CEDEFOP (2014) define green skills, in a broader sense, as ‘the skills needed by the workforce, in all sectors and at all levels, in order to help the adaptation of products, services and processes to the transformations due to climate change and to environmental requirements and regulations’ (p. 16).

Regarding the two countries researched in this study, green skills in the German context refer to ‘a set of competences that enable employees to navigate and actively shape the ongoing dynamic transformation of the workforce towards sustainability’ (Federal Ministry for Economic Affairs and Climate Action 2023, 6). Aligning with the European understanding of green skills, these competences in Germany comprise green knowledge, transferability competencies and a sustainability mindset (ibid.). In the Chinese context, green skills are understood in the academic discourse as a combination of both narrow and broad definitions introduced earlier. These include technical occupational skills for sustainable development and transversal skills for the green transition (Liu 2014). However, a clear definition of green skills is rarely found in the policy-making discussions (cf. International Labour Organisation 2019, 77).

To facilitate a comprehensive comparison of the results across both national contexts, this study adopts the broad understanding of ‘green skills’, based on the newly recognised definition and categories outlined by the CEDEFOP (2024, 356), rather than relying on definitions from a single country. However, there is no established definition or standardised concept of green skills specifically for the logistics field in either the policy-making discussions or academic discourse of both countries.

To ensure a consistent understanding of ‘green skills’ as the criterion of comparison in this study, the author has formulated a working definition applicable to both Chinese and German logistics vocational education contexts, based on a recent report⁴ published by Economist Impact (2024). In this study, ‘green skills’ in the logistics field are defined as the knowledge,

abilities, values and attitudes required to work and act within the logistics industry to support its transition to green growth (cf. Economist Impact 2024, 9; GIZ 2021; Thai, Cahoon, and Tran 2011; Tsironis 2023). These green skills can be further conceptualised into three categories: *logistics-specific green skills*, *cross-sectoral green skills*, and *generic green skills*. The *logistics-specific green skills* pertain to ‘the use of green technologies or methods within the logistics industry that improve the environmental outcomes of specific activities’. The *cross-sectoral green skills* are ‘related to environmentally friendly processes and functions that are applicable across multiple sectors of the economy’. The *generic green skills* refer to ‘non-vocational, non-technical skills essential for excelling in green occupations’ (ibid.). The concept of ‘green skills’ in the logistics field for this study is derived from the findings of the Economist Impact’s (2024) report, as illustrated in the Table 2.

4 | Research Design

To address the research question concerning the extent to which green skills are integrated into logistics vocational curricula in China and Germany, it is necessary to clarify which specific aspects of the vocational curriculum should be analysed before data collection.

According to the ILO’s practical guidance tool on greening TVET and skills development, a curriculum typically contains a range of key elements of a training programme that are crucial for addressing greening issues (ILO 2022, 49). Given its comprehensiveness and thematic relevance, the framework for curriculum analysis in this study is derived from the curriculum elements and their typical meanings outlined in the ILO’s practical guidance tool (ibid.). The guiding questions for analysis are specifically tailored to the integration of green skills into the curriculum, rather than focusing on general greening aspects (Table 3).

As introduced in the first section, managerial roles are considered crucial for the green transition of the logistics industry. Consequently, this necessitates the integration of green skills into the training programmes related to logistics management. Against this backdrop, curricular documents from the *Logistics Management* in Chinese vocational colleges and the training programme for *Management Assistant for Freight Forwarding and Logistic Services* in German vocational schools were collected between 2021 and 2023, using a combination of purposeful and convenience sampling methods. These two training programmes were selected for this study because they both aim to cultivate future workforce for managerial functions in logistics. Additionally, the training content in both programmes is thematically convergent and internationally standardised, ensuring the comparability of the results from the curriculum analysis. Furthermore, the selected vocational colleges in China and vocational schools in Germany are situated in regions with well-developed logistics industries and high demand for the qualified workforce, which offer corresponding logistics training programmes. The sample information and statistics are presented in Table 4.

At the national level, two curricular documents in Germany that govern various aspects of planning and implementing

TABLE 2 | Concept of green skills in the logistics field (Economist Impact 2024, 9, 29, 33).

Green skills in the logistics field		
Logistics-specific green skills	Cross-sectoral green skills	Generic green skills
<ul style="list-style-type: none"> • Implementation of road transport environmental measures • Electric vehicle design, manufacture, servicing and repairs • Green logistics (including digitalisation to optimise efficiency) • Waste management and reprocessing • Battery engineering, management and recycling • Pollution remediation (including bioremediation) • Green software engineering • Evaluation of vehicle ecological footprint • Expertise in recycling vehicle parts • Life cycle assessment • Fuel cell engineering • Expertise in ship pollution prevention • ChargePoint installation and operation • Green hydrogen production, storage and management • Ecosystem restoration • Implementation of airport environmental policy 	<ul style="list-style-type: none"> • Sustainability disclosure and reporting • Environmental impact assessment • Sustainability compliance • Sustainable procurement • Green/lean manufacturing • Green chemical engineering • Sustainable finance and accounting • Circular economy business planning • Advanced quantitative data analysis • Greenhouse gas auditing and accounting • Climate science • Climate risk modelling 	<ul style="list-style-type: none"> • Environmental awareness • Innovation and creativity • Problem solving • Adaptability • Teamwork and collaboration • Systems analysis • Communication and influencing • Entrepreneurship

vocational education processes were collected: the ‘Framework Curriculum’ (ger. *Rahmenlehrplan*) created by the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany, and the ‘Vocational Training Regulation’ (ger. *Ausbildungsverordnung*) announced by the Federal Minister for Economic Affairs and Labour in 2004. In China, the ‘National Educational Programme Teaching Standard’ (chn. 专业教学标准, *zhuan ye jiao xue biao zhun*) and the ‘On-the-Job Internship Standard’ (chn. 顶岗实习标准, *ding gang shi xi biao zhun*) issued by Chinese Ministry of Education were collected. These national-level documents provide a foundation for vocational institutions to design and implement their own internal curricula for their training programmes. Additionally, in Germany, three regional-level curricular documents⁵ (*Lehrpläne*) were obtained, whereas in China, no such regional curricular documents were available during the data collection phase. At the institutional level, various intramural documents from the targeted vocational institutions in both countries were gathered. These documents include, for example, institutional talent training programmes, syllabi, curriculum (teaching) standards, work plans for specific disciplines or learning modules, practical training regulations and instructional guidelines. Nevertheless, the data collection process faced notable limitations. A significant imbalance exists between the collected German and Chinese curricular documents, primarily due to restricted accessibility caused by data protection regulations governing school-internal curricula in

Germany. This limitation posed challenges to the depth and scope of interpreting the comparative findings derived from the curriculum analysis.

The collected curricular documents were analysed using a qualitative text analysis method, which has been shown to be well-suited for curriculum analysis (Chen et al. 2024; Levander and Mikkola 2009; Pilz et al. 2016). The data analysis in this study followed the qualitative text analysis procedure outlined by Kuckartz (2019) and was conducted by a multilingual researcher proficient in Chinese, English and German. This approach allowed for the direct analysis of the curricular documents in their original languages, thereby minimising the risk of information loss during translation (cf. Pilz 2021).

5 | Presentation of Research Findings

In this section, the findings from the analysis of Chinese and German curricular documents across different levels are presented to address the first two research sub-questions: (1) Which green skills have been integrated into the logistics vocational curricula? (2) In which elements of the curricula are these green skills integrated? These findings are organised by national context, starting with an overall picture of integrating green skills into the logistics vocational curricula. This is then followed by detailed insights spanning national to school-level

TABLE 3 | Framework for curriculum analysis (ILO 2022, 49–52).

Element	Typical meaning	Guiding questions for analysis
Objectives and level	Indicates the relationship of the curricula to occupations/the labour market and specifies the national qualification framework level	Do the objectives reflect the need for development of green skills in the logistics field?
Learning outcomes	Encompasses knowledge, skills and attitudes and grouping into modules	Do the learning outcomes include any green skills in the logistics field? Which green skills are specified as learning outcomes in the curricula?
Entry requirements	Specifies qualifications learners will need to take the curriculum	Do the entry requirements for the curriculum contain any prerequisites related to green skills in the logistics field for students?
Curriculum structure	Contains duration, sequencing, unit/module and location (school, workplace and distance/online)	Does the curriculum structure support the development of green skills? Are green skills integrated into existing units/modules or introduced through new units/modules?
Teaching, learning and assessment strategies	Suggests appropriate pedagogies and assessment criteria and methods	Do the suggested pedagogies and assessment methods adequately support the development of green skills? If so, which skills?
Resources	Refers to requirements and supportive materials for teaching and learning	Do the resources address any green skills? If so, which skills?
Destinations after graduation	Indicates possible pathways into employment or further learning	Does the curriculum indicate any employment opportunities related to greening in the logistics sector?
Teacher requirements	Indicates the competencies or qualifications required	Do teacher requirements contain any prerequisites regarding green skills in the logistics field?

TABLE 4 | Sample information and statistics.

Curricular documents	Accessibility of curricular documents	Number of sampled documents	
		China	Germany
National curricular standards	Accessible to the public	2	2
Regional curricular guidelines	Accessible to the public	/	3
School internal curricula (including instruction guidelines)	Accessible to educators and/or students within the institution	72 from 10 colleges	14 from 6 schools

curricula. Selected coded statements, translated by the researchers, are included as illustrative examples.

5.1 | Key Findings Concerning Green Skills in Chinese Logistics Vocational Curricula

In general, the integration of the green skills concept is evident in Chinese logistics vocational curricula at different levels (Figure 1), even though the directly translated term ‘green skills’ (chn. 绿色技能, *lǜ se jì néng*) is not explicitly mentioned in any analysed curricular documents. Instead, the term ‘sustainability competences’ (chn. 可持续发展能力, *ke chí xu fá zhan néng lì*) appears frequently in one national curriculum

standard and six internal school curricula, such as ‘this training programme cultivates ... high-quality well-skilled talents with ... professional ethics, innovative and entrepreneurial awareness, humanistic professionalism and *sustainability competences*, in addition to mastering logistics professional knowledge, technical skills and management methods ...’ (CN-S10-LM-SIC, 1). However, a precise definition of *sustainability competences* is lacking in these curricular documents in which the term is embedded. Based on the context of the coded sentences, it can be inferred that sustainability competences are categorised under general (green) skills, alongside professional ethics, innovation and other related aspects. Analysing the code frequencies revealed that generic green skills are more integrated into the curricula than logistics-specific green skills. Surprisingly, cross-sector green skills are almost entirely absent from

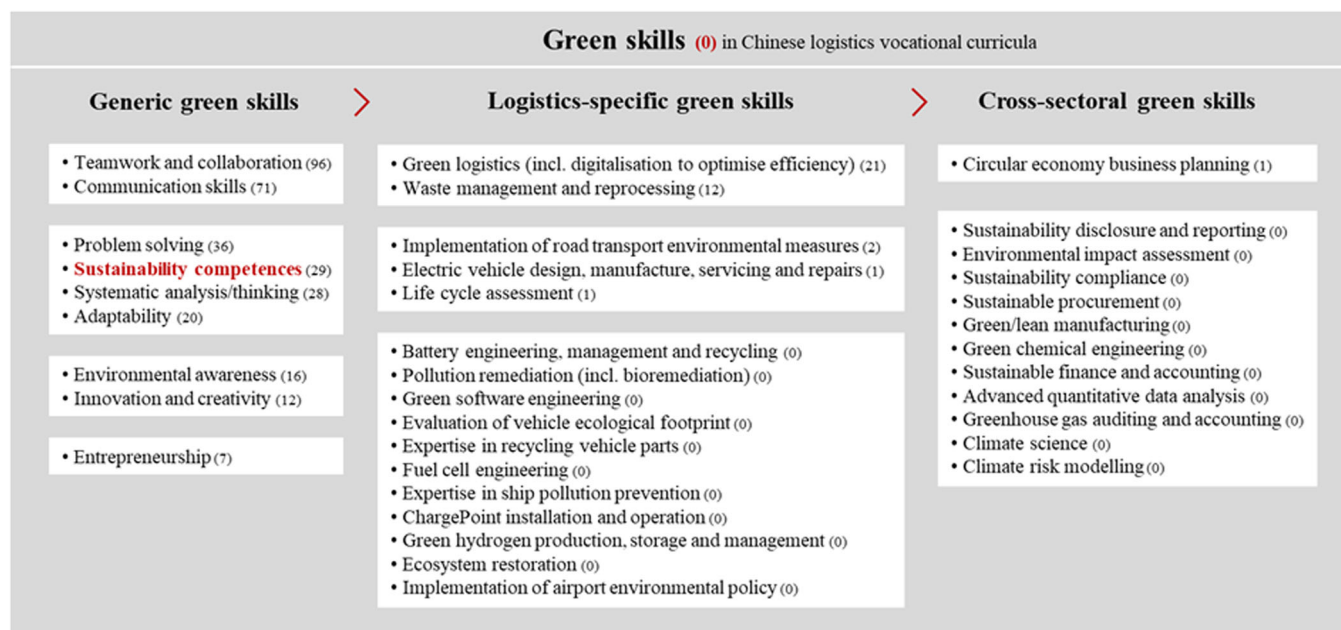


FIGURE 1 | Overview of the green skills embedded in the Chinese logistics vocational curricula (N = code frequencies). [Color figure can be viewed at wileyonlinelibrary.com]

the curricula in the Chinese samples. The only evidence found is in the content overview of a course called ‘Commodity Basics’ within an instructional guideline, which addresses the topic of ‘circular economy’ (CN-S7-LM-IG5, 53).

Findings from Chinese national curricular standards

At the national level, two curricular documents were analysed: the *National Teaching Standard for Logistics Management Training Programme* and the corresponding *On-the-Job Internship Standard*. No evidence of green skills integration is observed in the latter document concerning the practical training. Conversely, three subcategories of general green skills—*sustainability competences*, *environmental awareness*, and *systematic thinking*—were incorporated into the former document. *Sustainability competences* were emphasised in the overarching curriculum objectives, as described previously, but they were not explicitly defined or detailed. *Environmental awareness* and *systematic thinking* were specified as intended learning outcomes: ‘(students should) *acquire the knowledge related to environmental protection*’ (CN-NTS-LM, 3) and ‘(students should) be able to *apply supply chain integration design concepts* to solve real-world business problems’ (ibid., 4). However, no evidence was found to indicate that other curricular elements of the national curricula—curriculum structure, entry requirements, teaching and learning strategies, resources, post-graduation pathways, assessment, and teacher requirements—explicitly address the integration of these general green skills.

Findings from Chinese school internal curricula

The analysis of the integration of green skills into school internal curricula, based on the framework of this study, revealed that green skills were incorporated in a fragmented manner across various parts of the curriculum. At first, it is

worth noting that not all school curricula have adopted *sustainability competences* as specific objectives; however, these competences were included in the overarching objectives of the national curriculum standard. This is despite the fact that school curricula are theoretically expected to align with national curriculum standards.

It is evident that generic green skills, such as *teamwork*, *communication*, *problem solving*, *environmental awareness*, *innovative thinking* and *entrepreneurship*, were reflected in the analysed school curricula, listed mainly as intended learning outcomes. The integration of logistics-specific green skills, compared to those generic green skills, was often accompanied by specific teaching and learning strategies. For instance, it was recommended that the content about ‘material recovery and management for manufacturing companies’ could be better learned through company visits, whereas project-based learning was suggested for units covering ‘return management in reverse logistics’ (CN-S1-LM-SIC12, 18).

Furthermore, the results indicated that the integration of green skills into the curriculum structure varies. Some green skills, such as *awareness of green issues* and *environmental protection*, were embedded into existing modules or units through thematic learning activities. The *specific green skills related to reverse logistics* and *green supply chain management* were more integrated as new modules or extended projects within the core professional courses. However, the analysed documents did not reveal any new courses specifically created to address sustainable development topics in logistics or specifically to facilitate the development of green skills.

The resource element of the curriculum rarely addressed green skills. Only one curricular document suggested ‘using case study materials accessed through digital platforms’ (CN-S2-LM-SIC4, 12). This approach aimed to improve students’ learning

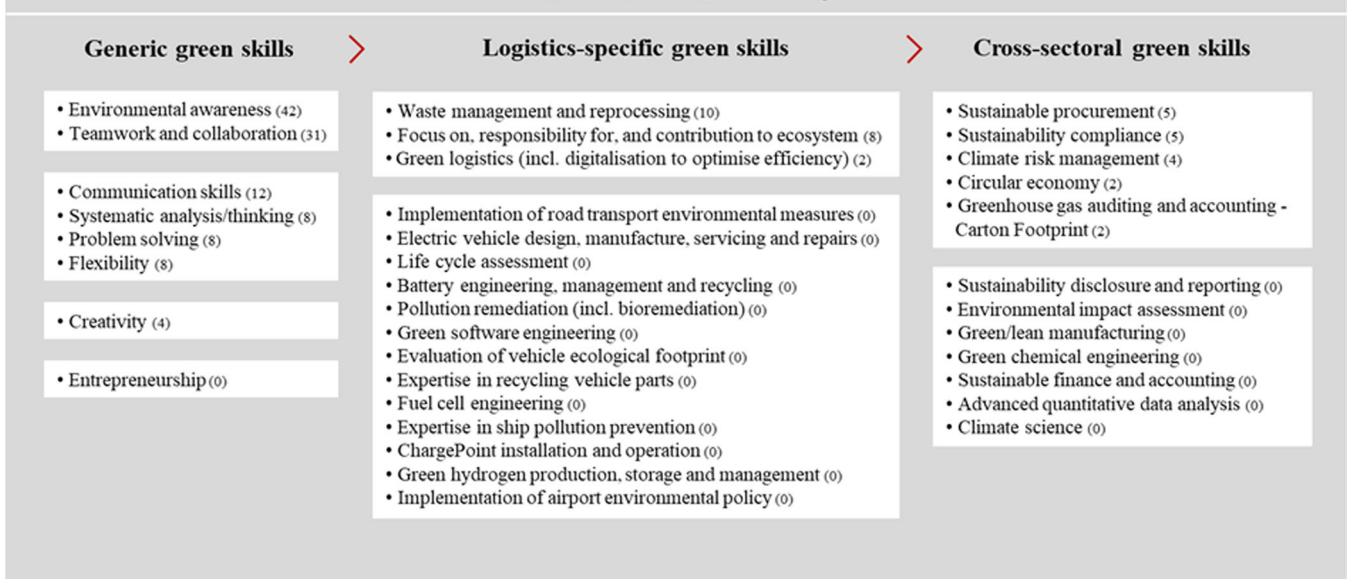


FIGURE 2 | Overview of the green skills embedded in the German logistics vocational curricula (N = code frequencies). [Color figure can be viewed at wileyonlinelibrary.com]

interest, enable resource reutilisation and save material costs, which could be considered related to green skills in principle. However, the analysed internal school curricula and instructional guidelines did not contain any requirements for responding teachers or students concerning green skills. These documents also did not indicate any employment opportunities related to greening in the logistics sector.

In summary, the integration of green skills within the analysed national curricula in China is notably limited. The focus is predominantly on general skills related to environmental awareness, with no specific attention given to logistics-specific or cross-sectoral green skills. In contrast to the national curricula, some school internal curricula in China, including instructional guidance documents, have begun incorporating green skills topics, such as *environmental protection*, *green logistics*, and *reverse logistics*, either by embedding them into existing learning units or by introducing new modules. However, the relevant references and explanations provided in these curricular documents remain highly fragmented and superficial.

5.2 | Key Findings Concerning Green Skills in German Logistics Vocational Curricula

The analysis results indicate that the concept of green skills is incorporated to varying extents into German logistics vocational curricula at different levels (Figure 2). Similar to the Chinese curricula, there is also no explicit mention of the term 'green skills' (ger. *grüne Kompetenzen*) or 'sustainability competences' in any analysed German logistics vocational curricula. The focus of the coded statements related to the green skills concept predominantly revolves around the environmental aspect of sustainable development. This is evidenced by the frequent use of

terms such as 'environmental protection and policy' (ger. *Umweltschutz und -politik*), 'environmental concepts' (ger. *Umweltkonzepte*) and 'environmentally friendly' (ger. *umweltschonend*). Overall, the majority of coded statements in the analysed German logistics vocational curricula pertain to generic green skills such as *environmental awareness*, *teamwork* and *communication*. The frequency of logistics-specific green skills codes slightly exceeds that of cross-sectoral green skills. Logistics-specific green skills related to reverse logistics and ecosystem management receive more attention in the German logistics vocational curricula, whereas the incorporation of skills related to green logistics is relatively rare. The integration of cross-sectoral green skills is notably broader than what was found in the Chinese curricula.

Findings from German national curricular standards

The analysis of the Framework Curriculum revealed valid evidence of incorporating all three subcategories of green skills into the objectives and intended learning outcomes across the existing learning fields. For example, in learning field 4—Comparing Modes of Transport and Processing Freight Orders in Road Haulage—the objectives specify that 'students are able to provide customer-oriented advice on selecting appropriate modes of transport, *considering factors such as transport policy, ecological sustainability, geographical conditions, and economic aspects. ...*' (DE-FC-KfSL, 12). Similarly, in learning field 12—Running and Organising Procurement Logistics—the objectives state that '... students evaluate procurement principles based on criteria of cost, production reliability, and *environmental protection*. They also contribute to developing a logistics concept. ...' (DE-FC-KfSL, 20).

In contrast, the Vocational Training Regulation contained relatively few references to the concept of green skills. Only *environmental protection* was explicitly included as part of the training occupation

profile, with the skills and knowledge to be acquired clearly defined as learning outcomes: ‘*Contribute to the prevention of environmental pollution within the professional scope of influence, specifically by: a) explaining potential environmental impacts caused by the training company and illustrating its contributions to environmental protection through examples; b) applying environmental protection regulations relevant to the training company; c) Utilising opportunities for the efficient and environmentally responsible use of energy and materials; d) Minimising waste and ensuring the environmentally friendly disposal of substances and materials*’ (DE-AVO-KfSL, 1906).

Moreover, *environmental awareness* was incorporated as a criterion in the final assessment: ‘... the candidate should demonstrate that he or she can solve practical operational tasks appropriately, take economic, technical, ecological, and legal contexts into account, and conduct discussions systematically and in a situation-related manner’ (DE-AVO-KfSL, 1903). However, other curricular elements, such as teaching and learning strategies, resources and post-graduation pathways, did not contain any references or statements related to green skills.

Findings from German regional curricular guidelines

The national curriculum allows regions to either directly adopt it or develop their own regional curricula (cf. DE-RLP-KfSL, 2). Therefore, in this study, three regional curricula, which differ from the Framework Curriculum, were collected and analysed separately.

When comparing the integration of green skills into the learning objectives, there were minimal differences between the regional and national curricula. Although these three regional curricular guidelines adhered to the training objectives and content outlined by the national curriculum, they offered more specific suggestions and examples regarding the intended learning outcomes in the learning fields, along with recommended teaching and learning strategies: e.g. ‘in the vocational training programme for Management Assistant for Freight Forwarding and Logistic Services, opportunities for *interdisciplinary cooperation* exist, such as *on the topic of ‘Globalisation and Sustainability’ in conjunction with the subject of politics and social studies*’ (DE-NRW-LP-KfSL, 21).

Regarding the curriculum structure for supporting the development of green skills, it was evidential that all coded green skills were generally integrated into existing learning fields through specifically designed learning situations, rather than creating entirely new learning fields. Within these learning situations, the analysed regional curricular guidelines offered examples or leading questions of thematic areas to promote in-depth learning in the Training Programme for Freight Forwarding and Logistic Services. Moreover, the thematic areas were not simply listed in the curricular documents, the relevance and connections between these areas were explicitly articulated as well: ‘In the learning fields, the development of logistics-related professional activities is reflected in initial training through the inclusion of procurement and distribution logistics, as well as warehouse logistics. Beyond this function-specific focus, *connections to production and disposal logistics* are also highlighted, fostering a *comprehensive understanding of logistics as interconnected process chains*’ (DE-NRW-LP-KfSL, 42).

Findings from German school internal curricula

The integration of green skills in the analysed school-level curricula exhibited significant variation across the analysed samples. Some curricular documents provided relatively comprehensive training content and pedagogical guidance on integrating green skills, organised by each existing learning field. For instance, one school internal curriculum addressed a wide range of topics related to specific logistics green skills, such as *CO₂-neutral logistics, laws and regulations on occupational and environmental protection in warehouses, tasks and types of recycling and waste disposal logistics, with references to the Circular Economy Act*. Additionally, it covered general sustainability themes, including *economic, environmental, and social responsibility*, as well as *carbon footprint and environmental management* (DE-S6-SIC-KfSL, 5–13).

In contrast, some documents resembled internal teaching and learning records. For example, entries such as ‘expert survey (company, e.g. environmental officer)’, ‘use of films to visualise conflicting sustainability goals between economics and ecology’ and ‘presentation of own food consumption and its CO₂ footprint using spreadsheets and other visualisation tools’ were documented as teaching methods or media used in the didactic annual planning (Ger. *Didaktische Jahresplanung*) of one school (DE-S2-DJP-KfSL, 3, 4).

Additionally, it is notable that not all green skills outlined in the national and regional curricula were precisely incorporated into the school internal curricula, even within documents that cover the same learning fields.

The analysed German logistics curricula at all three levels did not include any requirements for teachers or students related to green skills, nor did they highlight any opportunities for green jobs within the logistics sector that pertain to sustainability initiatives.

In summary, the analysis indicates that the integration of green skills within the analysed logistics curricula in the German cases remains limited, predominantly confined to the levels of objectives and content, despite an overarching emphasis on three categories of green skills. Additionally, the findings reveal that the analysed German curricula exhibit a more explicit incorporation of green skills at the national and regional levels, albeit with less consistency at the school or teacher level. However, it is important to note that, due to the limitations in data collection, the findings of this study are specific to the analysed cases and should not be generalised to other contexts.

6 | Discussion and Conclusion

The comparative analysis of green skills integration into logistics vocational curricula in China and Germany reveals both shared priorities and distinct differences between the two countries. This section will discuss and interpret the comparative findings within their respective contexts (Figure 3), reflect on the study’s limitations and outline potential directions for further research.

Green skills		China		Germany		
Integrated Green Skills*	Generic green skills	<ul style="list-style-type: none"> Teamwork and collaboration (96) Communication skills (71) Problem solving (36) Systematic analysis/thinking (28) Adaptability (20) Environmental awareness (16) Innovation and creativity (12) Entrepreneurship (7) 		<ul style="list-style-type: none"> Environmental awareness (42) Teamwork and collaboration (31) Communication skills (12) Systematic analysis/thinking (8) Problem solving (8) Flexibility (8) Creativity (4) 		
	Logistics-specific green skills	<ul style="list-style-type: none"> Green logistics (incl. digitalisation to optimise efficiency) (21) Waste management and reprocessing (12) Implementation of road transport environmental measures (2) Electric vehicle design, manufacture, servicing and repairs (1) Life cycle assessment (1) 		<ul style="list-style-type: none"> Waste management and reprocessing (10) Focus on, responsibility for, and contribution to ecosystem (8) Green logistics (incl. digitalisation to optimise efficiency) (2) 		
	Cross-sectoral green skills	<ul style="list-style-type: none"> Circular economy business planning (1) 		<ul style="list-style-type: none"> Sustainable procurement (5) Sustainability compliance (5) Climate risk management (4) Circular economy (2) Greenhouse gas auditing and accounting - Carton Footprint (2) 		
Non-integrated Green Skills**	Generic green skills			<ul style="list-style-type: none"> Entrepreneurship (0) 		
	Logistics-specific green skills	<ul style="list-style-type: none"> Battery engineering, management and recycling (0) Pollution remediation (incl. bioremediation) (0) Green software engineering (0) Evaluation of vehicle ecological footprint (0) Expertise in recycling vehicle parts (0) Fuel cell engineering (0) Expertise in ship pollution prevention (0) ChargePoint installation and operation (0) Green hydrogen production, storage and management (0) Ecosystem restoration (0) Implementation of airport environmental policy (0) 		<ul style="list-style-type: none"> Implementation of road transport environmental measures (0) Electric vehicle design, manufacture, servicing and repairs (0) Life cycle assessment (0) Battery engineering, management and recycling (0) Pollution remediation (incl. bioremediation) (0) Green software engineering (0) Evaluation of vehicle ecological footprint (0) Expertise in recycling vehicle parts (0) Fuel cell engineering (0) Expertise in ship pollution prevention (0) ChargePoint installation and operation (0) Green hydrogen production, storage and management (0) Implementation of airport environmental policy (0) 		
	Cross-sectoral green skills	<ul style="list-style-type: none"> Sustainability disclosure and reporting (0) Environmental impact assessment (0) Sustainability compliance (0) Sustainable procurement (0) Green/lean manufacturing (0) Green chemical engineering (0) Sustainable finance and accounting (0) Advanced quantitative data analysis (0) Greenhouse gas auditing and accounting (0) Climate science (0) Climate risk modelling (0) 		<ul style="list-style-type: none"> Sustainability disclosure and reporting (0) Environmental impact assessment (0) Green/lean manufacturing (0) Green chemical engineering (0) Sustainable finance and accounting (0) Advanced quantitative data analysis (0) Climate science (0) 		
Adapted Curricular Elements for Green Skills Integration		National curricular standards	School internal curricula	National curricular standards	Regional curricular guidelines	School internal curricula
Objectives		✓	✓	✓	✓	✓
Learning outcomes		✓	✓	✓	✓	✓
Entry requirements		×	×	×	×	×
Curriculum structure		×	✓	✓	✓	✓
Teaching and learning strategies		×	✓	×	✓	✓
Assessment strategies		×	×	✓	×	×
Resources		×	(✓)	×	×	×
Destinations after graduation		×	×	×	×	×
Teacher requirements		×	×	×	×	×

* Green skills that are, to some extent, already integrated into the analyzed logistics vocational curricula.

** Green skills that are not yet addressed into any analyzed logistics vocational curricula.

FIGURE 3 | Summary of the comparative findings on the integration of green skills in the Chinese and German logistics vocational curricula (N = code frequencies).

Similarities in integrated green skills in curricula

Drawing on the concept of green skills outlined in this study, a key similarity in the findings is that the analysed curricula of both countries tend to integrate more general green skills compared to logistics-specific or cross-sectoral green skills. This

predominance of generic green skills can be attributed to the fact that these skills are not exclusive to green jobs but rather represent conventional transferable skills that have been integrated into curricula for decades. Consequently, it is unsurprising that these general green skills are relatively widely embedded in the analysed curricula.

In contrast, the limited incorporation of logistics-specific and cross-sectoral green skills can be explained by two primary factors. First, the lack of intra-industry standardisation regarding the green skills required for key logistics occupations in the context of the green transition, as well as an absence of a global consensus on cross-sectoral green skills, hinders their systematic inclusion in the logistics vocational curricula across different national contexts. Second, the methodological limitations of this study, as outlined in Section 4 on research design, may have contributed to the observed under-representation of these conceptualised green skills within the analysed curricula.

Although the concept of green skills adopted from Economist Impact (2024) is both recent and highly relevant, its focus and scope remain narrowly centred to the job market demands and the perspective of business leadership. When applying this concept to curriculum analysis, this framing reveals significant conceptual limitations. Specifically, it tends to prioritise immediate occupational needs, often overlooking the broader systemic, educational and developmental dimensions essential for a more comprehensive understanding and integration of green skills. Hodge, Mavin, and Kearns (2020) emphasised two critical hermeneutic dimensions in the progressive process of interpreting and integrating competencies into VET practice: first, the translation of competencies required in professional practice into competency frameworks or texts, and second, the subsequent translation of these texts into corresponding educational activities and curricula in competency-oriented vocational education (35–36). In this context of integrating green skills into logistics vocational education and its curricula, there is a notable gap in efforts to conceptualise green skills specifically for key logistics occupations, as well as in further operationalising these green skills into actionable training programmes and curricula. This misalignment between professional practice, competency frameworks and educational design limits the potential for green skills to be effectively embedded into logistics education.

This situation underscores the need for policymakers and training developers to collaborate on green skills in the future.

Another issue arises from the ambiguous understanding of ‘sustainability competence’ in the Chinese case, which presents significant uncertainty in interpreting curriculum objectives. It remains unclear whether this term aligns with the notion of *key competences for sustainability* as described by Bianchi (2020) and Wiek, Withycombe, and Redman (2011), emphasising systemic, anticipatory and strategic thinking to address complex global challenges; or if it corresponds to *personal competences for individual sustainable development*, as discussed by Montanari, Agostini, and Francesconi (2023), which focus on personal agency, ethical values, and sustainable behaviours. This conceptual ambiguity directly affects curriculum interpretation and alignment, making it difficult to assess the depth and adequacy of green skills integration.

The distinction between these two interpretations has implications for how curriculum objectives are framed and implemented. If sustainability competences are primarily conceptualised as the *key competences for sustainability*, curriculum design tends to align with the emancipatory approach that emphasises equipping learners

with systemic problem-solving skills and leadership capacities to drive sustainability transitions (cf. Wals and Benavot 2017, 4). Conversely, an emphasis on the *personal competences for individual sustainable development* steers curriculum development towards an instrumental approach, prioritising the cultivation of individual responsibility, ethical decision-making, and sustainable lifestyles (ibid.). This lack of consensus on which interpretation to adopt not only complicates curriculum design but also raises broader concerns about the coherence of educational strategies aimed at advancing sustainability.

A similar lack of clarity is also evident in the German case, where terms like ‘green skills’, ‘sustainability competences’ or ‘competences in the context of the green transition’ are not explicitly defined in any of the analysed curricular documents across different levels. The variability in conceptualisation and interpretation of ‘green skills’ and ‘sustainability competences’ across cultural and linguistic contexts, as discussed in Section 3, underlines the inherent difficulties of integrating globally shared concepts into localised vocational curricula.

This absence of clear definitions reflects broad challenges in contextualising and operationalising global or foreign concepts within local educational frameworks. These challenges risk misalignment with local educational goals and practices, leading to inconsistencies in how sustainability is approached and implemented. To address this, establishing precise definitions and comprehensive conceptual frameworks is crucial. Such clarity would help minimise the risk of misinterpretation or misleading outcomes and facilitate a more consistent and effective integration of green skills into vocational curricula. This would ensure better alignment with global sustainability goals while addressing local educational priorities.

Differences in the approaches to integrating green skills

Based on the findings of curriculum analysis, the integration of green skills into the logistics vocational curricula in China and Germany varies in emphasis, coherence and approach, shaped by the structural and cultural characteristics of each country’s VET system.

In the Chinese case, the integration of green skills in the analysed national curricular documents appears fragmented and predominantly general in nature, with limited emphasis on logistics-specific or cross-sectoral green skills. Compared to the lack of explicit definitions and the superficial embedding of sustainability competences at the national level, school-level curricula demonstrate a broader and more explicit integration of various types of green skills. These are not only embedded in learning objectives and intended learning outcomes, but are also incorporated in teaching and learning strategies within existing courses or modules. This disparity underlines a systemic incoherence between national curricular frameworks and school-level curricula, reflecting a predominantly bottom-up approach to green skills integration. While national-level curricula offer limited direction or specific prescriptions for green skills development, school-level curricula exhibit diverse and contextually tailored implementations. This pattern can be attributed to two main factors. On the one hand, the Chinese national-level curricula serve as minimum standards, providing

overarching guidelines for the development of school-level curricula across different provinces and regions. Due to significant disparities in the educational development across these provinces and regions, provincial governments can exercise a degree of autonomy to design and promote tailored VET practices for their regional economic and social needs (MoE of China 2014). On the other hand, this heterogeneity is not only confined to differences between regions, but is also evident within one individual region, where vocational colleges adopt varying approaches to the curriculum integration. As a result, the embedding of green skills within school-level curricula varies widely, reflecting regional and institutional heterogeneity. The findings further indicate that the analysed VET curricula primarily reflect ‘cosmetic reform’, as the integrated green skills are often mentioned only briefly in the objectives and learning outcomes, with limited detailed guidance on the corresponding pedagogical approaches. According to the adapted theoretical framework of ‘responding action’ in the VET curricula based on the Sterling’s (2004) model, this pattern in the Chinese case can be characterised as a ‘Bolt-on’ approach to integration. In this approach, existing practices are only marginally adjusted rather than being reflectively adapted or fundamentally reimaged to fully embrace green skills in the VET curricula.

In contrast, the analysed German curricula exhibit a more comprehensive and explicit integration of different types of green skills. At the national and regional levels, green skills tend to be more broadly incorporated into the objectives and learning outcomes, whereas at the school level, they are incorporated more specifically into the content of existing learning fields and the corresponding teaching and learning strategies. This pattern demonstrates a top-down approach to integration, starting from national frameworks and cascading down to regional and school curricula. Drawing on the adapted theoretical framework derived from Sterling’s model (Section 2), the intention of this approach appears to practice a ‘Built-in’ incorporation of green skills, enriched and contextualised at both school and practitioner levels, and consequently to achieve a ‘serious greening’ of the VET curricula. However, the findings in this study reveal that green skills are still under-integrated in the logistics school internal curricula, remaining also largely at the stage of ‘cosmetic reform’. These inconsistencies at the school level highlight significant gaps in translating the overarching objectives into localised practices. As a result, opportunities for critically reflective adaptation and reform are missed, limiting the potential for deeper transformations in both pedagogical approaches and institutional paradigms.

It is undeniable that the under-integration of green skills in the analysed logistics vocational curricula of both national contexts can, to some extent, be attributed to the methodological limitations of this study, particularly the lack of access to extensive data sampling and collection. Future research should prioritise expanding the scope of data collection to include diverse regions and VET organisations, enabling a more comprehensive curriculum analysis. Moreover, the influence of the hidden curriculum within textbooks and other teaching materials (cf. Cornbleth 1984; Lee 2014) may also play a role in the

insufficient integration of green skills into the intended curricula at the school level. Future research should explore the integration of green skills within these hidden dimensions of the curriculum by analysing corresponding textbooks and supplementary materials. Such investigations could provide a more nuanced understanding of how green skills are operationalised—or overlooked—in educational practice and inform strategies to enhance the integration of green skills into vocational curricula and their effective implementation.

In conclusion, the comparative analysis of curricular documents from both national contexts offers valuable insights into the similarities and differences in how green skills have been integrated into logistics vocational curricula. Using the adapted model of responding actions in VET curricula to sustainability transitions as a framework, it becomes evident that although both contexts exhibit some evidence of green skills integration, their logistics vocational curricula predominantly remain at the stage of ‘cosmetic reform’.

In the scope of this study, the integration of green skills within the Chinese logistics vocational curricula lacks depth, breadth, and coherence. These curricula could benefit from systemic reforms to better align national and school-level objectives, adopting a more transformative perspective. Such a shift could help establish a cohesive framework for green skills development, ensuring that sustainability principles are embedded across all levels of vocational education and training. In contrast, the German logistics vocational curricula show a stronger foundation for systemic learning, as reflected in the analysed documents. However, the limited integration of green skills at the school level highlights the need for enhanced operational support during the top-down implementation process. Bridging the gaps between national directives and their practical application in vocational schools requires targeted measures to ensure the systematic and coherent embedding of green skills across curricular levels. These efforts would contribute to achieving a more ‘serious greening’ of VET curricula. Both cases underline the potential of vocational education to act as a driver for sustainability transitions, provided that a systemic and transformative perspective is fully embraced. This requires moving beyond superficial reforms to address structural and pedagogical barriers to embedding green skills into curricula and their practices.

This study also identifies several key strategies for enhancing the integration of green skills into logistics vocational education. These include standardising the green skills required for key logistics occupations transitioning to sustainable practices, developing a global consensus on cross-sectoral green skills in the logistics industry, and engaging in greater conceptual and hermeneutic efforts to define green skills specifically for vocational education programmes and their curricula. Additionally, the findings of this study emphasise the importance of explicit embedding pedagogical approaches that cultivate green skills within curricula at both national and school levels. This would provide clear guidance for educators across diverse VET contexts, enabling them to adopt teaching and learning practices that effectively promote green skill development. By addressing these areas, vocational education and training can better align with broader sustainability goals and equip learners with the

competences needed to navigate and actively contribute to the green transition in their professional fields from a transformative perspective.

Acknowledgements

Open Access funding enabled and organized by Projekt DEAL.

Conflicts of Interest

The author declares no conflicts of interest.

Endnotes

¹More detailed information about the research projects is available at the following link: <https://www.bibb.de/de/60709.php>.

²The *Green New and Emerging Occupations*, as defined by the National Center for O*NET Development, refer to new occupations created in response to the growing impact of green economy activities and technologies, necessitating unique skills and worker requirements, such as blockchain engineers (Dierdorff et al. 2009).

³Sustainability competences are defined as ‘the interlinked set of knowledge, skills, attitudes, and values that enable effective, embodied action in the world with respect to real-world sustainability problems, challenges, and opportunities, according to the context’ (Bianchi 2020, 2; Wiek, Withycombe, and Redman 2011).

⁴This report, launched by Economist Impact in 2024, identifies green skills in four sectors, including logistics. It draws on data and insights from over a thousand business leaders worldwide (including China and Germany) who work in these sectors. Consequently, the report provides evidence of the actual demand for green skills from the perspective of the job market and employers in the logistics sector. This information can serve as a convincing reference for conceptualising green skills in logistics, supporting the analysis of their curriculum integration in this study.

⁵The curricular documents for the training programme *Management Assistant for Freight Forwarding and Logistic Services* at the regional level were collected from the federal states of North Rhine-Westphalia, Baden-Württemberg and Saxony. These states have adapted their curricular documents based on the national Framework Curriculum, rather than adopting it directly.

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