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The Integration of Green Technology Elements in the Curriculum of Industrial Training at Malaysian Vocational Colleges

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Abstract

This study explores the integration of green technology elements in the On-the-Job Training (OJT) industrial training curriculum at Vocational Colleges (VC) in Malaysia. The study aligns with the demands of Industrial Revolution 4.0 (IR4.0) and the emphasis on Education for Sustainable Development in Technical and Vocational Education and Training (TVET). The study addresses two main questions: (1) What green technology elements are integrated into the OJT industrial training curriculum at VC? and (2) How are green technology elements incorporated into this curriculum? Using a qualitative case study methodology, research data were gathered through semi-structured interviews with eight informants, comprising TVET policymakers, VC educators, and practitioners in the green technology sector. The sampling utilised convenience and snowball methods. Research data were subsequently examined using thematic analysis. The findings indicate that green technology is integrated into the OJT curriculum through the application of acquired knowledge, skills, and affective elements. Three key approaches are utilized: curriculum-based integration, assessment and evaluation strategies, and institutional initiatives. The study suggests that integrating green technology enhances the effectiveness of vocational education in advancing the Sustainable Development Goals (SDGs). Recommendations highlight the need to develop a curriculum that prioritizes green technology integration, ensuring a greater contribution to national sustainable development goals.

Keywords: green technology, vocational education, industrial training curriculum, SDG 4, industrial revolution 4.0

1. Introduction

The industrial training curriculum is a key educational strategy for producing highly skilled and competent individuals to meet industry demands (M. Said et al., 2015; Minghat & Yasin, 2010). At Vocational Colleges (VCs), the On-the-Job Training (OJT) program is implemented to fulfill the requirements of the industrial training curriculum. All VC students are required to complete OJT before being awarded the Malaysian Vocational Diploma (DVM). The OJT program is conducted in real work environments, aligning with the objectives of the Vocational College Standard Curriculum (KSKV) (MOE, 2012), which aims to equip students with technical knowledge, practical skills, and soft skills (Hasan et al., 2015; Minghat & Yasin, 2010).

Sern et al. (2018) argue that in addition to soft skills, graduates must acquire green competencies to support sustainable development, particularly in environmentally related industries. Similarly, Ramli et al. (2018) suggest that the development of a green curriculum should be prioritized in Technical and Vocational Education (TVE) training programs. The integration of green technology has emerged as a crucial approach in addressing the challenges posed by the Fourth Industrial Revolution (IR 4.0) while simultaneously promoting sustainable development (Mohamad Fahmi Ramli et al., 2022). This underscores the need to prioritize an industrial training curriculum that establishes a foundational skill set for students, preparing them for careers in the green industry.

However, a preliminary analysis of the VC OJT course outline (MOE, 2012) reveals the absence of explicit objectives and directives regarding the integration of sustainable development, environmental education, and green technology. While the standard curriculum document for Science at Vocational Colleges explicitly mentions green technology (MOE, 2012), this integration is not extended across all VC curricula. Consequently, Yee et al. (2020) found that TVET graduates lack the green skills required by industry, as the curriculum does not incorporate environmentally sustainable components. Likewise, Mustapha (2016) highlights the absence of a structured and comprehensive framework linking education and training policies with climate change mitigation and green initiatives. Additionally, Saibani et al. (2012) note that the Ministry of Education's review of the secondary school curriculum found inadequate implementation of green technology subjects, necessitating updates to better align with students' levels of comprehension.

Therefore, this study investigates the integration of green technology elements into the VC industrial training curriculum. It aims to address existing gaps and contribute to the development of a sustainable training strategy, particularly within the OJT program at Malaysian VCs. Specifically, the study seeks to answer the following research questions: (i) To what extent are green technology elements integrated into the VC industrial training curriculum? and (ii) How are green technology elements incorporated into the VC industrial training curriculum?

The findings of this study will provide valuable insights for the Malaysian Ministry of Education (KPM), as the governing body for TVET, to inform policy adaptations and the strategic development of a new curriculum aligned with Education 2030, the Sustainable

Development Goals (SDGs), and IR 4.0. A strategic plan is essential for creating a dynamic, future-ready curriculum that evolves with industry demands while incorporating community perspectives and emerging developments (Ng, 2019).

2. Models for Integrating Green Technology in Education

Pal et al. (2023) have developed a 'Green Smart Education' framework to facilitate the integration of green technologies into the curriculum. This framework is driven by two primary objectives. First, it aims to cultivate environmentally knowledgeable and efficient individuals, thereby accelerating the transition toward a more sustainable society. Second, it seeks to enhance civic competence, particularly in fostering entrepreneurial skills. The green curriculum framework aspires to nurture a younger generation that is both environmentally conscious and committed to sustainability. Additionally, the framework mandates the inclusion of specific green competencies. Table 1 presents the list of 'green abilities' embedded within this framework.

Table 1. 'Green Abilities' berdasarkan Green Smart Education

Green curriculum	Green abilities
Comprehension	Considering and prioritizing environmental aspects
Knowledge	Ecology, ecosystem, global warming, nano green technology
Creativity	Synthesizing existing knowledge to advance green technologies
Visionary	Identifying and seizing untapped sustainability opportunities
Resources Management Skills	Ability to create, adapt, modify, and reuse ecologically to develop low-carbon, environmentally friendly technologies
Colaborative Skills	Engaging in group exercises to address environmental challenges
Self-Awareness	Building resilience and openness to change
Transferability	Acquiring knowledge through interdisciplinary encounters to achieve sustainability

According to Pal et al. (2023), implementing a green curriculum with these competencies has the potential to fulfill the key requirements for integrating 'Green Education.' This is achieved by embedding values, traits, skills, and cognitive changes that foster environmental

consciousness and sustainability.

On the other hand, the Green Curriculum Model (GCM), derived from Besong's (2017) study, is structured around five distinct levels: Content, Principles, Pedagogical Approach, Competence/Success, and Indicators. In this model, the term "Pedagogical Approach" refers to various instructional methodologies supported by research literature. According to the GCM, four pedagogical methods have been identified as crucial for integrating sustainability into the teaching and learning process. These approaches aim to develop essential green competencies. The four methodologies for designing a green curriculum are Experience-Based Learning, Value-Ethical Learning, Constructivist Learning, and Transformation-Based Learning (Besong, 2017). Table 2 provides a detailed overview of each pedagogical approach.

Table 2. Green Pedagogy Approach

Green Pedagogy Approach	Description
Experience-Based Learning	• Sustainability learning is action-oriented. The goal of sustainability education is to change attitudes and behaviours toward sustainability. • Learning becomes more effective when students apply sustainability knowledge through experiential learning contexts.
Value-Ethical Based Learning	• Enhances values and ethics to promote sustainability. • Advocates for values such as respect, equity, fairness, unity, and democratic principles in green pedagogy. • Establishes ethical values as a foundation for a safe and democratic collaborative learning environment.
Constructivist Learning	• Enhances critical thinking skills, encourages action-oriented learning, and prepares students for collaborative group work. • Socio-constructivist teaching fosters students' competencies in collaborative decision-making and problem-solving related to sustainability challenges.
Transformation-Based Learning	• Involves significant modifications to fundamental assumptions, emotions, and behaviours. • Emphasizes intensive transitions toward sustainability. • Facilitates the effective transfer of sustainability knowledge and skills through student-centered reforms and pedagogy. • Employs innovative educational methodologies essential for sustainability instruction and learning.

The integration of green pedagogical approaches plays a vital role in embedding sustainability into educational frameworks. By adopting these methodologies, educators can foster a generation equipped with the necessary skills, values, and competencies to navigate the challenges of environmental sustainability effectively.

3. Method

This study employs a qualitative research design. Specifically, a case study methodology is utilized, which is crucial for identifying specific situations at the outset of research (Creswell & Poth, 2018). The case in this study pertains to the integration of green technology within the context of Vocational Colleges (VCs). According to Yin (2014), the case study approach is appropriate when behavioral manipulation is not feasible and when the context of the phenomenon under study is essential. Additionally, this approach is useful in situations where the boundaries between the phenomenon and its surrounding context remain unclear within a specific system. Thus, the study investigates the integration of green technology within the Malaysian VC system, focusing on key stakeholders involved in this process. Within this framework, informants provide detailed insights into the implementation and challenges of green technology integration in VC environments.

3.1 Sampling Method

The study sample comprises three distinct groups: policymakers, teachers, and industry representatives. A snowball purposive sampling method was employed to identify informants with expertise in green technology and direct involvement in implementing the Industrial Training Curriculum, commonly referred to as 'On-the-Job Training' (OJT) at VCs.

The process of identifying potential informants for policymakers and teachers began with consultations with BPLTV officials, who acted as gatekeepers. These officials recommended initial informants who met specific criteria established by the researcher, such as individuals responsible for developing the VC industrial training curriculum, VC teachers directly involved in administering the curriculum, and representatives from the green industry.

Using the suggested initial sample, additional informants were identified through recommendations from the initial informants, based on their past collaborations with other stakeholders in the green industry. Industry representatives were selected based on teacher informants' recommendations.

As a result of this sampling technique, a total of eight informants participated in the study. To maintain confidentiality, pseudonyms were assigned to all informants, as reflected in Table 3 and throughout this paper.

Table 3. Informants Details

Informant	Age (years)	Academic Qualification	Experience in TVET (years)	Fields
Informan 1	54	Master	30	Mechanical Engineering
Informan 2	43	Master	25	Civil Engineering
Informan 3	51	Master	29	Electrical Engineering
Informan 4	37	Master	11	Air Conditioning & Refrigeration Technology
Informan 5	36	Master PhD (students)	12	Air Conditioning & Refrigeration Technology
Informan 6	52	Master	30	Electrical Technology
Informan 7	45	PhD	32	Air Conditioning & Refrigeration Technology
Informan 8	53	Master	15	Electrical Technology & Computer Science

Data collection commenced in early 2020, coinciding with the global spread of COVID-19. While a larger sample was initially anticipated, participation was constrained due to the pandemic. Many potential informants declined interviews due to adjustments in their personal and professional lives during this period.

3.2 Data Collection and Analysis

Data was gathered through semi-structured interviews. Given that three distinct groups of informants participated, tailored interview protocols were developed to capture diverse perspectives. Despite pandemic-related challenges, most informants preferred in-person interviews, likely due to the limited adoption of online meeting platforms at that time. Only one interview was conducted online.

All interview sessions were audio-recorded, and the researcher also took notes to document key points. The recorded interviews were subsequently transcribed verbatim. Data analysis followed a thematic approach, involving step-by-step coding, categorization, and theme development. The analysis employed both inductive and deductive methods to ensure a comprehensive understanding of the data.

3.3 Ethical Considerations

Ethical considerations were meticulously observed throughout the study. Informants were fully briefed on the research objectives before and during the interviews. Their rights as participants were explicitly communicated, including the voluntary nature of their participation and their freedom to withdraw at any stage or refrain from answering specific questions. Prior to each interview, informed consent was obtained for audio recording. Additionally, ethical approval for the study was secured from the Ethics Committee of the research institution.

4. Results

In the following paragraphs, the findings will be presented and discussed based on the two research questions outlined in the introduction section.

4.1 Elements of A Posteriori

A posteriori knowledge refers to knowledge derived from experience. In the context of this study, it encompasses the knowledge that Vocational College (KV) students acquire during their on-the-job training (OJT) in the industry and how it relates to their practical work in workshops.

Findings from different respondents indicate a consensus that knowledge gained through experiential learning is more meaningful and valuable. This suggests that each student's prior knowledge serves as a foundation for developing a comprehensive understanding of green technology. When prior knowledge and experiences are integrated, students are better equipped to think critically and act with a deeper appreciation of green technology. As Informant 4 stated:

> *"Students' preparation levels are based on their previous knowledge, but it also depends on the course they select."*

The KV framework aims to develop competent human capital in green technology. Through the OJT curriculum, green technology is embedded into individualized learning, allowing students to internalize and apply the concept of 'green' while working in the green industry. As students gain knowledge, they develop implicit judgments about new concepts, fostering self-awareness of green technology's importance. Informant 2 emphasized:

> *"Students will gain knowledge and set boundaries for themselves."*

Green Education integrates environmental sustainability by fostering knowledge, skills, values, and cognitive transformations through sustainable learning (Pal et al., 2023). The findings suggest that technical and hands-on (TH) knowledge is acquired through experiential learning and practical application. However, the depth of TH knowledge depends on the nature of the industrial activities undertaken.

Kordi et al. (2018) highlight Malaysia's need for more experts in green technology to effectively disseminate knowledge to the public. The integration of TH aspects within the KV OJT curriculum supports individualized learning, reinforcing students' understanding and application of the 'green' concept when engaging with the green industry.

Ramli (2019) argues that developing both hard and soft skills is critical for knowledge acquisition, abilities, attitudes, and green skills. This aligns with the assertion made by Informant 3:

> *"Fundamental knowledge and skills must be strengthened, along with the latest advancements in Green technology."*

A solid understanding of green technology is essential for KV students to appreciate environmental sustainability. Informant 8 provided insights on this matter:

> *"I think there's not much emphasis on soft skills, but they need a basic understanding of green concepts. This means not just control but also proper waste disposal. For example, littering is a green issue, right? Controlling waste, preventing dumping into drains, and conserving water and electricity are crucial, especially when discussing green buildings."*

4.2 The Role of ICT in Green Technology Knowledge Acquisition

For students to effectively engage with new green technology knowledge, they must possess basic technological literacy, including ICT skills. The Green technology sector increasingly integrates digital elements, making ICT proficiency essential. KV has begun incorporating digital components into its learning modules, albeit still limited to specific programs such as Power Plant Utilization (PPU), which aligns with the latest industrial advancements. This technological integration enhances students' employability prospects upon graduation. The study's findings reinforce this perspective:

> *"So this is what we want for graduates: they can earn a high salary, but they must have the 'weapon' of technology."*

The integration of technological and digital knowledge enriches students' learning experiences, preparing them for the workforce and improving KV graduates' employability.

4.3 Skill Elements in Green Technology

The skill elements integrated into green technology education include green skills, technical skills, safety skills, and waste management skills.

Green skills are gaining popularity across industries as they promote environmental consciousness and responsible behavior. The findings indicate that the green technology industry's KNX curriculum incorporates energy efficiency principles aligned with the National Occupational Skills Standard (NOSS). Students are expected to analyze environmental data and related phenomena as part of their coursework (Ibrahim et al., 2020). Informant 8 highlighted this integration:

> *"Now we have incorporated the curriculum into NOSS, so students gain exposure to energy efficiency."*

Kaliappan et al. (2023) assert that green technology is embedded within a holistic framework encompassing academic learning, practical training, and employability. Technical skills form a crucial component of green technology integration, as students acquire foundational skills through practical and industrial training. Exposure to TH elements occurs through field-specific technical training, whether in workshops or OJT placements. For example, Power Plant Utilization (PPU) relies on Electrical Engineering knowledge. This is evident from Informant 8's statement regarding multi-tasking skills:

> *"When working with chillers, it's not just about servicing pipes or air conditioning.*

> *You need to link it with computers because everything is computerized now. Learning about IoT is essential—this is part of a green building. If you only focus on maintaining air conditioning, like fixing leaks, you miss the bigger picture."*

4.4 Waste Management Skills in Green Technology

Waste management skills are another essential component integrated into the KV curriculum. Practical training in workshops involves the use of significant amounts of consumables, necessitating an understanding of proper waste management practices to avoid environmental issues stemming from poor waste disposal. Pal et al. (2023) emphasize the need for Resource Management Skills in Green Curriculum design.

KV students must acquire relevant knowledge and skills to manage waste effectively, ensuring the implementation of sustainable waste management practices after completing their OJT. Students must also develop competencies in handling environmentally hazardous materials. Informant 7 reinforced this point:

> *"Management skills are essential for Green technology practitioners. This includes waste management and safety aspects related to chemical materials."*

Informant 5 further highlighted the importance of sustainability in workshop practices:

> *"Vocational Colleges (KV) often use waste materials for practical work. After using them, we usually recycle them, but actually, there are many other things we can do with those materials."*

The integration of knowledge, skills, and technology within the KV curriculum plays a critical role in preparing students for the green technology industry. A holistic understanding of green technology, coupled with technical proficiency and management skills, enhances students' employability and readiness to contribute to sustainable practices in their future careers.

4.5 Integration Through Affective Elements

The affective aspect highlights how green technology is integrated into the KV industrial training curriculum by emphasizing safety, social values, ethical principles, and awareness of green technology. This integration plays a crucial role in shaping students' character and fostering a deeper understanding of green technology's significance. Informant 7 described how the green technology Management subject integrates these values into the curriculum:

> *"One subject is Green technology Management, right? So within that, we can relate it to the values in the curriculum. This way, we elevate the status of Green technology to make it more practical at the vocational training level."*

Awareness of Green technology is further reinforced through character development, enabling students to appreciate its significance. Additionally, safety integration is a key focus in the OJT KV curriculum, as a secure working environment ensures work quality while reducing costs associated with maintenance, employee compensation, and operations. Each KV course incorporates safety aspects, covering apparatus, workshop environments, and

other crucial elements related to sustainability. Informant 4 highlighted safety considerations in green technology:

> *"The second aspect is safety. Safety for users. Green technology actually uses DC systems, which are much safer compared to AC systems."*

Beyond safety, social and ethical values are embedded within the KV curriculum. According to Mohd Salleh and Sulaiman (2020), TVET should emphasize career-related skills, such as critical thinking, problem-solving, and collaboration, while instilling values such as integrity, tolerance, ethics, flexibility, and a positive attitude. These values ensure that all KV students have equitable access to green technology education. Informant 4 further explained:

> *"Social skills like teamwork, ethics, leadership, and responsibility are also relevant to green practices. Responsibility and ethics align well with green principles."*

Moreover, KV students must balance professional responsibilities with community impact. Informant 3 noted:

> *"The implications for health are significant. So, this is the mindset that technologists need to adopt—thinking about how to reduce impacts on our ozone layer. Even small actions can have a big impact."*

By integrating affective elements such as values, safety, and social responsibility, KV institutions ensure that green technology education goes beyond technical knowledge, fostering a holistic understanding among students.

4.6 Approaches to Green Technology Integration in OJT KV

Three key methods are employed to integrate green technology into KV: curriculum implementation, assessment and evaluation, and institutional initiatives.

4.6.1 Curriculum Implementation

The integration of green technology in KV is primarily carried out through the curriculum. This is particularly evident in science subjects, where students follow the Form 4 Science DSKP syllabus, which includes the topic "Green Technology in Preserving Nature" (BPK, 2019). Informant 3 clarified that while green technology elements are present in some mandatory subjects, they are not uniformly included across all KV curricula. Informant 2 elaborated on the indirect inclusion of green technology:

> *"In Core Abilities, as we understand, it doesn't mention environmental sustainability. It doesn't clearly state that. However, in the Core Abilities, there's a focus on cleanliness, which is related but doesn't directly reference environmental sustainability. This Core Ability is part of one NCS, and there's another NCS related to green technology."*

Furthermore, the incorporation of Teaching and Learning (PdP) in workshops has indirectly facilitated green technology integration, as highlighted by Informant 1:

> *"When we comply with green technology or safety and health regulations, we indirectly expose students to the industry, helping them understand the concepts of IR 4.0 and green technology."*

Additionally, the hidden curriculum approach ensures students gain exposure to green technology through hands-on experiences during industrial training. Informant 6 emphasized the importance of early exposure:

> *"I started seeing the need for green technology from the early stages of vocational training, but at that time, we couldn't find an industry connection. So, I initiated it when I sent students to the World Skills Malaysia Youth competition; where I sent students in 2016."*

4.6.2 Assessment and Evaluation

Assessment and evaluation play a critical role in green technology integration. Green technology-related questions are included in KV examinations, and students are encouraged to incorporate green technology into their Final Year Projects. Informant 6 highlighted this initiative:

> *"We started last year by giving students a bit of freedom to develop their Final Year Projects. When they work on these projects, we provide some space for them to build innovations using Arduino. Although Arduino isn't part of our course, we included it because it combines programming and uses DC voltage. At the same time, we can connect it to IoT. So, it's more aligned with IR 4.0, especially for the Final Year Projects."*

KV students' industrial training assessments also incorporate green technology elements. Informant 3 explained:

> "Students undergoing OJT are also assessed by the industry or relevant employers. Therefore, if students are doing their industrial training with employers who practice Green technology, the assessment related to Green practices will also be evaluated by their employers... because the assessment is conducted by the industry."

4.6.3 Institutional Initiatives

KV institutions have launched various initiatives to bridge the gap between education and industry. Students are required to complete specialized courses, including workplace safety and industry best practices, to qualify for the "Green Card." Informant 1 described this requirement:

> *"To obtain the green card, they must attend a two-day briefing and receive exposure related to CIDB elements and green technology."*

Green technology integration is also enhanced through collaboration with industries. Informant 6 noted:

> *"Vocational training, yes, that's right. Because in green technology at vocational training, it's not a main course. We just add value for our students. For instance, in Electrical Technology, we have a course called Control Systems. So, in that Control Systems course, we add Automation Building Systems, where my students learn about green technology. Then, I also add some basics about solar energy. So, we enhance it with basic knowledge, using examples like that."*

Collaborations between KV institutions and industry partners further strengthen the integration of green technology. Informant 3 provided an example:

> *"Another collaboration, for example, is with MAZDA. They work with several vocational training institutions, and in one of their modules, where they train teachers and students on how to manage MAZDA's parts for green technology."*

Such partnerships offer students valuable real-world experiences, preparing them for sustainable careers in the industry.

The findings indicate that green technology is integrated into KV training through affective elements, curriculum development, assessment strategies, and institutional initiatives. These approaches collectively equip students with the necessary competencies and awareness to apply green technology principles in their professional and personal lives. Furthermore, industry collaboration enhances the practical implementation of these elements, ensuring that KV graduates are well-prepared for sustainable employment.

5. Discussion

The integration of green technology elements into the On-the-Job Training (OJT) curriculum at Vocational Colleges (VC) represents an evolving effort to align vocational education with global sustainability goals. This alignment fosters critical thinking and ethical awareness among students, preparing them for future challenges in a sustainable economy (Lei & Zainal Abidin, 2024).

Based on the findings, it is evident that the incorporation of green elements in industrial training is both direct and indirect, with varying degrees of depth depending on the industry placement, curriculum structure, and institutional support. The study highlights the significance of *a posteriori* knowledge in shaping the practical and conceptual understanding of green technology among Vocational College (KV) students. The consensus among respondents affirms that experiential learning is not only more meaningful but also instrumental in embedding sustainability values in students' professional identity. Consistent with Pal et al. (2023), the findings also emphasize the transformative potential of green education. Students not only gain technical (TH) knowledge but also develop values and behaviors aligned with sustainable living.

The integration of green technology elements within vocational education is crucial to addressing industry demands and supporting sustainable development, as emphasized by Sern et al. (2018) and Ramli et al. (2018). This aligns with the broader goals of the Vocational

College Standard Curriculum (KSKV) (MOE, 2012), which aims to equip students with technical knowledge, practical skills, and soft skills. Students are introduced to real-world practices such as energy conservation, waste management, responsible material handling, and the use of eco-friendly technologies. These elements reflect a hands-on approach to green education, which reinforces theoretical understanding with direct experience.

The findings of this study indicate that while the integration of Technological and Holistic (TH) elements was positively received by all informants, the implementation strategy remains unclear and largely depends on initiatives taken at each KV and its geographical location. The exposure to TH components in KV institutions remains limited, requiring further exploration. This supports prior research indicating that TVET graduates often lack sufficient exposure to Green technology elements due to the absence of structured curriculum components (Yee et al., 2020; Mustapha, 2016). The integration of TH elements is more prominent in metropolitan areas due to the accessibility of collaborations between TH-based enterprises and relevant KVs, further exacerbating disparities in green skills development across different regions.

To address this gap, the 'Green Smart Education' framework developed by Pal et al. (2023) provides a structured approach to embedding green technology in the curriculum. The framework emphasizes green competencies such as environmental awareness, resource management skills, and visionary thinking, all of which are essential for producing graduates who are both environmentally conscious and competent in sustainable practices. Additionally, the Green Curriculum Model (GCM) proposed by Besong (2017) highlights pedagogical strategies that could be instrumental in integrating sustainability into vocational education, including Experience-Based Learning, Value-Ethical Learning, Constructivist Learning, and Transformation-Based Learning. These approaches can enhance students' critical thinking, ethical awareness, and hands-on experience with green technology, fostering a work and thought culture oriented towards sustainability.

The necessity of green technology must be explicitly defined and documented within the Program Learning Outcomes (PLOs) of Vocational College's On-the-Job Training (OJT). The knowledge, skills, and affective components associated with green technology should be embedded in the curriculum for all KV students from the outset of their education. Furthermore, initiatives promoting lifelong learning among KV educators and students should be strengthened by establishing clearer objectives, ensuring that graduates acquire green competencies that align with the needs of the green industry and IR 4.0.

TVET institutions play a crucial role in providing professional development courses that facilitate the adoption of new technologies, thereby contributing to the sustainability of ASEAN countries (Mohd Salleh & Sulaiman, 2020). Given this, it is recommended that KV industrial training curriculum developers place greater emphasis on the integration of green technology within PLO statements. This will ensure that KV educators prioritize the application of TH elements in their teaching and that these elements are systematically embedded within the OJT curriculum. A structured integration of green technology components will enable educators to effectively implement and assess sustainability-related

learning outcomes in teaching and learning practices.

These findings suggest that while the KV system has laid important groundwork for integrating green technology, the effectiveness of this integration is uneven and often dependent on individual initiative and institutional creativity. According to (Wang et al., 2022), the impact of green technology innovation on the manufacturing value chain is highly dependent on the institutional environment. KV institutions may need to revise curriculum documents, develop standardized green modules across disciplines, and provide professional development for educators to effectively deliver this content.

6. Conclusions

Efforts to enhance understanding and exposure to green technology knowledge and skills are believed highly beneficial for KV graduates in making them more competitive in the green job market. In addition, this aligns with the advancement of Industrial Revolution 4.0 (IR 4.0). Previous studies suggest that green training would positively impacts employees' green behavior, enhancing their commitment to environmental stewardship (Bahizire & Pea-Assounga, 2024, Judeh & Khader, 2023). The findings of this study support this idea, indicating that students' appreciation of TH elements is significantly influenced by their exposure and experience in the Green Industry during their OJT. These findings highlight the importance of providing meaningful industry engagement opportunities that foster practical knowledge transfer and sustainability competencies. The incorporation of TH elements seem can significantly enhance the employability of KV graduates by equipping them with relevant skills for the green job market. The shortage of green technology experts in Malaysia, as noted by Kordi et al. (2018), further highlight the importance of embedding green knowledge into the vocational education framework. KV's emphasis on experiential learning can be seen as a strategic response to this gap, enabling students to become future knowledge carriers and advocates for green practices.

This study provides important implications for policymakers, particularly BPLTV, in developing a more structured strategic plan for the KV OJT industrial training curriculum. The KV curriculum policy planning department should initiate the integration of Sustainable Development education across all KV programs. As the governing body responsible for the success of KV graduates, BPLTV must ensure that the KV program structure aligns with industry requirements, particularly those related to the Green Industry. This alignment is essential to bridge the existing gap in green technology education and to support Malaysia's commitment to SDGs and the evolving demands of IR 4.0.

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