A CRITICAL REVIEW OF TVET POLICY ALIGNMENT AND WORK-BASED LEARNING STRATEGIES FOR INDUSTRY 4.0 TALENT DEVELOPMENT IN MALAYSIA

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Abstract:

The Fourth Industrial Revolution (IR4.0) demands structural alignment between education policy, industry systems, and workforce development mechanisms. This study undertakes a critical policy review of Malaysia's Technical and Vocational Education and Training (TVET) ecosystem, with particular emphasis on Work-Based Learning (WBL) strategies under the Twelfth Malaysia Plan and Dasar TVET

Negara 2030. Using qualitative document analysis and comparative policy benchmarking against Germany, Singapore, South Korea, and Finland, the study evaluates alignment across three analytical dimensions: governance coherence, institutional capacity, and industry co-ownership. The findings indicate that while Malaysia demonstrates strong policy intent in embedding digital competencies and WBL within national frameworks, structural fragmentation across ministries, limited institutional autonomy, symbolic industry partnerships, and weak longitudinal performance monitoring constrain effective implementation. Unlike coordinated dual systems such as Germany's, Malaysian WBL operates largely within institution-led arrangements lacking regulatory obligation and shared financing mechanisms with industry actors. The study contributes a multi-tiered analytical framework for assessing IR4.0 talent alignment in developing TVET systems and proposes actionable policy reforms, including governance consolidation, performance-based funding models, structured industry co-design mechanisms, and longitudinal graduate tracking systems. These reforms are essential to shift Malaysia's TVET transformation from policy aspiration to systemic execution capable of sustaining global competitiveness.

Introduction

The Fourth Industrial Revolution (IR4.0) has transformed global economic systems through the integration of artificial intelligence (AI), cyber-physical systems, the Internet of Things (IoT), advanced robotics, and data-driven production architectures (Mazlan et al., 2025a). These technological shifts necessitate not only curriculum reform but systemic realignment of governance, financing structures, institutional autonomy, and industry collaboration to sustain workforce competitiveness (World Economic Forum, 2020; Schwab, 2017). In this context, the strategic coherence between education policy and labour market transformation has become central to national development planning.

Malaysia's response to IR4.0 has been largely anchored within its Technical and Vocational Education and Training (TVET) ecosystem, which is increasingly positioned as a primary instrument for talent development (Mohd Yusoff et al., 2025; Mazlan et al., 2025b; Masran et al., 2025). National policy instruments such as the Twelfth Malaysia Plan and the Dasar TVET Negara 2030 emphasise digitalisation, industry engagement, and the expansion of Work-Based Learning (WBL) pathways as mechanisms for strengthening graduate employability and IR4.0

readiness (EPU, 2021; MOHE, 2022; Mazlan et al., 2025a). These frameworks signal strong policy intent to align TVET with emerging technological demands.

However, policy ambition does not automatically translate into structural effectiveness. Previous critiques suggest that Malaysian TVET reforms often emphasise strategic blueprints while underestimating institutional capacity constraints, governance fragmentation, and sustainability of implementation mechanisms (Chettiar, 2017; Grech & Camilleri, 2020). Unlike coordinated systems such as Germany and Singapore where TVET is embedded within national innovation strategies and supported by institutionalised industry co-ownership Malaysia continues to experience multi-layered governance arrangements and uneven implementation across institutions (Paryono & Mashod, 2025). Consequently, while TVET and WBL are conceptually aligned with IR4.0 imperatives, their operational execution reveals structural inconsistencies.

Existing scholarship on Malaysian TVET has largely focused on employability outcomes, curriculum enhancement, or institutional reforms. There remains limited critical examination of how governance coherence, institutional autonomy, and industry collaboration interact systematically to influence IR4.0 talent alignment (Mazlan et al., 2026). Without such structural analysis, reform discourse risks reinforcing descriptive narratives of policy progress without interrogating underlying mechanisms of constraint.

This study addresses that analytical gap by conducting a critical review of Malaysia's TVET policy alignment and WBL strategies in the context of IR4.0 talent development. Drawing comparative insights from Germany, Singapore, South Korea, and Finland, this article evaluates alignment across three interrelated dimensions: governance coherence, institutional capacity, and industry co-ownership. By advancing a structured analytical lens rather than a descriptive overview, the study contributes conceptual clarification and policy-relevant recommendations for strengthening Malaysia's TVET transformation in an increasingly digital and competitive global economy.

Methodology

This study adopts a qualitative critical policy review design to examine the structural alignment between Malaysia's TVET policies and IR4.0 talent development imperatives. Rather than employing empirical field data, the study systematically analyses policy documents, strategic blueprints, regulatory guidelines, and peer-reviewed academic literature to evaluate governance coherence, institutional capacity, and industry co-ownership mechanisms.

Research Design

The research is grounded in qualitative document analysis, which enables systematic interpretation of policy texts and institutional frameworks within their socio-economic context. Document analysis is particularly appropriate for policy evaluation studies where structural mechanisms, governance arrangements, and strategic alignment require critical interrogation rather than statistical measurement.

The review focuses on three categories of documents:
1. National Policy Instruments - including the Twelfth Malaysia Plan (EPU, 2021), Dasar TVET Negara 2030 (MOHE, 2022), and *Transformasi Politeknik* 2023-2030 (JPPKK, 2023).
2. Quality Assurance and Regulatory Frameworks - including the Malaysian Qualifications Agency's Guidelines on Good Practices: Work-Based Learning (MQA, 2016).
3. Peer-Reviewed Academic Literature and International Comparative Reports - including OECD (2021), UNESCO-UNEVOC (2020), Lee et al. (2022), Paryono (2022), Paryono and Mashod (2025), Ramli and Zakariah (2024), and Mazlan et al. (2025a, 2025b, 2025c).

Only documents directly addressing governance structures, WBL mechanisms, digital competency frameworks, or IR4.0 talent development were included. Opinion pieces, non-regulatory blog materials, and non-scholarly commentary were excluded.

Analytical Framework

The analysis is guided by a three-tier evaluative framework:
1. Governance Coherence - examining ministerial coordination, regulatory integration, and policy consistency.
2. Institutional Capacity and Autonomy - assessing curriculum flexibility, technological readiness, educator competence, and financing structures.
3. Industry Co-Ownership and Accountability - evaluating depth of partnership, co-design mechanisms, shared financing, mentor preparation, and longitudinal monitoring.

This framework is informed by comparative governance models from Germany's dual system and Singapore's SkillsFuture ecosystem, as documented by OECD (2021) and Paryono (2022). The comparative lens enables structural benchmarking rather than descriptive comparison.

Analytical Procedure

Documents were analysed using thematic coding procedures. Key themes related to implementation gaps, coordination mechanisms, financing models, curriculum reform cycles, and monitoring systems were identified and categorised under the three analytical dimensions. Comparative insights were then mapped against international TVET governance models to identify structural divergences and systemic constraints.

This approach enables the study to move beyond descriptive policy narration toward evaluative structural analysis, thereby addressing gaps identified in prior scholarship that often focuses on program-level outcomes rather than systemic alignment (Lee et al., 2022; Ramli & Zakariah, 2024).

The Connection between Educational Policy, Industry 4.0, and Workforce Development

In the context of IR4.0, education policy functions not merely as a curriculum directive but as a systemic coordination mechanism that integrates governance structures, labour market intelligence, institutional autonomy, and industrial participation. Countries at the forefront of technological competitiveness such as Germany, Singapore, and Finland demonstrate that effective TVET systems are characterised by regulatory coherence, decentralised institutional

flexibility, and embedded industry accountability mechanisms (OECD, 2021; Paryono, 2022; Mazlan et al., 2025c). In these systems, policy operates as an enabling architecture rather than a declarative blueprint.

Malaysia's education policy framework has evolved through initiatives such as the Malaysia Education Blueprint (Higher Education), the Twelfth Malaysia Plan, and *Dasar* TVET *Negara* 2030, all of which emphasise digital skills integration, IR4.0 competencies, and work-based learning pathways (EPU, 2021; MOHE, 2022; Mazlan et al., 2025b). These reforms signal a strategic recognition that workforce competitiveness depends on technological adaptability and employability enhancement. However, policy articulation alone does not guarantee institutional transformation.

Chettiar (2017) and Mazlan et al. (2025a) argue that despite comprehensive policy documentation, structural bottlenecks persist at the implementation level, particularly in curriculum responsiveness, funding sustainability, and outcome-based accountability. This reflects a broader challenge observed in developing economies, where education institutions often operate in isolation from industrial transformation due to fragmented governance and outdated pedagogical models (Banga & te Velde, 2019; Grech & Camilleri, 2020; Mazlan et al., 2025d).

In contrast to Germany's governance model where chambers of commerce, industry associations, and federal authorities co-determine training standards Malaysia's TVET institutions frequently operate under top-down regulatory directives with limited discretion in curriculum redesign or industry co-certification (OECD, 2021; Paryono & Mashod, 2025). This centralised yet fragmented arrangement reduces adaptive capacity, particularly in responding to rapidly evolving technological skill demands.

Moreover, Singh (2023) highlights that vocational reforms in emerging economies often emphasise expansion and access without simultaneously strengthening structural coordination between ministries, institutions, and employers. This structural misalignment contributes to the persistence of skills mismatch, even in contexts where policy frameworks appear comprehensive.

Therefore, in the IR4.0 era, education policy must be evaluated not solely on its strategic rhetoric but on its structural capacity to institutionalise coordination, enable curriculum dynamism, and embed industry co-ownership within governance mechanisms. Without these enabling conditions, policy reform risks remaining performative rather than transformational.

Policy Analysis: Alignment of Malaysian TVET with IR4.0

Malaysia has articulated strong policy commitment to aligning its TVET ecosystem with IR4.0 imperatives through major national instruments, including the Twelfth Malaysia Plan and *Dasar* TVET *Negara* 2030 (EPU, 2021; MOHE, 2022). These frameworks emphasise digital competency integration, industry collaboration, governance reform, and expansion of WBL models such as 2u2i and 3u1i. At the level of policy rhetoric, Malaysia demonstrates strategic clarity in recognising the importance of technological adaptation and workforce digitalisation. However, structural alignment requires more than strategic articulation; it depends on governance coherence, financing stability, and institutional accountability mechanisms.

Governance Fragmentation

One of the most significant structural constraints lies in the fragmented governance of Malaysian TVET. Responsibilities are distributed across multiple ministries, including the Ministry of Higher Education (MOHE), Ministry of Human Resources (MOHR), MARA, and other agencies. This multi-ministerial arrangement generates overlapping accreditation systems, funding streams, and regulatory directives (Lee et al., 2022; Paryono & Mashod, 2025).

Unlike Singapore, where TVET coordination is centralised under a unified authority, or Germany, where federal and industry bodies operate within clearly defined regulatory mandates (OECD, 2021), Malaysia's dispersed governance reduces policy coherence. The absence of a single coordinating body weakens long-term strategic alignment and creates inconsistencies in curriculum standards, industry engagement requirements, and performance monitoring.

Institutional Capacity and Autonomy

While national policies encourage curriculum digitalisation and IR4.0 skill embedding, institutional autonomy to rapidly redesign programs remains constrained. Chettiar (2017) observes that Malaysian TVET institutions often rely on centrally approved curricula, limiting their responsiveness to local industrial demands. Mazlan et al. (2025a) further highlight that although IR4.0 competencies are recognised at policy level, institutional capability in terms of educator readiness and technological infrastructure remains uneven.

In contrast, European TVET systems implement structured curriculum revision cycles often every three to five years based on labour market forecasting and employer feedback (Grech & Camilleri, 2020). Malaysian institutions, however, frequently lack access to real-time labour market intelligence and systematic tracer data (Salleh, 2020; Mazlan et al., 2025a), constraining adaptive reform.

Industry Co-Ownership and Financing Mechanisms

Although WBL is heavily promoted within Malaysian policy frameworks, industry participation is often operationalised through memoranda of understanding rather than legally embedded co-determination structures (Ramli & Zakariah, 2024). Harikirishanan (2024) notes that many partnerships remain documentation-driven, with limited joint curriculum development, co-assessment, or shared financing models.

Germany's dual training system provides a structural contrast, where firms are legally obligated to provide apprenticeships and co-finance training under a regulated framework (OECD, 2021). This shared accountability ensures alignment between training standards and labour market demand. Malaysia lacks comparable regulatory obligations or levy-based financing mechanisms, resulting in WBL arrangements that depend heavily on institutional negotiation rather than systemic commitment.

Monitoring and Outcome Accountability

Another structural limitation concerns performance monitoring. While employability rates are frequently cited as key indicators, Malaysia does not consistently implement longitudinal tracking systems that assess graduate progression, industry retention, or productivity outcomes over extended periods (Ramli & Zakariah, 2024).

In benchmarked systems such as Germany and Singapore, apprentice outcomes are tracked and fed back into policy cycles, enabling continuous program recalibration (OECD, 2021). The absence of structured feedback loops in Malaysia limits evidence-based policy refinement and weakens adaptive governance.

Structural Synthesis

Taken together, Malaysia's TVET policies demonstrate strong strategic intent but encounter systemic constraints across governance fragmentation, constrained institutional autonomy, limited industry co-ownership, and weak longitudinal accountability mechanisms. The challenge, therefore, is not policy absence but structural execution capacity.

Effective IR4.0 alignment requires consolidation of governance functions, performance-based funding models, regulatory embedding of industry obligations, and institutional empowerment to implement agile curriculum reform. Without such structural recalibration, Malaysia risks sustaining a policy-rich but execution-constrained TVET ecosystem.
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Global TVET Practices and Alignment with Industry Revolution 4.0

International experience demonstrates that successful alignment between TVET systems and IR4.0 is not driven solely by curriculum modernisation, but by structural integration between governance, industry, and institutional ecosystems. While Germany, Singapore, Finland, South Korea, and Japan operate within distinct socio-economic contexts, their systems share common enabling mechanisms that sustain long-term workforce competitiveness.

Germany's Dual Training System remains one of the most institutionally embedded apprenticeship models globally. Its effectiveness derives from legally codified industry participation, shared financing responsibilities, and regulatory oversight by chambers of commerce and industry associations (OECD, 2021). Apprenticeship standards are co-determined, and firms are obligated to provide structured training placements. This institutionalised co-ownership reduces skills mismatch and ensures curriculum relevance (Mustapha & Hussain, 2021; Mazlan et al., 2025a). The key structural feature is not merely industry participation, but legally enforced accountability.

Singapore's SkillsFuture ecosystem similarly embeds industry within governance structures, albeit through a centralised state-coordinated model. SkillsFuture Singapore provides unified oversight, national skills forecasting, modular micro-credential pathways, and funding incentives for lifelong learning (Lee et al., 2022). Unlike traditional linear pathways, the Singaporean model emphasises stackable credentials and continuous upskilling aligned with labour market projections. Centralised data integration enables policy recalibration based on workforce analytics, strengthening adaptive capacity.

Finland and South Korea extend TVET alignment beyond training into innovation ecosystems. Finnish vocational institutions collaborate with enterprises through challenge-based learning and local innovation hubs (UNESCO-UNEVOC, 2020). Similarly, South Korea's Meister High Schools align vocational curricula directly with national industrial strategies, supported by targeted funding and equipment-sharing partnerships (Paryono, 2022). In both systems, policy coherence is reinforced by strategic industrial policy integration rather than isolated educational reform.

Japan's vocational model, although culturally distinct, emphasises long-term employer-employee integration and structured workplace socialisation (Yamada & Tanaka, 2021). Post-placement tracking and organisational embedding enhance graduate retention and skills maturation. This highlights an important dimension often underemphasised in Malaysian WBL implementation longitudinal workforce integration.

Despite contextual differences, these global systems exhibit four recurring structural enablers:
1. Centralised or clearly coordinated governance architecture
2. Legally embedded or financially incentivised industry co-ownership
3. Institutional autonomy to redesign curricula responsively
4. Continuous monitoring through labour market intelligence systems

In contrast, Harikirishanan (2024) observes that many Malaysian WBL partnerships remain documentation-oriented, often limited to memoranda of understanding without operational co-design or shared accountability. The absence of structured financing models, formal industry obligations, and integrated labour market forecasting weakens systemic alignment.

Therefore, international benchmarking suggests that Malaysia's challenge is not conceptual recognition of IR4.0, but the absence of embedded structural mechanisms that convert policy intent into institutionalised practice. Policy replication without enabling legal, financial, and governance infrastructure is unlikely to yield equivalent outcomes.

The Function of Malaysian Polytechnics in Policy Implementation

Malaysian polytechnics serve as the principal operational arm of the national TVET system, functioning as the institutional interface between policy ambition and workforce outcomes. Under policy instruments such as *Dasar* TVET *Negara* 2030 and *Transformasi Politeknik* 2023-2030, polytechnics are expected to integrate IR4.0 competencies, expand work-based learning pathways, and enhance graduate employability (JPPKK, 2023; MOHE, 2022). Programmatic expansions including bachelor's degree offerings and *Asasi* TVET pathways reflect the state's commitment to elevating the status and vertical mobility of vocational education.

However, structural readiness remains uneven. Ali, Rahman, and Karsidi (2024) highlight institutional gaps in technological infrastructure, lecturer upskilling, and curriculum flexibility, which constrain effective IR4.0 integration. While digital competencies are formally embedded in policy, the operationalisation of these competencies depends on institutional capacity, equipment investment cycles, and industry exposure opportunities.

Institutional autonomy is another critical determinant. In contrast to Singapore's Institutes of Technical Education (ITE), which operate with considerable curriculum flexibility and direct industry coordination (Paryono & Mashod, 2025), Malaysian polytechnics remain embedded within layered bureaucratic approval systems. Curriculum revisions, procurement of advanced equipment, and establishment of new industry-driven programs often require multi-tier administrative endorsement, slowing adaptive responsiveness.

Financing mechanisms further shape implementation capacity. Although national policies articulate digital transformation goals, funding allocations frequently prioritise expansion and enrolment targets over technological upgrading and lecturer industrial attachment. Without performance-linked funding structures or co-financing models involving industry partners, institutions may struggle to sustain high-cost IR4.0 laboratories or simulation environments. This structural constraint mirrors broader challenges in developing TVET systems where policy ambition outpaces institutional resourcing.

The implementation of hybrid initiatives such as TVET-Tahfiz programmes illustrates both innovation and structural tension. While these programmes reflect Malaysia's attempt to integrate cultural and technical aspirations, questions of scalability, standardisation, and long-term sustainability remain (Singh, 2023). Similar observations in vocational reform across emerging economies suggest that policy diversification must be accompanied by coherent resource alignment to avoid fragmentation.

Moreover, industry partnerships at the polytechnic level often remain transactional rather than strategic. Harikirishanan (2024) and Ramli and Zakariah (2024) note that collaborative arrangements frequently revolve around student placements rather than joint curriculum development, co-certification, or shared supervision models. This limits the depth of industry co-ownership necessary for IR4.0 talent ecosystems.

Thus, while Malaysian polytechnics have formally aligned with national IR4.0 aspirations, their execution capacity is mediated by governance centralisation, constrained institutional autonomy, financing limitations, and variable industry engagement depth. Strengthening polytechnic performance therefore requires not merely program expansion, but structural recalibration that empowers institutions with greater flexibility, sustained technological investment, and embedded industry accountability mechanisms.

The Significance of Work-Based Learning and Collaboration between Industry and Universities

WBL constitutes a central policy instrument in Malaysia's strategy to cultivate IR4.0-ready talent. Models such as 2u2i and 3u1i aim to embed structured industry exposure within academic programs, facilitating the integration of technical, cognitive, and professional competencies required in digitally mediated work environments (Mohd Yusof et al., 2020; Hanafi et al., 2023). In principle, WBL serves as a bridging mechanism that reduces the gap between educational provision and industrial practice.

The Malaysian Qualifications Agency (MQA) formalises WBL quality assurance through its Guidelines on Good Practices: Work-Based Learning (MQA, 2016), which require dual supervision, clearly articulated learning outcomes, and workplace-validated assessment

mechanisms. This framework provides regulatory clarity. However, regulatory presence does not necessarily guarantee structural effectiveness.

A key limitation lies in the depth of industry co-ownership. Ramli and Zakariah (2024) argue that many WBL arrangements remain institution-driven, with industries primarily functioning as placement hosts rather than co-designers of curriculum and assessment. Harikirishanan (2024) further observes that partnerships frequently rely on memoranda of understanding without embedding operational accountability mechanisms, shared financing commitments, or structured mentor preparation systems. Such arrangements risk reducing WBL to internship-style exposure rather than apprenticeship-based integration.

Comparatively, Finland integrates WBL within regional innovation ecosystems, where students participate in problem-based industrial projects co-designed with enterprises (UNESCO-UNEVOC, 2020). Germany's Berufsausbildung system embeds WBL within legally regulated apprenticeship contracts, mandating employer participation and shared training responsibility (OECD, 2021). These systems institutionalise industry engagement beyond voluntary collaboration, ensuring structured skill transmission and measurable training standards.

Another structural concern involves mentor readiness and pedagogical capacity within industry settings. Harikirishanan (2024) notes that some industry supervisors lack training in instructional design or assessment alignment, limiting the developmental value of placements. Without systematic mentor training frameworks, WBL outcomes may depend on individual workplace culture rather than regulated competency progression.

Monitoring and longitudinal evaluation also remain underdeveloped. While employability indicators are frequently cited as success metrics, systematic post-placement tracking of graduate career trajectories is inconsistent (Anthony et al., 2022). In benchmarked systems, graduate progression data feeds back into curriculum redesign and funding recalibration (OECD, 2021). Malaysia's limited integration of tracer data into policy cycles weakens adaptive governance and evidence-based improvement.

Despite these structural challenges, empirical studies indicate that WBL exposure enhances student adaptability, soft skills, and workplace confidence (Anthony et al., 2022). However, the absence of embedded industry co-determination, financing obligations, structured mentor development, and longitudinal monitoring limits the transformational potential of WBL within Malaysia's IR4.0 strategy.

For WBL to function as a systemic alignment mechanism rather than a programmatic supplement, Malaysia must transition toward co-owned governance structures where industries participate in curriculum co-design, shared assessment, financing contribution, and performance evaluation. Without such recalibration, WBL risks remaining operationally active yet structurally shallow in its contribution to IR4.0 talent ecosystems.

Conclusion and Policy Recommendations

This study critically examined the structural alignment of Malaysia's TVET policies and WBL strategies within the broader demands of IR4.0. While national instruments such as the Twelfth Malaysia Plan and *Dasar* TVET *Negara* 2030 articulate strong strategic intent toward digitalisation and industry integration (EPU, 2021; MOHE, 2022), the analysis reveals that

systemic constraints persist across governance coordination, institutional capacity, industry co-ownership, and monitoring mechanisms.

The central finding is not the absence of policy commitment, but the presence of structural fragmentation that limits execution fidelity. Drawing from comparative benchmarks including Germany, Singapore, Finland, and South Korea (OECD, 2021; Paryono, 2022; UNESCO-UNEVOC, 2020), effective IR4.0 alignment requires institutionalised coordination mechanisms rather than declarative reform.

Based on the three-tier analytical framework, several policy recalibrations are proposed:

Governance Consolidation

First, Malaysia should consider consolidating TVET governance functions under a more unified coordinating authority to reduce ministerial overlap and regulatory duplication (Lee et al., 2022; Paryono & Mashod, 2025). Clear delineation of accreditation, funding, and curriculum oversight responsibilities would enhance coherence and strategic consistency. Inter-ministerial coordination platforms must be formalised with defined accountability indicators rather than ad hoc consultation mechanisms.

Performance-Based and Co-Financing Models

Second, financing structures should evolve from expansion-driven allocations toward performance-linked funding tied to graduate outcomes, industry satisfaction, and innovation engagement. Introducing industry co-financing models or levy-based mechanisms similar to regulated apprenticeship systems could institutionalise shared accountability and reduce overreliance on public funding (OECD, 2021). Sustainable technological upgrading requires predictable and outcome-oriented resource allocation.

Institutional Autonomy and Curriculum Agility

Third, polytechnics and TVET institutions require enhanced curriculum autonomy within regulated quality assurance frameworks. Structured curriculum review cycles informed by labour market intelligence and tracer data should be institutionalised (Grech & Camilleri, 2020; Ramli & Zakariah, 2024). Lecturer industrial attachment programs and digital upskilling initiatives must be systematically embedded rather than implemented episodically.

Deepening Industry Co-Ownership in WBL

Fourth, WBL arrangements should transition from placement-based models to co-designed apprenticeship-style ecosystems. Industry partners must participate in curriculum development, assessment validation, mentor training, and graduate evaluation processes (Harikirishanan, 2024; Anthony et al., 2022). Clear role delineation and formalised accountability mechanisms are essential to elevate partnerships beyond documentation-driven collaboration.

Longitudinal Monitoring and Data Integration

Finally, Malaysia should institutionalise longitudinal graduate tracking systems that measure not only employability rates but also retention, productivity, and career mobility over time. Feedback loops linking tracer outcomes to curriculum reform and funding recalibration would enable adaptive governance, mirroring benchmarking systems identified by OECD (2021).

Theoretical and Practical Contribution

This study contributes to the literature by advancing a structured multi-tier framework for evaluating IR4.0 talent alignment in developing TVET ecosystems. By integrating governance coherence, institutional capacity, and industry co-ownership into a unified analytical lens, the article moves beyond descriptive policy reviews toward structural evaluation.

Practically, the findings underscore that successful TVET transformation depends not on policy proliferation but on embedded coordination mechanisms, shared financing structures, institutional empowerment, and continuous evidence-based recalibration.

Without systemic recalibration across these dimensions, Malaysia risks maintaining a policy-rich yet execution-constrained TVET ecosystem. Sustainable competitiveness in the IR4.0 era demands structural alignment that integrates governance, institutions, and industry within a coordinated and accountable talent development architecture.

analysis and comparative benchmarking, and prepared the original draft of the manuscript. Saifullizam provided methodological guidance, supervised the overall research direction, and critically reviewed and refined the manuscript for intellectual content. Muhammad Ikhwan Hafiz contributed to data organization, literature synthesis, and assisted in drafting selected sections of the manuscript. Zunuwanas supported the industry-related analysis, provided technical insights on IR4.0 implementation within polytechnic contexts, and reviewed the manuscript for practical relevance. Nor Lisa contributed to theoretical framing and policy interpretation and participated in critical revisions of the manuscript. Kahirol provided expertise in TVET governance and institutional strategy and contributed to policy analysis refinement. Wan Rosemehah assisted in validating the comparative analysis and contributed to manuscript editing and final review. All authors have read and approved the final version of the manuscript prior to submission and agree to be accountable for all aspects of the work.

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