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DEVELOPING GREEN EMPLOYABILITY SKILLS THROUGH VOCATIONAL EDUCATION: THE ROLE OF CURRICULUM INNOVATION AND INDUSTRY COLLABORATION

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ABSTRACT

The global transition toward a green economy is transforming labor markets and increasing the demand for sustainability-oriented competencies across industries. Technical and vocational education and training (TVET) institutions play a strategic role in preparing graduates who possess green employability skills that support environmentally responsible economic activities. However, many vocational education systems still rely on traditional curricula that inadequately integrate sustainability principles and socio-cultural dimensions of sustainable development. This conceptual paper develops an integrative framework explaining how curriculum innovation and industry collaboration contribute to the development of green employability skills in vocational education. Drawing upon Human Capital Theory and Stakeholder Theory, the study synthesizes interdisciplinary literature from vocational education, sustainability education, and workforce development. The proposed framework emphasizes that sustainability-oriented curriculum innovation enables the integration of environmental knowledge, cultural values, and responsible production practices within vocational training. In addition, collaboration between educational institutions and industry partners ensures alignment between educational programs and emerging labor market demands associated with green industries. The study further proposes that green employability skills mediate the relationship between curriculum innovation, industry collaboration, and sustainable workforce development. Beyond economic outcomes, these competencies contribute to broader socio-cultural transformation by fostering environmental responsibility, collaborative work practices, and sustainability-oriented professional identities. This study contributes to the literature by integrating vocational education, sustainability competencies, and socio-cultural perspectives on workforce development. The proposed framework provides theoretical and practical implications for policymakers, educators, and industry stakeholders seeking to strengthen sustainability-oriented vocational education systems.

KEYWORDS: Green Employability Skills, Vocational Education, Curriculum Innovation, Industry Collaboration, Green Skills, Sustainable Workforce.

1. INTRODUCTION

Environmental degradation, climate change, and resource depletion have intensified global discussions about sustainable development. Governments, industries, and international organizations increasingly recognize the need to transition toward a green economy that integrates environmental sustainability with economic growth and social inclusion (OECD, 2023). This transformation has significant implications for labor markets, as industries increasingly require workers who possess competencies related to sustainability, environmental responsibility, and resource efficiency.

In addition to economic and technological transformations, the transition toward a green economy also involves significant socio-cultural change. Sustainable production systems require not only technological innovation but also shifts in cultural values, professional identities, and workplace practices that emphasize environmental responsibility and collective action (Geels, 2011; Wiek et al., 2011). Within this context, vocational education institutions play an important role in shaping the socio-cultural dimensions of sustainability by cultivating environmental awareness, ethical responsibility, and collaborative competencies among future workers (Maclean & Pavlova, 2020; Pavlova, 2017).

The emergence of green jobs has reshaped workforce skill requirements across multiple sectors, including renewable energy, sustainable manufacturing, environmental management, and green construction (Bowen & Kuralbayeva, 2015). Workers in these sectors are expected to possess not only technical expertise but also sustainability-oriented competencies that enable them to contribute to environmentally responsible production systems.

These competencies are often referred to as green skills. Green skills encompass both technical and non-technical competencies. Technical competencies include knowledge related to renewable energy technologies, environmental monitoring systems, and sustainable production processes. Non-technical competencies include environmental awareness, problem-solving skills, teamwork, communication, and adaptability (Pavlova, 2017).

Together, these competencies form the foundation of green employability skills, which enable individuals to participate effectively in sustainable economic systems.

Educational institutions play a critical role in developing these competencies and preparing individuals for sustainable employment. Among various educational sectors, technical and vocational education and training (TVET) institutions are particularly important because they focus on practical skill development and workforce preparation (Pilz & Li, 2021).

However, many vocational education systems continue to rely on traditional curricula that emphasize conventional industrial practices rather than environmentally responsible production systems. As industries increasingly adopt sustainable technologies and green production processes, vocational education institutions must adapt their training programs to incorporate sustainability principles and green competencies (Sern et al., 2021).

One strategy for addressing this challenge is curriculum innovation. Curriculum innovation refers to the redesign of educational programs to respond to changing societal and technological needs (Fullan, 2016). In vocational education, curriculum innovation may involve integrating sustainability concepts into technical training programs and promoting environmentally responsible practices within learning activities.

Another critical factor in developing green employability skills is collaboration between vocational institutions and industry partners. Industry collaboration ensures that vocational training programs remain aligned with labor market demands and technological developments (Cedefop, 2021).

Despite increasing interest in sustainability education, research examining how curriculum innovation and industry collaboration jointly contribute to the development of green employability skills remains limited. Most existing studies focus on sustainability education in higher education rather than vocational education contexts (Lozano et al., 2020).

Therefore, this conceptual paper proposes a framework explaining how sustainability-oriented curriculum innovation and industry collaboration can support green employability skill development in vocational education.

2. LITERATURE REVIEW

2.1 Green Economy and Workforce Transformation

The concept of the green economy has emerged as a central framework for achieving sustainable development while maintaining economic growth. The green economy promotes economic activities that reduce environmental risks, enhance resource efficiency, and support sustainable development (OECD, 2023). This transition requires significant

structural changes in production systems, energy use, and workforce competencies across industries.

One of the most significant implications of the green economy is the transformation of labor market demands. Industries are increasingly adopting environmentally sustainable technologies and practices, which require workers to possess new types of competencies commonly referred to as green skills. Green jobs are defined as employment opportunities that contribute to preserving or restoring environmental quality while promoting economic growth (Bowen & Kuralbayeva, 2015).

According to the World Economic Forum (2023), the global shift toward sustainable industries will create millions of new jobs in sectors such as renewable energy, sustainable agriculture, green construction, and environmental services. However, the success of this transition depends on the availability of a workforce equipped with sustainability-related competencies.

Educational institutions therefore play a critical role in preparing individuals to participate in a green economy. In particular, technical and vocational education and training (TVET) institutions are expected to produce graduates who possess both occupational skills and sustainability competencies required by emerging industries (Rauner & Maclean, 2021). TVET systems are uniquely positioned to support the green transition because they focus on practical skill development and direct engagement with industry needs.

However, many TVET systems still rely on traditional curricula that emphasize conventional industrial practices rather than environmentally responsible production systems. As a result, graduates may lack the competencies needed to work effectively in green industries. Consequently, integrating sustainability principles into vocational education has become an important priority for policymakers and educators worldwide (UNESCO-UNEVOC, 2022).

2.2 Green Employability Skills

Employability skills refer to a set of competencies that enable individuals to obtain employment, perform effectively in the workplace, and adapt to changing job requirements (Yorke, 2006). These skills include communication abilities, teamwork, problem-solving, critical thinking, and adaptability.

In recent years, the concept of employability skills has expanded to include sustainability-related competencies. These competencies are commonly referred to as green employability skills, which combine traditional employability skills with environmental awareness and sustainability knowledge (Pavlova, 2017).

Green employability skills involve a combination of technical and non-technical competencies. Technical competencies include knowledge of renewable energy technologies, sustainable manufacturing processes, and environmental monitoring systems. Non-technical competencies include environmental awareness, ethical responsibility, and the ability to implement sustainable practices in professional contexts (Huang & Wang, 2021).

Research suggests that developing green employability skills requires integrating sustainability concepts into educational curricula and training programs. For example, studies by Sern et al. (2021) indicate that embedding green skills into vocational education curricula can significantly enhance students' employability outcomes and prepare them for emerging green industries.

Furthermore, the development of green employability skills is closely linked to the broader concept of sustainable workforce development. According to Khan and Law (2022), sustainable workforce development involves equipping individuals with competencies that support environmentally responsible economic activities while promoting social and economic well-being.

However, developing green employability skills presents several challenges for vocational education institutions. These challenges include limited teacher expertise in sustainability topics, inadequate institutional resources, and insufficient collaboration between educational institutions and industry partners (Nguyen & Le, 2022). Addressing these challenges requires systemic changes in vocational education systems, including curriculum reform, teacher training, and stronger industry engagement.

2.3 Sustainability Integration in Vocational Education

Integrating sustainability principles into vocational education has become an important policy priority in many countries. Sustainability integration in education refers to the incorporation of environmental, social, and economic sustainability principles into educational curricula, institutional policies, and teaching practices (Sterling, 2021).

Vocational education institutions play a particularly important role in sustainability education because they prepare learners for occupations that directly influence industrial practices and environmental outcomes. For example, workers in sectors such as manufacturing,

construction, and energy production have a significant impact on resource consumption and environmental sustainability.

According to UNESCO (2021), education for sustainable development aims to equip learners with the knowledge, skills, values, and attitudes necessary to contribute to sustainable societies. In the context of vocational education, this involves integrating sustainability concepts into technical training programs and promoting environmentally responsible workplace practices.

Several scholars argue that sustainability integration in vocational education requires a systemic approach that involves curriculum reform, institutional leadership, and collaboration with industry stakeholders (Lozano et al., 2020). Rather than being limited to individual courses, sustainability principles should be embedded across the entire institutional environment.

Research also highlights the importance of teacher competencies in sustainability education. Teachers must possess both subject knowledge and pedagogical skills to effectively integrate sustainability concepts into teaching practices (Diep & Hartmann, 2016). Professional development programs therefore play an important role in supporting sustainability-oriented curriculum innovation.

2.4 Socio-Cultural Dimensions of Green Skills

Sustainability transitions are not solely technological or economic processes; they also involve socio-cultural transformations that influence how individuals perceive environmental responsibility and sustainable practices. Cultural norms, values, and professional identities shape how workers engage with sustainability-oriented practices in workplace settings (Sterling, 2021; Wiek et al., 2011).

Recent research emphasizes that green skills should be understood not only as technical competencies but also as socio-cultural capabilities that enable individuals to participate in environmentally responsible production systems. These capabilities include environmental ethics, collaborative problem-solving, and a shared commitment to sustainable practices within organizational contexts (Pavlova, 2017; Renwick et al., 2013).

Vocational education institutions therefore play an important role in shaping these socio-cultural competencies. Through sustainability-oriented learning environments, students can develop professional identities that integrate technical expertise with environmental responsibility. This socio-cultural perspective highlights the role of education in fostering sustainability-oriented mindsets that support broader societal transitions toward sustainable development (Lozano et al., 2020; UNESCO, 2021).

Beyond technical competencies, sustainability transitions also require the development of a sustainability-oriented culture within educational institutions and workplaces. Sustainability culture refers to shared values, norms, and practices that promote environmental responsibility and collective commitment to sustainable development (Schein, 2010; Sterling, 2021). In vocational education settings, cultivating such a culture can influence how students interpret professional responsibilities, engage in environmentally responsible practices, and develop sustainability-oriented professional identities (Pavlova, 2017; Wiek et al., 2011).

2.5 Curriculum Innovation in TVET

Curriculum innovation refers to the process of redesigning educational programs to respond to changing societal needs, technological developments, and labor market demands (Fullan, 2016). In vocational education, curriculum innovation often involves updating technical training programs to reflect emerging technologies and industry practices.

Sustainability-oriented curriculum innovation involves embedding environmental principles into vocational education curricula. This may include incorporating sustainability topics into technical courses, adopting environmentally responsible workshop practices, and promoting project-based learning related to sustainability challenges (Pavlova, 2017).

Curriculum innovation in TVET also involves adopting new pedagogical approaches that encourage active learning and problem-solving. For example, project-based learning and work-based learning approaches enable students to develop practical competencies while addressing real-world sustainability challenges (Rauner & Maclean, 2021).

However, implementing curriculum innovation in vocational education can be challenging. Institutions may face barriers such as limited resources, insufficient teacher training, and resistance to organizational change (Cedefop, 2021). Addressing these challenges requires supportive leadership, institutional commitment, and collaboration with external stakeholders.

2.6 Industry Collaboration and Skills Development

Industry collaboration is a defining characteristic of vocational education systems. Partnerships between educational institutions and industry ensure that training programs remain aligned with labor market needs and technological developments (Pilz & Li, 2021).

Industry collaboration may take several forms, including joint curriculum development, internship programs, apprenticeship training, and industry-led training initiatives. These partnerships enable vocational institutions to provide students with practical learning experiences that reflect real workplace conditions.

In the context of sustainability education, industry collaboration plays a particularly important role because emerging green industries require specialized skills and knowledge. Collaboration between vocational institutions and industry partners can facilitate the integration of sustainability practices and green technologies into vocational training programs (Cedefop, 2021).

Research indicates that strong industry–education partnerships can significantly enhance the relevance and effectiveness of vocational education programs (Li et al., 2023). By engaging industry stakeholders in curriculum development and training activities, vocational institutions can ensure that graduates possess competencies that align with evolving industry needs.

3. CONCEPTUAL MODEL DEVELOPMENT

Based on the literature reviewed above, this study proposes a conceptual model explaining how curriculum innovation and industry collaboration contribute to the development of green employability skills and sustainable workforce development.

Drawing upon Human Capital Theory (Becker, 1993), education is viewed as a critical mechanism for developing competencies that enhance individual productivity and employability. In the context of the green economy, vocational education institutions must cultivate sustainability-oriented competencies that enable graduates to contribute to environmentally responsible industries.

In addition, Stakeholder Theory (Freeman, 1984) emphasizes the importance of collaboration between organizations and external stakeholders. In vocational education systems, partnerships between educational institutions and industry stakeholders ensure that training programs remain responsive to technological changes and labor market demands.

Building upon these theoretical perspectives, this study proposes that sustainability-oriented curriculum innovation and industry collaboration represent key institutional mechanisms for developing green employability skills. Curriculum innovation integrates sustainability principles into training programs, while industry collaboration provides practical learning opportunities that expose students to real-world sustainability practices.

Furthermore, green employability skills are expected to mediate the relationship between educational practices and sustainable workforce outcomes. These competencies enable graduates to participate effectively in environmentally responsible production systems and contribute to broader socio-cultural transformations associated with sustainability transitions.

4. PROPOSED CONCEPTUAL FRAMEWORK

The conceptual framework of this study illustrates the relationships among curriculum innovation, industry collaboration, green employability skills, and sustainable workforce development.

Curriculum innovation is expected to influence the development of green employability skills by integrating sustainability principles into vocational training programs. Industry collaboration contributes to green employability skills development by providing practical learning opportunities and aligning training programs with industry requirements.

Green employability skills, in turn, contribute to sustainable workforce development by enabling graduates to apply environmentally responsible practices in professional contexts.

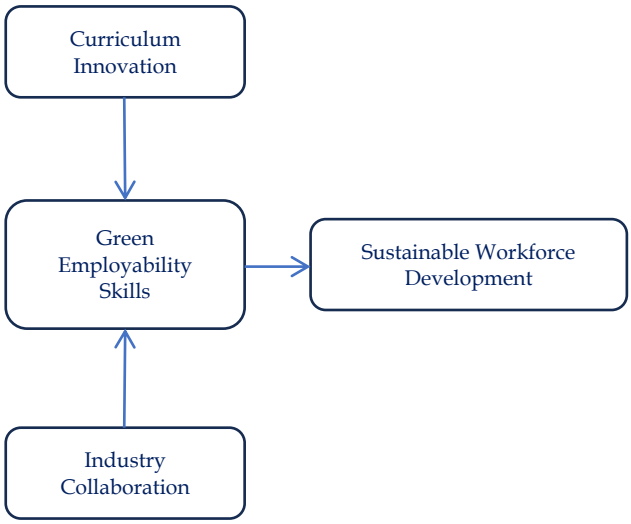

Figure 1. Conceptual Framework of Green Employability Skills Development in Vocational Education

Explanation of the Conceptual Framework

The framework illustrates how vocational education institutions can contribute to sustainable workforce development through curriculum innovation and industry collaboration (Maclean & Pavlova, 2020; Pavlova, 2017).

Curriculum innovation focuses on integrating sustainability principles, environmental awareness, and green technologies into vocational training programs. Through such innovations, students can develop competencies required by emerging green industries (Lozano et al., 2020; Pavlova, 2017).

Industry collaboration ensures that vocational education programs remain aligned with labor market needs. Collaboration with industry partners provides students with opportunities to gain practical experience and exposure to sustainability-oriented workplace practices (Pilz & Li, 2021; Jackson, 2015).

Green employability skills serve as a mediating variable that links educational practices with workforce outcomes. By developing these competencies, vocational education institutions can prepare graduates who are capable of contributing to sustainable economic activities (Vona et al., 2018; Wiek et al., 2011).

5. RESEARCH PROPOSITIONS

Based on the conceptual framework, several research propositions are proposed for future empirical investigation.

Proposition 1: Sustainability-oriented curriculum innovation positively influences the development of green employability skills among vocational education students.

Proposition 2: Industry collaboration positively influences the development of green employability skills by providing workplace-based learning opportunities.

Proposition 3: Green employability skills positively contribute to sustainable workforce development by enabling graduates to participate in environmentally responsible economic activities.

Proposition 4: Green employability skills mediate the relationship between curriculum innovation and sustainable workforce development.

Proposition 5: Green employability skills mediate the relationship between industry collaboration and sustainable workforce development.

6. DISCUSSION

The transition toward a green economy has created significant challenges and opportunities for education systems worldwide. Vocational education institutions, in particular, play a critical role in preparing graduates who possess competencies required for sustainable industries. The conceptual framework proposed in this study highlights the importance of curriculum innovation and industry collaboration in developing green employability skills within vocational education systems.

6.1 Curriculum Innovation and the Development of Green Skills

Curriculum innovation represents a fundamental strategy for aligning vocational education with the evolving demands of the green economy. Traditional vocational education curricula often focus on technical competencies associated with conventional industrial practices. However, as industries increasingly adopt environmentally responsible technologies and production processes, vocational education institutions must redesign their training programs to incorporate sustainability principles (Azahar et al., 2026; Ibrahim et al., 2024).

Sustainability-oriented curriculum innovation involves integrating environmental knowledge, resource efficiency practices, and sustainable production techniques into vocational training programs. Such integration enables students to develop both technical competencies and sustainability-oriented attitudes that are essential for green industries. According to Pavlova (2017), integrating sustainability into vocational education curricula enhances learners' understanding of environmental challenges and prepares them to apply sustainable practices in professional contexts.

Furthermore, curriculum innovation encourages the adoption of learner-centered pedagogical approaches such as project-based learning, problem-based learning, and experiential learning. These pedagogical approaches allow students to engage with real-world sustainability challenges and develop practical competencies related to environmental problem-solving. As a result, vocational education institutions can cultivate graduates who are capable of adapting to technological changes and contributing to sustainable economic activities (Lozano et al., 2020; Sern et al., 2021).

6.2 The Role of Industry Collaboration in Green Skills Development

Industry collaboration plays a critical role in ensuring that vocational education programs remain relevant to labor market demands. Partnerships between vocational institutions and industry partners facilitate the exchange of knowledge,

technological expertise, and practical training opportunities. Through such collaboration, educational institutions can gain insights into emerging industry trends and integrate these developments into their curricula (Li et al., 2023; Pilz & Li, 2021).

In the context of sustainability, industry collaboration is particularly important because green industries often require specialized competencies that are not yet widely incorporated into traditional vocational training programs. For example, industries adopting renewable energy technologies or sustainable manufacturing processes require workers who possess both technical expertise and environmental awareness (Bowen & Kuralbayeva, 2015; Pavlova, 2017).

Collaboration with industry partners enables vocational institutions to update their training programs and provide students with opportunities to gain hands-on experience in sustainability-oriented workplaces. Internship programs, apprenticeship systems, and industry-led training initiatives can significantly enhance students' employability skills by exposing them to real-world workplace practices (Jackson, 2015; Li et al., 2023).

Moreover, industry collaboration contributes to the co-development of curricula that reflect the competencies required by emerging green industries. By involving industry stakeholders in curriculum design, vocational institutions can ensure that graduates possess skills that are directly applicable to workplace contexts (Jackson, 2016; Pilz & Li, 2021).

6.3 Green Employability Skills and Sustainable Workforce Development

Green employability skills represent a crucial link between vocational education and sustainable workforce development. These skills encompass both technical competencies related to environmentally responsible technologies and broader competencies such as critical thinking, adaptability, and teamwork (Huang & Wang, 2021; Zhang & Chen, 2022).

In the context of the green economy, employers increasingly seek workers who can contribute to sustainable production systems and environmental management practices. Workers equipped with green employability skills are better positioned to support organizational sustainability initiatives and contribute to environmentally responsible economic activities (Renwick et al., 2013; Vona et al., 2018).

Vocational education institutions therefore play a strategic role in developing a workforce capable of supporting sustainable economic transformation. By integrating sustainability principles into vocational training programs and strengthening collaboration with industry partners, vocational institutions can prepare graduates who are capable of addressing complex environmental challenges (Maclean & Pavlova, 2020; Nguyen & Le, 2022).

Furthermore, developing green employability skills contributes to broader societal goals related to sustainable development. Workers who possess sustainability competencies can contribute to resource efficiency, environmental protection, and responsible consumption practices (Pavlova, 2017; Wiek et al., 2011).

6.4 Integrating Curriculum Innovation and Industry Collaboration

The conceptual framework proposed in this study emphasizes the complementary roles of curriculum innovation and industry collaboration in developing green employability skills. Curriculum innovation ensures that sustainability principles are embedded within vocational education programs, while industry collaboration provides practical learning opportunities that reinforce these competencies (Pavlova & Maclean, 2020; Pilz & Li, 2021).

The integration of these two factors enables vocational education institutions to develop training programs that are both academically relevant and industry responsive. Such integration ensures that graduates possess the competencies required by emerging green industries while also promoting sustainable workforce development (Nguyen & Le, 2022; Pilz & Li, 2021).

Moreover, the collaboration between educational institutions and industry stakeholders supports the continuous improvement of vocational education programs. As industries evolve and adopt new technologies, vocational institutions must continuously update their curricula to reflect these changes (Jackson, 2015; Pilz & Li, 2021).

Therefore, the integration of curriculum innovation and industry collaboration represents a strategic approach to ensuring that vocational education systems remain responsive to sustainability challenges and labor market transformations (Nguyen & Le, 2022; Pilz & Li, 2021).

6.5 Theoretical Contribution

This study contributes to the literature in several ways. First, it integrates vocational education research with sustainability and workforce development perspectives by proposing

a conceptual framework that links curriculum innovation, industry collaboration, and green employability skills (Maclean & Pavlova, 2020; Pilz & Li, 2021). Second, the study extends existing research by highlighting the socio-cultural dimensions of green skills development, emphasizing that sustainability competencies involve not only technical knowledge, but also cultural values and professional identities related to environmental responsibility (Renwick et al., 2013; Wiek et al., 2011). Finally, the framework provides a theoretical foundation for future empirical research examining how vocational education systems can support sustainability transitions in labor markets (Vona et al., 2018).

This study contributes to the literature by extending existing discussions on green skills and sustainability education through a socio-cultural perspective on vocational workforce development (Pavlova, 2017; Wiek et al., 2011). While previous studies have primarily focused on technological competencies and curriculum reform in sustainability-oriented education (Lozano et al., 2020; Sern et al., 2021), this study highlights the importance of institutional culture, professional identity formation, and collaborative stakeholder engagement in shaping sustainability-oriented employability skills (Jackson, 2016; Renwick et al., 2013).

7. IMPLICATIONS

7.1 Policy Implications

Policymakers should recognize the importance of integrating sustainability principles into vocational education systems. National education policies should encourage vocational institutions to adopt sustainability-oriented curricula and promote green skills development (Pavlova, 2017; Wiek et al., 2011).

7.2 Educational Implications

Educational leaders should support curriculum innovation initiatives that incorporate sustainability concepts into vocational training programs. Professional development programs for teachers should also emphasize sustainability education and green skills development (Diep & Hartmann, 2016; Sterling, 2021).

7.3 Industry Implications

Industry stakeholders should actively collaborate with vocational institutions to support curriculum development and training initiatives. Such collaboration ensures that vocational education programs remain aligned with industry needs and technological developments (Li et al., 2023; Pilz & Li, 2021).

8. CONCLUSION

The transition toward a green economy requires substantial transformation in workforce development systems. Vocational education institutions play a critical role in preparing graduates who possess competencies required for sustainable industries. This study proposes a conceptual framework explaining how curriculum innovation and industry collaboration contribute to the development of green employability skills in vocational education.

The framework highlights that sustainability-oriented curriculum innovation enables the integration of environmental knowledge and socio-cultural values into vocational training programs. Meanwhile, collaboration between educational institutions and industry partners ensures that training programs remain aligned with evolving labor market demands.

By developing green employability skills, vocational education institutions can prepare graduates who are capable of supporting sustainable economic activities while promoting broader socio-cultural transformation toward environmental responsibility. Beyond its implications for workforce development, the proposed framework highlights the role of vocational education institutions in fostering a culture of sustainability among future workers. By integrating sustainability values into educational practices and strengthening collaboration with industry stakeholders, vocational institutions can contribute to broader socio-cultural transformations that support sustainable economic systems. Future research may empirically test the proposed framework to examine the relationships among curriculum innovation, industry collaboration, and green employability skills development across different vocational education contexts.

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