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# Challenges of Integrating Green Skills in the Indonesian Vocational Training System

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**Keywords**
Green skills; vocational training; green economy; green workforce; industrial transformation

**Abstract**
The transition toward a green economy necessitates a workforce equipped with green skills as a core competency to support industrial sustainability and competitiveness. However, the integration of green skills into the vocational training system in Indonesia continues to face various structural challenges and has yet to be managed in a systematic manner. This study aims to analyze the concept of green skills through the lens of the most recent literature, identify the challenges of their integration within vocational training institutions, and examine early practices of green skills implementation through a case study at the LPP Quantum Sampit Vocational Training Institute (*Lembaga Pelatihan Profesi Quantum Sampit*). The research employed an integrative literature review combined with an explanatory case study approach, utilizing policy document analysis, international reports, and graduate tracer data from LPP Quantum Sampit for the period 2022–2025. The findings reveal six principal challenges in the integration of green skills: limitations in the existing policy framework; a curriculum that is not yet oriented toward green principles; insufficient instructor competence; inadequate training facilities and equipment; increasingly complex industry demands; and the absence of established green skills certification standards. These findings serve as the basis for the formulation of conceptual recommendations in the form of a five-pillar green skills integration framework, proposed as a strategic effort to strengthen the vocational training system in supporting Indonesia's transition to a green economy.

## INTRODUCTION

The transition to a green economy is becoming a global strategic agenda that changes the structure of labor needs in various sectors (Pavlova & Singh, 2022). The International Labour Organization (ILO) projects that the transformation towards a green economy will create more than 24 million new jobs by 2030, mainly in the clean energy sector, sustainable agribusiness, and resource-efficient manufacturing industries (ILO, 2022). This change places green skills as a fundamental competency that workers need to adapt to low-carbon production processes. The OECD's latest report (2025) confirms that countries that fail to prepare a workforce with green competencies will experience a decline in global competitiveness and the risk of productivity stagnation. This condition shows that the development of green skills is no longer an option, but a strategic need in the national development agenda (Pavlova, 2016).

Indonesia faces greater urgency given the direction of national development policies and the Golden Indonesia 2045 roadmap, underscoring the importance of strengthening the green competence of the workforce in supporting sustainable industrialization (Bappenas, 2020). The challenges are increasingly complex because

most of Indonesia's workforce is still working in labor-intensive sectors that have not fully implemented green production practices. The palm oil industry, as one of the largest sectors in Central Kalimantan with a significant contribution to GDP and exports, is under global pressure to ensure a sustainable supply chain (Özakın et al., 2025). Certifications such as RSPO and ISPO require the implementation of strict environmental standards, including energy efficiency, waste management, safe chemical use, and ecosystem protection (RSPO, 2024). Therefore, the need for vocational workers with green skills is becoming increasingly urgent, especially in plantation center areas such as Central Kalimantan (Zulfadly Mohd Zubir et al., 2021).

Vocational training has a strategic role in producing an operational workforce that meets the needs of the industry. UNESCO (2022) states that modern TVET must place green skills at the core of the 21st century curriculum so that graduates are able to contribute to a low-carbon economy. However, various recent studies show that the integration of green skills in the Indonesian vocational training system is still weak, fragmented, and does not yet have clear national competency standards (Cedefop, 2023; Pavlova & Singh, 2022). Some vocational institutions even still rely on traditional curricula that have not adopted the needs of environmentally friendly skills (Thunqvist et al., 2023). These findings underscore the gap between the needs of the industry and the quality of graduates of training institutions.

Theoretically, green skills refer to a set of technical and non-technical abilities that allow a person to work efficiently and sustainably. According to Pavlova, (2019), green skills include technical skills such as waste management, use of renewable energy, maintenance of green equipment, to non-technical skills such as environmental awareness, problem-solving skills, collaboration, and sustainability values. Various developed countries have made green skills as the basic framework of TVET. Australia, for example, has integrated the green jobs framework in vocational training since 2018, while Germany has included it in the dual system curriculum since 2020 (OECD, 2025). These practices show that green skills are not only related to technical aspects, but also related to changes in mindset and work culture.

The problem of this research arises from the gap between ideal conditions (das sollen) and reality in the field (das sein). Normatively, Indonesia already has a green development policy, green industry regulations, and a commitment to the SDGs (United Nations, 2025). Ideally, vocational training institutions are able to integrate green skills into the curriculum, provide competent instructors, and facilitate resource-efficiency-based learning practices (ILO, 2022). However, the reality shows that most training institutions still focus on conventional technical skills. Cedefop research (2023) found that many vocational institutions in developing countries do not have instructors with adequate environmental competence, practice facilities do not yet support green technology, and there is no standardized green skills evaluation mechanism. This gap is increasingly evident in non-formal training institutions in areas that have limited access to learning resources (Thunqvist et al., 2023).

In the context of the palm oil industry, this gap is increasingly critical. A study by Sumarno et al. (2022) found that new workers in the palm oil industry often find it difficult to meet company sustainability standards due to a lack of environmental literacy since the training period. In fact, the international market's demands for sustainability are getting tighter. Thus, the issue of green skills does not only concern education, but also the image of the Indonesian palm oil industry in the global market (Wedayanti et al., 2023).

Analysis of previous research shows that most studies on green skills in Indonesia focus on formal education levels such as vocational schools and polytechnics (Pavlova & Singh, 2022). Studies on the integration of green skills in non-formal vocational training institutions, especially those based on the needs of the palm oil industry, are still very limited (Herdiansyah & Mamola, 2025; PAGE, 2024a). In addition, there is no comprehensive conceptual model to integrate green skills in non-formal training institutions in the regions, especially institutions that serve the needs of local industries such as LPP Quantum Sampit. The absence of this literature indicates that there is a research gap that needs to be filled.

The novelty (state of the art) of this article lies in its comprehensive approach that combines integrative literature review with explanatory case studies, an approach recommended for vocational education research that requires simultaneous mapping of practice and policy (Braun & Clarke, 2022; Snyder, 2019). This article not only identifies structural challenges in the integration of green skills, but also maps the actual conditions of its implementation in one of the non-formal vocational training institutions in the region, namely LPP Quantum Sampit. This effort to combine national policy analysis with local practice is in line with the OECD's (2025) and UNESCO's (2022) calls that emphasize the need for context-based TVET research to bridge the gap between regulation and field implementation.

In addition, this article identifies the structural challenges of green skills integration and synthesizes institutional strategic directions, one of which is represented in a five-pillar framework as conceptual implications. This model makes a theoretical contribution because it clarifies the structure of green competencies in the context of Indonesian TVET, which was previously still understudied; Cedefop, 2023). At the same time, this model also makes a practical contribution in the form of implementable recommendations that vocational training institutions can use to strengthen the green vocational ecosystem, especially in sustainable industrial sectors such as palm oil which increasingly need a workforce with green competencies (Wedayanti et al., 2023).

The purpose of this research is to present a comprehensive analysis of the challenges of integrating green skills in the Indonesian vocational training system, examine the initial practice of its implementation in LPP Quantum Sampit, and formulate a conceptual model that can be used to strengthen the capacity of vocational training institutions in supporting the transition to a green industry. This research provides theoretical benefits in the form of enriching literature on the integration of green skills in the non-formal vocational training system in Indonesia, as well as practical benefits as a

reference for training institutions, policy makers, and industry partners in developing strategies to strengthen the competence of the green workforce. This narrative formulation of goals is consistent with scientific writing standards that emphasize the coherence of argumentative flows in policy-driven TVET studies-based research (OECD, 2025; UNESCO, 2022)

## METHODS

This research used an integrative literature review approach combined with explanatory case studies to gain a comprehensive understanding of the integration of green skills in the vocational training system in Indonesia (Snyder, 2019). The integrative review approach was chosen because it is able to combine various empirical, conceptual, and policy findings so as to allow researchers to build new perspectives on complex and multidimensional phenomena (Braun & Clarke, 2022). Literature sources in this study include articles from international and national journals indexed by Scopus and Sinta, reports from international institutions such as the ILO, OECD, and UNESCO, as well as Indonesian government policy documents related to TVET, sustainable development, and the green economy agenda.

To strengthen the contextual relevance, this study applied an explanative case study to LPP Quantum Sampit (Snyder, 2019). This case study was carried out through curriculum analysis, learning practices, graduate tracking documents, and internal institutional reports for the 2022–2025 period. Data analysis was carried out using thematic analysis techniques to identify patterns, categories, and relationships between concepts related to structural challenges in the integration of green skills. Thematic analysis techniques were chosen because they were able to extract deep meaning from qualitative data and allow for systematic theoretical interpretation (Braun & Clarke, 2021). The combination of integrative review and explanatory case studies provides a strong methodological foundation to map the gap between green skills theory and its implementation in vocational training institutions, as well as formulate relevant conceptual models to support TVET's transformation towards a green economy (Cedefop, 2023; ILO, 2022; LinkedIn, 2025; OECD, 2025; UNESCO, 2022).

## RESULTS AND DISCUSSION

### 1. Challenges of Integrating Green Skills in the Vocational Training System

The integration of green skills in the vocational training system in Indonesia still faces structural challenges that are national in nature and rooted in systemic weaknesses, as also highlighted in a global report on the readiness of TVET developing countries in the face of the transition to a green economy (Pavlova & Singh, 2022; UNESCO, 2022). The results of the synthesis of integrative literature review and policy analysis show that these obstacles arise due to the lack of a solid regulatory foundation, the weak integration of sustainability concepts in the curriculum, limited instructor competence, inadequate green learning facilities, the dynamics of industry needs that develop faster than the response of training institutions, and the absence of structured green competency

certification standards. These findings are in line with the UNESCO (2022), OECD (2025), and Cedefop (2023) reports which confirm that developing countries tend to face systemic gaps in transforming vocational education and training towards a green economy. The six main challenges are summarized in Table 1 as the basis for further analysis of the readiness of the vocational training system in supporting the national sustainability agenda.

**Table 1.** Six Challenges of Green Skills Integration in the National Vocational Training System

| No. | Challenge | Description and Scientific Basis |
|---|---|---|
| **1** | Limitations of the National Policy Framework | Indonesia does not yet have green skills competency standards *in* SKKNI and KKNI, so vocational training institutions do not have a formal reference to develop a sustainability-oriented curriculum. The absence of this standard creates variations in implementation between institutions and makes green TVET policies run uncoordinated. These findings are in line with Cedefop (2023), which states that developing countries generally face regulatory gaps in the integration of green competencies, and the OECD (2025) which assesses that Indonesia's TVET policy framework is still partial and has not yet formed an integrated national strategy. |
| **2** | The training curriculum is not yet green-oriented | The vocational training curriculum in many institutions is still focused on conventional technical skills without including the principles of resource efficiency, circular economy, 3Rs, and clean production practices. UNESCO (2022) shows that TVET curricula in Southeast Asia, including Indonesia, have not responded systematically to the needs *of the green economy*. also emphasized that the green curriculum in Indonesia is still in the early stages of development, so it has not been able to meet the expectations of a sustainable industry. Pavlova & Singh, (2022) |
| **3** | Limited Instructor Competencies | The capacity of instructors in teaching green technology, environmental management, and sustainability pedagogy is still minimal. This limitation has an impact on the low quality of green *skills learning*. emphasizing that the lack of instructor training is a major obstacle to the adoption of green skills in Asia. UNESCO (2022) also noted that most TVET instructors in developing countries do not have formal training related to the environment and green technology. (Pavlova & Singh, 2022) |
| **4** | Training Facilities and Facilities Not Supporting | Many training institutions, especially in the regions, do not have learning facilities that support the practice of green skills such as energy laboratories, electricity efficiency measuring instruments, composters, or paperless-based digital learning systems. UNESCO (2022) emphasizes that the limitations of green infrastructure are a significant obstacle in practical learning, so green competencies are only obtained theoretically without applicable experience. |
| **5** | Increasingly Complex Industry Demands | Strategic industries such as palm oil, manufacturing, and renewable energy increasingly demand a workforce that understands sustainability principles and is able to work according to global standards. The ILO (2022) projects that the transition to |

| | | |
|---|---|---|
| | | a green economy will create millions of new jobs that require technical competence and environmentally oriented behavior. |
| **6** | Absence of Green Skills Certification Standards | The absence of a national certification system for green skills makes it difficult for graduates' competencies to be verified by industry, thereby reducing trust in the workforce of vocational institutions. The OECD (2025) notes that Indonesia still lacks a standardized green competency assessment mechanism, while UNESCO (2022) emphasizes that the absence of certification schemes hinders the widespread adoption of *green skills* in the TVET ecosystem. |

Source: Compiled from various sources

The six challenges show that the weaknesses of integrating green skills in the vocational training system are not only technical, but also structural and institutional. One of the main obstacles is the lack of a national policy framework that explicitly regulates green competency standards for vocational training institutions (Pavlova & Singh, 2022). Although the government has affirmed the orientation of development towards a green economy in the 2025–2045 RPJPN document, this policy direction has not been operationally translated into competency standards and curriculum guidelines that can be used as a reference for TVET organizers (Thunqvist et al., 2023). This situation is clarified by national priorities that place the green economy as the focus of vocational development, as affirmed by the Coordinating Ministry for Human Development and Culture (2024), and strengthened by the preparation of the Indonesia Green Workforce Development Roadmap 2025–2029 which emphasizes the importance of strengthening green skills as part of the transition to a low-carbon economy (Bappenas, 2025). Unlike Australia or South Korea which have established green occupational standards as the basis for TVET development, Indonesia is still in the conceptual stage so that training institutions develop green skills initiatives in a non-uniform manner and tend to be reactive to industrial demands (OECD, 2025).

The second challenge arises from the training curriculum that is still predominantly technical-conventional (Alvunger, 2024; Pujun, 2025; Setiawan, 2017). Most of the curriculum of non-formal training institutions is still oriented towards basic job skills and has not included the principles of sustainability, energy efficiency, circular economy, or 3Rs as part of the core competencies. Pavlova & Singh, (2022) show that TVET institutions in Southeast Asia are still in the early phase of green skills integration. Indonesia's condition reflects the same phenomenon, where curriculum reform is slow and depends more on institutional initiatives than on national regulatory support.

The third challenge relates to the low competence of instructors in sustainability teaching. The Cedefop (2023) and Pavlova & Singh, (2022) studies confirm that instructors play a central role in the green TVET transformation process. However, most instructors do not have adequate training related to low-carbon technology, environmental management, or green pedagogy. As a result, green skills material is often only introduced theoretically without the instructor's ability to teach it in practice.

The fourth challenge is related to the limited learning facilities and infrastructure. Many vocational training institutions, especially in the regions, do not have facilities that support energy efficiency practices, waste management, or the use of green technologies. UNESCO (2022) shows that facilities are a determining factor in the success of learning sustainability practices; Without adequate facilities, green skills are difficult to teach applicatively.

The fifth challenge relates to the dynamics of changing industrial needs. The palm oil industry, as one of the main sectors in Indonesia, faces increasingly stringent international sustainability standards. Herdiansyah & Mamola, (2025) emphasized that workers must have skills in waste management, emission reduction, and zero burning practices. However, many training institutions have not adjusted their curriculum to the green competencies needed by the industry, so graduates are not fully prepared to face global demands (Pujun, 2025).

The last challenge is the lack of a standardized green skills certification system. Without a national certification scheme, the green competence of graduates is difficult to verify by industry. The OECD (2025) and UNESCO (2022) emphasize that certification is an important component in ensuring the credibility of competencies and improving workforce mobility. The absence of certification makes green skills do not yet have formal legitimacy, so their adoption by industry is still limited (Pavlova, 2019).

**2. Initial Practice of Green Skills Integration in LPP Quantum**

The results of the explanatory case study show that LPP Quantum Sampit has begun to adopt a number of initial practices in integrating green skills, although its implementation is still limited and systemically structured. The initial efforts made by the institution can be seen from the application of the 3R principle in the management of classrooms and computer laboratories. Participants are encouraged to reduce the use of paper, minimize plastic waste, and utilize digital teaching materials through e-learning platforms. These steps are in line with UNESCO's (2022) recommendations that digitalization of learning and resource efficiency are effective gateways to building a culture of sustainability in the TVET ecosystem.

In addition to the application of the principle of resource efficiency, LPP Quantum has developed Green Skills training courses and habitualized green behavior through various routine activities. Participants were trained to save electricity, sort waste, and participate in environmental awareness projects (Fawehinmi et al., 2024; Khaw et al., 2025). This habituation practice is relevant to the findings of Hosain et al., (2025), which emphasize that behavior change is a core component of green skills, especially for prospective workers in land-based industrial sectors such as oil palm plantations.

Another driving factor comes from the industry's increasingly high need for a workforce with green competencies (Fuchs, 2024). Data traced by LPP Quantum graduates for the 2022–2025 period shows that most of the alumni are absorbed in the oil palm plantation and mill administration sectors, sectors that demand an understanding of energy efficiency, environmental documentation, sustainable SOPs implementation, and compliance with international standards such as RSPO and ISPO (PAGE, 2024). These

findings indicate that the integration of green skills is not only important from an institutional perspective, but also has direct relevance to the real needs of the world of work.

**Table 2.** LPP Quantum Graduate Search 2022–2025

| No | Sector | Year | | | | Quantity |
|---|---|---|---|---|---|---|
| | | 2022 | 2023 | 2024 | 2025 | |
| 1 | Agribusiness/Plantation | 51 | 58 | 69 | 47 | 225 |
| 2 | Mining | 0 | 0 | 0 | 1 | 1 |
| 3 | Trade and Retail | 35 | 38 | 42 | 22 | 137 |
| 4 | Services | 21 | 28 | 31 | 17 | 97 |
| 5 | Technology / IT | 7 | 5 | 3 | 2 | 17 |
| 6 | Government/SOEs/BUMD | 5 | 11 | 4 | 3 | 23 |
| 7 | Entrepreneur / Startup | 16 | 13 | 14 | 9 | 52 |
| | Quantity | 135 | 153 | 163 | 101 | 552 |

Source: LPP Quantum VET-C Career Center (2025)

Based on this data, during the 2022–2025 period LPP Quantum has produced a total of 723 graduates, with 552 graduates (76%) having worked in various industrial sectors. The three largest absorption sectors are agribusiness/plantation (225 graduates), trade and retail (137 graduates), and service sector (97 graduates). The dominance of the agribusiness/plantation sector shows LPP Quantum's strategic position in supplying labor for the palm oil industry, which is the main economic sector in Central Kalimantan, especially East Kotawaringin, Seruyan, and Katingan Regencies. The sector continues to face global pressures related to deforestation, carbon footprints, and sustainable practices, requiring human resources who adequately understand green competencies (Neto et al., 2014; Ramli et al., 2020; Wegenberger & Ponocny, 2025).

However, the integration of green skills in LPP Quantum is still partial and has not been fully integrated into the entire curriculum. Green Skills training courses are available, but green competencies are not yet fully reflected in all core training subjects. Limited environmental practice facilities and the lack of instructors who have formal training related to green skills are the main obstacles in the implementation of sustainability-based learning. This condition shows the need for systemic institutional strengthening so that institutions can meet the demands of the palm oil industry which further tightens its sustainability parameters.

**3. Gap Analysis: National System vs Implementation of Vocational Institutions**

Analysis of the gap between national policies and implementation at the level of training institutions shows that there is a significant difference between ideal conditions (das sollen) and actual conditions (das sein). Normatively, the Indonesian government has committed to developing a green workforce through policy documents such as the SDGs National Action Plan and the Green Economy 2045 roadmap (Bappenas, 2020). However, the policy has not been downgraded into operational guidelines that regulate the standard mechanism for the integration of green skills in vocational institutions. The

absence of these guidelines causes the implementation of green skills to be highly dependent on institutional initiatives, not systemic obligations.

Reality on the ground shows that training institutions, including LPP Quantum, face limitations in terms of curriculum, facilities, and instructor competencies (UNESCO, 2022). At the national level, there are no specific competency standards that describe the elements of knowledge, skills, and behaviors that are categorized as green skills. On the contrary, countries such as Germany and Finland have developed a green skills framework that is measurable according to the needs of the industry (OECD, 2025). This gap shows that Indonesia does not yet have a clear strategic direction in preparing human resources for a green economy.

On the other hand, industry needs continue to grow rapidly (LinkedIn, 2024). The palm oil industry requires a workforce that understands land conservation, environmentally friendly harvesting techniques, and sustainability documentation needed for international audits (RSPO, 2024a). However, training institutions do not have a curriculum that specifically builds these competencies. This gap shows the insynchronization between the world of vocational education and the demands of industry. Gap is also seen in the aspect of learning evaluation. Indonesia does not yet have a standard green skills measuring tool to assess the ability of trainees. In fact, Cedefop (2023) emphasizes the importance of competency-based evaluations to ensure that graduates really have relevant green skills. This condition hinders institutions such as LPP Quantum in proving that their graduates have green competencies that can be accounted for in the world of work.

**4. Conceptual Model of Green Skills Integration for Indonesia**

The results of the literature review and gap analysis show that the integration of green skills in vocational training institutions in Indonesia requires a systemic approach that goes beyond curriculum changes alone (Handayani et al., 2021; Kamis et al., 2017). The transformation towards green TVET must depart from a framework that unifies institutional policies (Thunqvist et al., 2023), learning processes, instructor capacity, infrastructure support, and relationships with industry. UNESCO (2022) emphasizes that green skills development is only effective if it adopts a holistic institutional approach, which is a model that integrates all components of educational organizations. Cedefop (2023) also emphasized the importance of whole-system transformation to ensure green skills become a core competency, not a cosmetic addition to the curriculum.

Based on this, this study formulated a Five Pillars Model of Green Skills Integration which is designed to answer the structural challenges of Indonesian TVET while providing an implementive direction for non-formal vocational training institutions such as LPP Quantum. This model is adaptive to the context of national strategic industries, especially the palm oil sector which has sustainability demands through RSPO and ISPO certification (Herdiansyah & Mamola, 2025). These five pillars do not work separately, but reinforce each other and form a consistent green learning ecosystem. The following image shows the conceptual structure of the model.

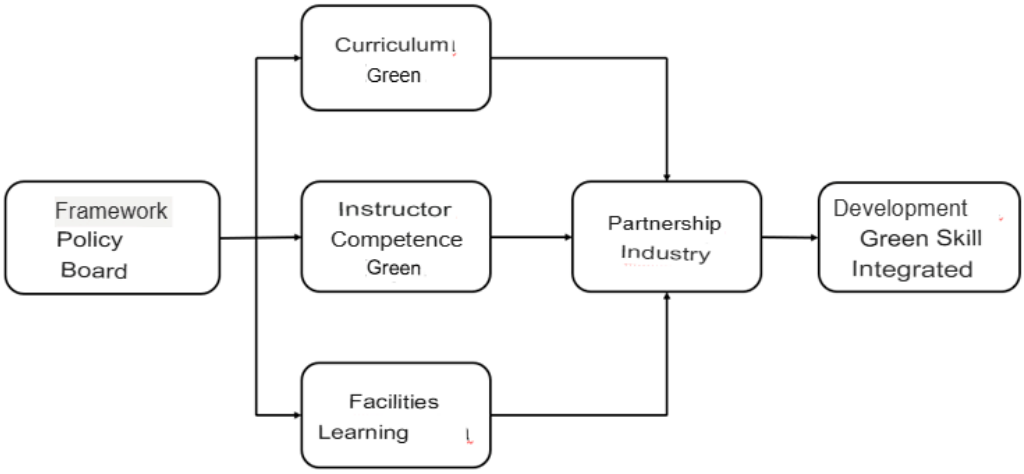


**Figure 1.** Synthesis of Challenges and Strategic Directions of Green Integration Skills in the Indonesian Vocational Training System
Source: Developed by the author based on UNESCO (2022), ILO, 2022, OECD (2025), Cedefop (2023).

This model starts from the need to strengthen the internal policy framework of vocational training institutions as the basic foundation of transformation (Thunqvist et al., 2023). In the absence of clear institutional policies, the integration of green skills tends to be partial and dependent on individual initiative (UNESCO, 2022). This policy framework includes the institution's green vision, operational guidelines, resource management, and sustainability practice standards that should be a reference for the preparation of training programs. The OECD (2025) emphasizes that the success of green competency integration is greatly influenced by the coherence of internal regulations that support the direction of national policies.

The development of a green curriculum is a core component of this model. The curriculum must include principles (Mutohhari et al., 2025), energy efficiency, waste management, emission mitigation, and the implementation of the 3R, so that trainees acquire technical competencies and behaviors relevant to industry demands (ILO, 2022; Zulfadly Mohd Zubir et al., 2021). Pavlova & Singh, (2022) note that the development of a green curriculum requires a paradigm shift in learning from conventional technical approaches to holistic sustainability approaches. In the context of the palm oil industry, the curriculum needs to be aligned with RSPO and ISPO standards that demand workers' skills in waste management, land conservation, and environmentally friendly work practices (Hossain et al., 2022; PAGE, 2024b).

Instructors have a central role in ensuring that green curriculum can be translated into learning practices (Kamis et al., 2017; Mutohhari et al., 2025). Environmental literacy, understanding of green technology, the ability to teach green pedagogies, and the competence to conduct green skills assessments are very important for the success of implementation. Cedefop (2023) shows that the low readiness of instructors is the biggest obstacle to developing green skills in developing countries. Therefore, increasing the

capacity of instructors should be an integral part of the green TVET strengthening strategy.

Learning facilities are also an important element in this model (Li & Pilz, 2023). The integration of green skills cannot be effective if learning only takes place theoretically without the support of a learning environment that allows for real practice (McGrath & Russon, 2023). Energy efficiency laboratories, composting units, waste management simulations, and digital infrastructure that support paperless learning are examples of facilities that can encourage the creation of sustainability-oriented learning experiences. UNESCO (2022) states that a green learning environment is a prerequisite to ensure that trainees are able to apply green competencies in an applicative manner.

All of these elements are then dynamically connected through strategic partnerships with industry. This partnership ensures that the competencies developed by the training institutions are aligned with the needs of the industrial sector, including the palm oil sector which has strict sustainability standards (McGrath & Russon, 2023). OECD (2025) emphasizes that the integration of green skills will be successful if training institutions develop strong relationships with the industrial world through curriculum collaboration, green apprenticeship programs, technology transfer, and graduate absorption (Kamis et al., 2017). In this context, the industry is not only a user of graduates, but also a partner in building sustainability competencies.

All pillars in this model are interconnected and form a single ecosystem of green skills development. The policy framework provides clear direction, the curriculum establishes the competencies that must be taught, instructors ensure that the learning process runs effectively, facilities provide practical learning support, and industry ensures the relevance of competencies to real needs. This model results in a green skills integration process that is not only structured but also sustainable. Figure 1 visually represents the relationship between the pillars, illustrating how the five pillars work simultaneously to produce green-certified graduates who are ready to face the challenges of a low-carbon economy.

Thus, this conceptual model makes a theoretical and practical contribution to efforts to strengthen the vocational training system in Indonesia. Theoretically, this model fills the gap in the literature related to the integration of green skills in non-formal training institutions, which has been very limited (Cedefop, 2023; UNESCO, 2022). In practical terms, this model offers an implementable strategy that can be applied by vocational training institutions, including in areas such as LPP Quantum, to prepare a competent workforce to face the transformation towards a green economy.

## CONCLUSION

This study confirms that the integration of green skills in the vocational training system in Indonesia still faces complex structural challenges, especially related to the absence of an operational policy framework, a curriculum that is not yet sustainability-oriented, limited instructor capacity, weak support for green facilities, and the dynamics of industrial needs that increasingly demand environmental competence. The case study

on LPP Quantum shows that although there have been initial efforts through the application of the 3R principles, digitization of learning, and the strengthening of green behaviors, the implementation is still partial and has not been fully integrated into the curriculum and learning process. The gap analysis between ideal conditions and actual conditions shows that the TVET ecosystem at the institutional and national levels still needs significant strengthening to be able to meet the demands of the palm oil industry and other green sectors. The findings of this study also confirm the importance of a systemic approach involving policy reform, curriculum reform, instructor competency improvement, provision of green learning facilities, and strategic partnerships with industry. The five-pillar conceptual model developed in this study offers a comprehensive framework for vocational training institutions to integrate green skills in a more structured and sustainable manner. By applying this model, training institutions can increase the relevance of graduates to the needs of green industries while contributing to the national transition agenda to a low-carbon economy. Thus, this research makes a theoretical and practical contribution to the development of green TVET in Indonesia, as well as opens up space for further research related to the evaluation mechanism and implementation of the model in various vocational training contexts.

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