

A Review of Industry Engagement in the Malaysian TVET Ecosystem

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ABSTRACT

Industry engagement is central to the responsiveness of technical and vocational education and training (TVET). Yet, Malaysian evidence on the subject remains scattered across employability, curriculum relevance, educator capability, workplace learning, Industry 4.0 readiness, and the emerging shift toward Industry 5.0. This scoping review maps how industry engagement has been conceptualised and operationalised in the Malaysian TVET ecosystem between 2016 and 2026, and develops an integrative framework for engagement quality. The review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR). The search configuration comprises Scopus ($n = 120$), ScienceDirect ($n = 97$), and a Google Scholar supplement of 227 relevance-ranked records identified with the query "industry" AND "TVET" AND "Malaysia". The final evidence base comprises 44 sources that met the eligibility criteria. The synthesis suggests four interdependent functions: policy and governance, curriculum co-design and educator development, work-integrated learning, and labour market feedback. Across these functions, engagement appears most consequential when it is continuous, reciprocal, and embedded in programme decisions, rather than limited to episodic consultation or placement provision. The proposed Ecosystem Industry Engagement Framework advances a synthesis-derived depth continuum spanning transactional, relational, and transformative engagement, together with two enabling conditions: engagement infrastructure and incentive symmetry. This may shift the analytical question from whether industry participates to the depth, continuity, reciprocity, and outcomes of that participation. The evidence remains mainly observational and context-dependent, making longitudinal validation of engagement quality and its graduate and employer outcomes a priority for Malaysian TVET research.

Keywords: TVET; industry engagement; industry collaboration; Malaysia

INTRODUCTION

Malaysia's technical and vocational education and training (TVET) system is expected to produce graduates for workplaces where technical, digital, and transferable capabilities change faster than conventional curriculum cycles. In this environment, industry is more than the final destination for graduates. Employers, professional bodies, and sector actors can shape occupational standards, curriculum content, authentic assessment, workplace learning, educator exposure, and feedback on graduate performance. The literature reviewed here reflects this wider role through studies of employer perceptions, industry-informed curriculum, work-based learning (WBL), apprenticeship, institutional partnership, Industry 4.0 alongside Industry 5.0 skills, and labour market alignment.

The same evidence exposes a persistent alignment problem. Studies document a disconnect between TVET institutions and industries, manifested as a gap between the competencies cultivated and those employers demand, with consequences for graduate employability and TVET's contribution to economic growth [1]. This misalignment may be considerable: the manufacturing sector faces shortages of skilled engineers and technicians [2]. Communication deficits and calls for institution–industry collaboration in curriculum design recur in the employer literature [3]; curriculum demand–supply mismatch is explicit in programme-level analyses [4]; and institution directors report practical barriers to managing partnerships [5]. At the same time, constructive arrangements appear in dual training, industry centres of excellence, WBL, apprenticeships, and joint

programme quality assurance. These apparently contradictory patterns imply that the decisive analytical issue is not the presence or absence of engagement, but the form, depth, and continuity through which it is organised.

The relevance of that alignment problem is evolving within the review's timeframe. The 2026 horizon coincides with a period in which Malaysian skills discourse is beginning to shift from Industrial Revolution 4.0 (IR4.0) to Industrial Revolution 5.0 (IR5.0) in which skilled workers will remain critical to national economic growth. At the same time, TVET is increasingly expected to produce a holistic, globally competitive workforce rather than automation-ready labour alone [6]. Policy-oriented analyses of Community Education 5.0 reach a similar conclusion, arguing that modernisation, digital infrastructure, and public-private collaboration must advance in step with IR5.0 goals [7]. Accordingly, this review treats the IR4.0 readiness literature as part of a broader industrial transition and asks how industry engagement must evolve as criteria for graduate readiness become more human-centred than purely technological.

Existing Malaysian reviews have examined graduate marketability [8], TVET reform and workplace learning [9], and graduate attributes and employability skills through a Preferred Reporting Items for Systematic Reviews and Meta-Analyses-based synthesis [10]. Other studies have examined employability strategies among public university policymakers [11], the sector's present and future [12], systemic challenges associated with fragmentation and accreditation [13], and the development of TVET-industry collaboration within national development-plan priorities [14]. Although some studies have examined industrial involvement [15], industry engagement has not yet been analysed comprehensively as an ecosystem-level phenomenon.

Studies focused on specific providers or instruments explain important aspects of the system, but they do not show how governance, curriculum, workplace learning, and labour market feedback interact. A scoping review therefore appears appropriate because it can map diverse evidence, clarify key mechanisms, and identify research gaps rather than estimate a pooled effect. The principal synthesis-level contribution of this review is the proposed Ecosystem Industry Engagement Framework, which links four functional domains to a three-level engagement-depth continuum and a related measurement agenda. Both the continuum and the agenda are offered as analytically grounded propositions for subsequent validation rather than as empirically confirmed constructs, and both shift the analytical question from whether industry participates to the depth, continuity, reciprocity, and outcomes of that participation.

METHODOLOGY

Review design

This study adopted a scoping review design to systematically examine industry engagement as a complex, cross-sectoral phenomenon represented across a heterogeneous body of empirical, review, policy, and applied literature. Reporting follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR), which specifies the minimum reporting items for scoping reviews across the title, abstract, introduction, methods, results, and discussion sections [16]. The unit of synthesis is the evidence source rather than a standardised effect size, consistent with the review's mapping purpose.

Information sources and search strategy

Scopus and ScienceDirect served as the principal databases, with Google Scholar as a supplementary source. The search was built on the core concept string "industry" AND "TVET" AND "Malaysia", restricted to publications from 2016 to 2026 and to English-language records. Scopus was searched across title, abstract, and keyword fields; ScienceDirect through its advanced search interface; Google Scholar through relevance ranking using the same three concepts. Table 1 reports the strategy as executed in each source, including field scopes, filters, records retrieved, and the date of execution.

Table 1. Search strategy

Source	Search string	Field scope and filters	Records
Scopus	(TITLE-ABS-KEY (industry) AND TITLE-ABS-KEY (TVET) AND TITLE-ABS-KEY (Malaysia)) AND PUBYEAR > 2015 AND PUBYEAR < 2027	Title, abstract, keywords; 2016–2026;	120
ScienceDirect	"industry" AND "TVET" AND "Malaysia" Year:2016-2026	Advanced search; 2016–2026;	97
Google Scholar	"industry" AND "TVET" AND "Malaysia" Year:2016-2026	Relevance-ranked; first 25 result pages screened; 2016–2026	227 screened

Searches were executed on 10th August 2026 and re-run on 17th August 2026, which served as the final search date for the review. Scopus returned 120 records and ScienceDirect 97, which were exported to Mendeley Reference Manager. Google Scholar returned 227 relevance-ranked records under the same concept string, of which the first 25 pages were screened. Across the three sources, 444 records were identified before de-duplication. Records were then consolidated in Mendeley Reference Manager, where 72 duplicates were removed by automatic duplicate detection followed by manual verification, leaving 372 records for title-and-abstract screening.

Two features of the configuration are stated explicitly so that the process can be reproduced or challenged. First, because Google Scholar results are relevance-ranked and vary over time, the review reports the number of result pages screened and the date of screening, and the 227 records are therefore the records screened within the configuration applied here rather than a fixed estimate of all retrievable results. Second, the Google Scholar supplement was capped at that number of pages rather than exhaustive; this cap is a reporting parameter of the review, and it is the reason the supplement is treated as supplementary rather than as a third principal database.

Eligibility criteria

Records were included when they addressed TVET in Malaysia and included a substantive industry engagement component; conversely, records were excluded when they concerned TVET outside Malaysia, general higher education without a TVET dimension, or lacked an engagement element. Table 2 outlines the full criteria.

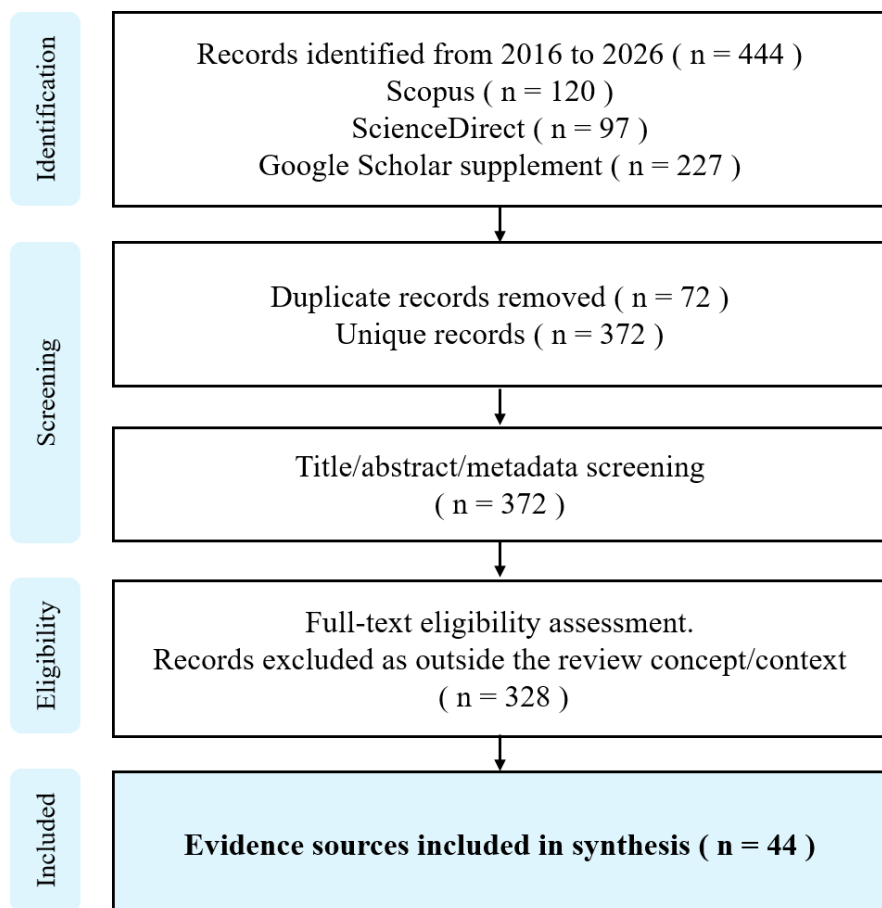
Table 2. Eligibility criteria

Criterion	Inclusion	Exclusion
Context	TVET in Malaysia, including polytechnics, community colleges, vocational colleges, technical universities, and skills training providers.	TVET outside Malaysia; general higher education without a substantive TVET dimension.
Phenomenon of interest	Industry or employer engagement, partnership, WBL, apprenticeship, industry input to curriculum or standards, educator industry exposure, employer perceptions, workplace transfer, skills gap feedback, or industry-linked capability development.	TVET outcomes with no industry engagement component; "industry" incidental to the study.
Evidence type	Empirical studies, peer-reviewed reviews, and substantive applied or conceptual studies.	Editorials, news items, indexes or prefaces, and non-substantive records.
Language	English-language indexed evidence.	Non-English evidence not captured by the search.

Screening and selection

Records were screened against the predefined operational eligibility criteria based on titles, abstracts, and metadata, followed by full-text assessment of potentially eligible sources. Following this process, 44 sources met the inclusion criteria and were retained for the final synthesis. Figure 1 presents the complete PRISMA-ScR flow for the review.

Figure 1. PRISMA-ScR flow for the retained database configuration



Data charting and synthesis

Charting was performed on the full text of every included source. A charting form was developed to record bibliographic details, publication year, country and provider or sector context, study design, the engagement mechanism examined, whether engagement was directly measured or inferred from related constructs, the framework domain(s) to which the source contributed, reported outcomes, and stated limitations.

Charting served three connected purposes. The first was thematic. Through iterative comparison of the charted entries, the evidence was consolidated into four ecosystem functions: policy and governance; curriculum co-design and educator development; work-integrated learning; and labour-market feedback. Cross-cutting implementation conditions were then identified from the recurrent barriers, enabling mechanisms, and recommendations reported across the sources. The second purpose was documentary, insofar as a scoping review should allow the reader to trace any thematic claim back to the studies behind it; accordingly, the full charted record of the sources is presented as the evidence map at the end of the Results section, alongside the themes it supports.

The third was analytical. The Ecosystem Industry Engagement Framework was derived from the charted record rather than imposed upon it: sources describing self-contained, activity-based engagement, such as one-off advisory meetings or placement hosting without shared assessment, were grouped as transactional; sources describing repeated interaction governed through stable roles and reciprocal obligations were grouped as

relational; and sources in which industry participation extended into standards, curriculum, assessment, and educator development were grouped as transformative. The four domains were retained because each recurred as a functional category across the charted sources, and the two enabling conditions were retained because they recurred as explanations offered for engagement that stalled. The sources supporting each domain are identified in the domain column of Table 3, so that the derivation can be audited against the evidence rather than accepted on assertion. The results follow the sequence of the synthesis, outlining the four functions before presenting the complete map. Before that evidence is presented, the applicable interpretive caution is delineated.

Theoretical grounding

Deriving the framework required a stated theoretical lens, which the review makes explicit here. Three traditions inform it. From systems and innovation-systems accounts of skill formation, the review takes the premise that vocational competence is produced by interacting institutional actors rather than by providers alone; this premise underlies the treatment of engagement as an ecosystem property rather than a programme attribute. From stakeholder accounts of organisational behaviour, it takes the proposition that participation is sustained when actors perceive both a reciprocal stake in outcomes and influence over decisions, which is the basis of the incentive-symmetry condition. From relational and co-production accounts of partnership, it takes the distinction between contractual exchange and jointly produced outcomes, which underpins the transactional–relational–transformative continuum.

The continuum is therefore advanced by this review as a synthesis-level construct, rather than adopted as an established or validated taxonomy. None of the 44 included studies explicitly tests, validates, or operationalises the continuum in the Malaysian context. Instead, the construct is derived by integrating complementary propositions from the three theoretical traditions with patterns identified across the reviewed evidence. Accordingly, the framework should not be read as an empirical typology imported into the Malaysian vocational education and training context; rather, it represents an interpretive synthesis developed through the review.

This distinction between theoretical inheritance and empirical synthesis is important to the framework's epistemic positioning. The theoretical traditions establish the conceptual premises from which the framework is derived, whereas the dimensions and relationships proposed within the framework constitute the review's own synthesis of the evidence. Making this distinction explicit clarifies which elements are grounded in established scholarship and which are propositions advanced by the present review, thereby avoiding an unwarranted attribution of empirical validation to a construct that remains to be tested.

RESULTS

Thematic structure of the evidence base

The 44 sources span 2016 to 2026, with their presence more pronounced in the latter years, alongside growing attention to IR4.0 readiness, work-integrated learning, and graduate readiness [17]; the most recent studies extend this concern to the transition toward IR5.0 [6]. The evidence covers technical universities, vocational colleges, polytechnics, skills institutions, and employer settings, with engineering, manufacturing, automotive, and construction especially prominent. Methods include employer and student surveys, interviews, mixed-method designs, action research, institutional studies, systematic reviews, bibliometric analyses [14], and conceptual studies. This diversity may support ecosystem mapping, although it also limits direct comparison of effect magnitudes.

Table 3 records the study type as characterised in each source; it does not represent independent methodological appraisal, and the domain mapping in its final column is a synthesis-level judgement made during charting. Because the included designs are predominantly cross-sectional, qualitative, or conceptual, no statement in this review about engagement producing curriculum relevance, workplace-learning quality, or graduate outcomes is supported by the reviewed evidence. Such relationships are framed throughout as patterns and plausible mechanisms requiring testing.

Table 3. Thematic delineation of the evidence base

Theme	Sub-themes addressed in the literature	Typical focus of included studies
Policy and governance	TVET repositioning; governance fragmentation; policy incentives	Education Blueprint shifts; ministry and agency mandates; tax and levy incentives; national coordination bodies
Curriculum co-design and educator development	Industry-driven curriculum; joint supervision; educator industry exposure	Programme reviews with industry input; final-year project co-supervision; lecturer industrial attachment
Work-integrated learning	WBL; Internships; dual training; apprenticeships; Academy in Factory	Placement structures, workplace institution time splits, supervision quality, graduate outcomes
Labour market feedback	Tracer studies; employer surveys; skills gap analyses	Graduate employment tracking; mismatch measurement; employer satisfaction and competency gaps

Policy and governance: from voluntary contact to ecosystem function

At the system level, policy design, incentives, institutional mandates, and training architecture condition engagement, including public-private partnerships, performance-based funding, and financial incentives such as tax breaks and grants intended to draw the private sector in [15]. The reviewed literature documents repeated attempts to increase employer participation through national strategies, incentives, and dual training structures; a systematic narrative review of government strategies and incentives from 2010 to 2021 concluded that stronger employer obligations and more durable engagement mechanisms are needed [15]. Provision remains dispersed across many providers, including ministries, agencies, universities, and private institutions, which collaborate without a shared view of the overall curriculum offer, creating duplication for students and companies alike. Although the National TVET Council was established in 2021 to implement the strategies and initiatives of the 12th Malaysia Plan [12], effective coordination, resource sharing, and articulation across the system may remain incomplete.

Studies suggest that weak collaboration might be due to the absence of formal mechanisms for industry involvement and a lack of incentives for employers to participate [1], while governance analyses document fragmented arrangements and overlapping mandates across ministries and agencies that weaken industry-academia alignment [13]. Sector-level studies of IR4.0 further note that attention to TVET may have historically lagged behind academic education, and that instructor hiring appears to have historically prioritized academic credentials over industry experience.

The reviewed evidence does not test whether exhortation alone sustains engagement; what it reports is a set of conditions associated with participation. Employers are reported to require identifiable entry points, stable roles, predictable quality expectations, and a distribution of costs and benefits that makes participation feasible across firm sizes. Institution-level governance matters as much. Partnership barriers reported by TVET leaders, including resourcing, coordination, and commitment issues in managing institution–industry relationships, contrast with more formal interfaces such as industry centres of excellence, whose success factors have been analysed within Majlis Amanah Rakyat (MARA) TVET [18], and the structured collaborative practices visible in vocational colleges, where student on-the-job training, joint quality assurance of programmes, human capital development, and professional sharing are already implemented [19]. Systematic evidence also points to a governance structure to intensify partnerships between TVET engineering institutions and industry [20]. We interpret this pattern as favouring institutionalised interfaces over one-off events such as standing councils, liaison functions, formal programme review cycles, and shared accountability although the reviewed studies

compare neither arrangement directly. Governance, in other words, may set the conditions under which the remaining three functions operate consistently, and those functions determine what students actually learn.

Employer-side evidence suggests both the potential and the unevenness of participation. Employer satisfaction ratings of polytechnic graduates appear to differ systematically across engineering clusters, with mechanical (46%), electrical (30%), and civil (24%) employers among 112 surveyed, and the findings have been recommended as a guide for curriculum revision [21]. Employers of National Dual Training System (NDTS) graduates likewise appear to evaluate employability skills and identify those needed for future employment demands [22]. Together, these patterns may frame the curriculum question: whether industry input reaches the classroom in a form that changes what students learn.

Curriculum co-design and educator development: workplace-relevant learning

Industry experts highlight communication requirements, reporting communication weaknesses and calling for institution–industry collaboration in developing teaching modules [3]. They also emphasise the need to support specialised technical instruction, such as nondestructive testing in welding courses [23], define the IR4.0 skills expected of workers [24], and develop sector-specific teaching approaches, including technical communication models for vocational colleges [25]. Industry engagement can therefore support curriculum development by identifying changes in technology and work practices. Education providers can then translate these needs into standards, modules, authentic learning tasks, and assessments.

IR4.0 skills and enabling conditions have been proposed for integration into national occupational standards and TVET curricula [26]. In addition, academic and industry experts identified 21 components across four domains: cognitive, operational work, individual, and professional skills as the IR4.0 talent base required by TVET students through WBL [27]. Recent Malaysian studies extend this focus by recommending the integration of artificial intelligence and holistic competencies into TVET, while aligning curriculum development with IR5.0 goals [6], [7]. Case-based simulation in automotive curricula has also been viewed by academic and industry stakeholders as a way to strengthen workplace readiness and soft skills [28]. Similarly, studies of Malaysian TVET programmes indicate that employability skills develop most effectively through practical, hands-on, and industry-supported activities [29].

The evidence also suggests that educator capability may mediate between consultation and implementation. Curriculum recommendations may have limited influence when lecturers and instructors lack current workplace exposure. Competency development studies identify related industry experience as necessary for TVET educators, thereby positioning workplace knowledge as a core, rather than optional, competency [30]. In contrast, instructor-level analyses identify skill mismatch across TVET institutions as a barrier [31]. Qualitative expert studies of TVET teacher education identify the industry roles needed to sustain such programmes, with mutual understanding between institutions and industries emerging as central [32], and research suggests that lecturers' industry experience may be associated with stronger experiential engagement and a greater orientation toward job readiness. Co-design therefore encompasses two targets: curriculum content and the professional currency of those who teach it; this distinction leads directly to the question of how learning may be enacted in real workplaces.

Work-integrated learning: bridging institutional learning and workplace practice

WBL, industrial training, apprenticeship, and dual-training arrangements constitute the most direct forms of engagement because industry becomes part of the learning environment rather than remaining an external adviser. The evidence spans placement structures, apprenticeship participation, where employer-side issues and challenges constrain effective engagement [33], workplace transfer from skills institutes [34], employer assessment [35], self-efficacy development in WBL programmes [36], and emerging IR4.0 talent models built through WBL [37]. Survey evidence from 159 final-year TVET students in WBL programmes across four Malaysian polytechnics suggests that students may value individual talents most, followed by cognitive, operational work, and professionalism talents [37]. Employer-side evaluations show that placements can develop psychomotor, affective, and non-technical competencies, as employers rate industrial training outcomes for civil engineering students under these domains [38], while also exposing gaps in communication and soft skills [39].

Readiness measurements for final-year Electrical and Electronics students across the Malaysia Technical University Network indicated an average of 3.61, which may be interpreted as approaching readiness, with statistically significant differences across universities and gaps against the IR4.0 skills employers consider essential, from technical knowledge to critical thinking [40].

Across the reviewed studies, the quantity of placements is not reported as sufficient for learning quality; what the sources associate with outcomes is task authenticity, trained supervision, assessment, feedback, and alignment with programme outcomes. We interpret this as indicating that volume is a weak proxy for educational quality. The inference is consistent with two findings the sources do report. Structured integration of experiential, work-based, and apprenticeship components can function as a workforce readiness mechanism [41], yet conceptual analyses flag low industry participation and unclear WBL structures in Malaysian higher education [42]. The NDTs's industry participation shortfall against its targets, 1,028 of 6,300 target industries by the end of 2010, suggests that volume alone may be insufficient [43]. Vocational college preparation for the construction workforce similarly depends on classroom and site-based methods strengthened through industry participation [44]. These conditions suggest that labour market feedback is essential, though whether its absence or presence explains differences in workplace-learning quality remains untested. Without systematic information on graduate and employer outcomes, institutions may be unable to determine whether workplace learning is producing the intended capabilities.

Labour market feedback: closing the alignment loop

Employer surveys, tracer studies, and skills gap analyses may function as the ecosystem's sensing layer. They may reveal mismatches in technical knowledge, for example, the electrical and electronic industry skills gap as seen by academicians and industry players [45], as well as in communication [3], generic skills as rated by industrial employers [46], and emerging IR4.0 requirements [24]. National statistics suggest polytechnic graduate employment rising from 62.1% in 2015 to 83.9% in 2018, yet 78.5% of ICT graduates in one study did not work in their field of study [47]. Among engineering graduates of Malaysian public universities, 66.8% secured employment within six months of graduation but only 34.6% were hired as engineers [48], and student self-assessments reveal the least confidence in technology and adaptability skills [49]. Programme-level analyses frame the mismatch between programme supply and labour market demand as a structural TVET alignment problem [4], and survey evidence compares graduate traits against industry demand, recounting the expansion of WBL from community colleges in 2007 to polytechnics in 2010 [50]. Readiness studies question whether Malaysian TVET graduate capabilities align sufficiently with future work [22]; employer importance-performance evidence indicates gaps in graduate attributes, especially knowledge [8]; and manufacturing sector reviews highlight technical and soft-skill deficits relative to sector requirements [51]. Academic-industry linkages on the TVET platform have also been positioned as a channel for developing construction safety and health culture [52].

The reviewed studies describe feedback instruments and the mismatches they identify, but do not trace this evidence through to subsequent programme-level decisions. Accordingly, whether such evidence informs programme change remains an inference rather than a demonstrated finding in the reviewed literature, and the practical value of these instruments may depend on this unexamined link. Feedback that is collected but not translated into programme review can therefore be understood as leaving the system better informed rather than substantively altered. A closed loop in which employer evidence and graduate outcomes systematically trigger curriculum revision, educator development, and adjustments to WBL design within a defined review cycle is consequently proposed as a proposition requiring empirical testing rather than as an observed practice.

Cross-cutting implementation challenges

Across the four themes, the reviewed sources report six recurring implementation problems: fragmented governance, episodic rather than sustained employer participation, skills and curriculum mismatch, uneven employer capacity, particularly across firm sizes, communication and transferable skill gaps, and variable WBL quality. We interpret these as cross-cutting because they appear under more than one theme, although no included study examines all six together. These challenges correspond to difficulties the wider Malaysian literature attributes to the sector: multiple providers with duplicated and segmented training [12], persistent negative

perceptions of vocational education [7], curricula that lag behind available jobs [4], and limited collaboration between institutions and industries [1].

The private sector's response to industrial training seems limited [12], and restricted cooperation between TVET establishments and industries is thought to degrade the quality of education imparted [53]. Stakeholder syntheses indicate limited corporate participation and expectation gaps between industry actors and providers [54], and institutional case studies suggest curriculum misalignment and stigma persist even within exemplar industry partnerships [7]. Reform-oriented reviews suggest that an ecosystem-wide response spanning governance, teacher training, curriculum, social partners, and innovation may be required for twenty-first-century skills [9]. Rapid technological change may intensify each of these problems because curriculum, equipment, and educator knowledge can become outdated before formal review cycles are completed, a risk that the transition from IR4.0 toward IR5.0 makes concrete.

Evidence map of the included sources

Table 4 presents the full evidence map compiled during data charting and synthesis. The table is descriptive: the 'Approach' column reports the study type as characterised in the source material and does not imply independent methodological verification.

Table 4. Evidence map of the 44 included sources

Author	Focus	Approach	Contribution to industry engagement synthesis
Zaid & Kamin (2026) [51]	Manufacturing skills deficit	Malaysian TVET review and analysis	Suggests technical and soft-skill deficits relative to manufacturing sector requirements.
Mazlan et al. (2026) [37]	Future fit WBL talent	WBL and applied research study	Delineates industry-relevant talent domains that may support future-fit TVET students.
Johan et al. (2025) [55]	Experiential learning	Student survey	Lecturer industry experience linked with stronger experiential engagement and job readiness orientation.
Mazlan et al. (2025) [27]	IR4.0 talent through WBL	Interviews with academic and industry experts	Identified cognitive, operational, individual, and professionalism components for WBL-oriented IR4.0 talent; academic and industry perspectives appeared to converge on future-work requirements.
Mohd Yusoff et al. (2025) [36]	WBL self-efficacy	Case study	Shows WBL as a structured bridge between university learning and industry-facing development.
Wong & Abdullah (2025) [40]	Job readiness in Electrical and Electronics Field	Empirical student study	Assesses readiness for 4.0 skills in an industry-relevant technical field.
Abd Rahman et al. (2025) [13]	TVET governance and workforce development	Qualitative interviews with 28 stakeholders	Documents fragmented governance and overlapping mandates that may weaken industry-academia alignment.

Baharuddin et al. (2025) [7]	TVET for Community Education 5.0	Mixed method case studies with enrolment and employment data	Suggests that PSDC and NDTs may constitute exemplary industry partnerships, although curriculum misalignment and stigma appear to persist.
Rohiat et al. (2025) [41]	Experiential learning, WBL and apprenticeship integration	Case study of technical university bachelor programmes	Illustrates structured academia-industry collaboration as a workforce readiness mechanism.
Arikpo & Musta'amal (2025) [54]	Industry stakeholder perspectives on TVET commercialisation	Stakeholder synthesis across databases	Industry actors favour collaborative curriculum design and WBL but report limited corporate participation and expectation gaps.
Azid et al. (2024) [28]	Automotive curriculum and pedagogy	Mixed methods with curriculum actors and industry	Industry and curriculum actors supported case-based simulation as a way to strengthen workplace readiness and soft skills.
Razali et al. (2024) [18]	Industry Centre of Excellence	Applied institutional study	Identifies success factors for an industry centre mechanism within MARA TVET.
Abd Majid et al. (2024) [29]	Graduate employability strategy	Malaysian public university TVET study	Examines strategies for employability skill development within a TVET programme, including NDTs-based on-the-job training.
Omar & Kamaruzaman (2024) [14]	TVET industry collaboration	Bibliometric review	Maps the growing collaboration literature and positions industry engagement within 11th and 12th Malaysia Plan priorities.
Sappar et al. (2024) [19]	Collaborative industry practices in vocational colleges	Qualitative multi case study	Identifies four implemented collaborations: student OJT, programme quality assurance, human capital development, and professional sharing.
Lim et al. (2024) [42]	WBL bridging theory and practice	Conceptual and empirical analysis	Flags low industry participation and unclear WBL structures in Malaysian higher education.
Mohamad et al. (2023) [5]	Partnership barriers	Qualitative management focused study	Institution directors report practical barriers in managing TVET industry partnerships.
Amin et al. (2023) [12]	Present and future of Malaysian TVET	Policy analysis	Documents acute technical skills shortages (e.g., RM50 billion estimated income loss) and the predominance of semi-skilled jobs.
Cheok & Li (2023) [17]	Role of TVET in IR4.0	Policy analysis	Argues Education 4.0 drives closer collaboration between learning and the workplace.
Subri et al. (2022) [20]	Institution-industry partnership	Public-private partnership study	Proposes a governance structure for intensifying TVET engineering institution industry partnership.

Ibrahim & Nashir (2022) [4]	Programme demand supply mismatch	Conceptual and empirical analysis	Frames mismatch between programme supply and labour market demand as a TVET alignment problem.
Rodzalan et al. (2022) [45]	Electrical and electronic skills gap	Academician and industry player study	Direct comparison of academic and industry perspectives maps skills gaps.
Ramamurthy et al. (2021) [3]	Technical communication	Qualitative interviews with industry experts	Employers reported communication deficits and called for institution-industry collaboration in pedagogical module development.
Hussain et al. (2021) [15]	National industrial engagement	Systematic narrative policy review	Mapped government strategies and incentives (2010 to 2021); argued for stronger employer obligations and more durable engagement.
Kenayathulla (2021) [22]	Future readiness	Graduate readiness study	Questions whether Malaysian TVET graduate capabilities are sufficiently aligned with future work.
Yunus et al. (2021) [34]	Learning transfer	PLS-SEM empirical study	Examines transfer from skills institutes to workplace, highlighting the workplace as part of the learning system.
Kaprawi et al. (2021) [33]	Apprenticeship employer engagement	Action research and descriptive mixed evidence	Documents employer-side issues and challenges affecting apprenticeship engagement.
Rahim et al. (2021) [23]	Technical skill teaching	Industry expert perspective	Uses industry experts to inform implementation of specialised vocational teaching.
Saari et al. (2021) [24]	IR4.0 workforce skills	Authorities and industrial player expectations	Identifies workforce skill sets expected by authorities and industrial players.
Adnan et al. (2021) [56]	IR4.0 skills and ASEAN TVET	Cross country empirical study	Includes Malaysia in examining critical skills and career readiness for IR4.0.
Ismail et al. (2021) [50]	TVET graduate employability supply demand mismatch	Survey and analysis of WBL programmes	Compares graduate traits against industry demand and recounts WBL expansion from community colleges (2007) to polytechnics (2010).
Mohd Saim et al. (2021) [38]	Industrial training outcomes (civil engineering)	Employer statistical study	Employers evaluate industrial training outcomes under psychomotor and affective domains, supporting training-based competence development.
Ahmad Razali et al. (2020) [52]	Construction safety linkages	Proposed and applied study	Positions academic-industry linkages as a platform for safety and health culture development.

Jamaludin et al. (2020) [25]	Technical communication pedagogy	Pedagogical model	Translates workplace communication needs into a vocational college pedagogical response.
Salleh & Sulaiman (2020) [9]	TVET reform and skills development	Systematic review	Frames TVET ecosystem reform: governance, teacher training, curriculum, social partners, innovation; against 21st century skills demands.
Hasnan et al. (2019) [31]	Instructor skill mismatch	Empirical mismatch study	Identifies mismatch among TVET instructors, implying need for stronger industry-relevant instructor development.
Yunos et al. (2017) [32]	TVET teacher education	Qualitative expert study	Identifies industry roles needed to sustain teacher education; mutual understanding emerges as central.
Rajadurai et al. (2018) [8]	Graduate marketability	Employer survey	Employer importance-performance evidence indicates alignment gaps in graduate attributes, especially knowledge.
Azmi et al. (2018) [35]	Non-technical skills development	Employers' perspective	Links industrial training (at least 8 weeks for accredited engineering programmes) with non-technical skill development.
Ismail et al. (2018) [30]	TVET educator competencies	Competency development study	Mandates related industry experience for TVET educators, making workplace knowledge a core educator competency.
Manap et al. (2017) [44]	Construction workforce preparation	Applied empirical study	Connects vocational graduate preparation with local construction industry workforce requirements.
Adam et al. (2017) [43]	National Dual Training System (NDTS)	Systematic review and framework study	Quantifies industry participation shortfall against NDTS targets (1,028 of 6,300 target industries by end of 2010) and proposes an involvement framework.
Salleh et al. (2016) [46]	Generic skills	Employer perception study	Industrial employer perceptions provide direct labour market feedback on technical graduate generic skills.
Chiu et al. (2016) [39]	Soft skills in industrial training	Employer assessment study	Employer assessments of trainees show gaps between workplace importance of soft skills and graduate competency.

Read together, these 44 sources do not simply inventory engagement activities; they suggest how the four functions interact and where they may fail to connect. The framework in the next section is therefore intended to capture this interaction.

Ecosystem Industry Engagement Framework

This review proposes the Ecosystem Industry Engagement Framework as a synthesis-derived proposition. Existing Malaysian work often frames collaboration primarily as a means of improving employability [22], and the framework reorganises the evidence rather than departing from it: the four functional domains; policy and

governance alignment, curriculum co-design and educator development, work-integrated learning, and labour market feedback together with the two enabling conditions, engagement infrastructure and incentive symmetry, are consolidated from the charted sources. Figure 2 represents their proposed relationships, in which solid arrows denote reciprocal functional links and dashed arrows denote the continuous feedback cycle; the figure should be read as a model of proposed relationships rather than as a validated structure.

Three conceptual moves distinguish the framework from prior Malaysian reviews. The first is a change in unit of analysis. Because prior reviews have examined marketability [8], reform [9], or bibliometrics [14], industry engagement itself has not been consistently treated as the object of analysis; the framework makes the engagement system, rather than any single partnership, the unit of study. The second is the engagement depth continuum. Transactional engagement is episodic and activity-based; relational engagement is repeated, reciprocal, and governed through stable roles; transformative engagement embeds industry participation in standards, curriculum, workplace learning, and feedback so that both provider and employer practices change over time. This distinction separates the existence of a partnership from its functional contribution: two institutions may report the same number of memoranda, placements, or advisory meetings while potentially generating substantially different learning and labour market effects. The distinction is interpretive rather than evidential. It offers a way of reading the volume–quality gap observed in the reviewed sources, but none of those sources was designed to test whether engagement depth explains differences in graduate or employer outcomes.

The third move specifies enabling conditions, which may explain why otherwise well-designed engagement stalls: without dedicated liaison infrastructure or incentive symmetry, engagement often faces sustainability challenges. The framework also makes explicit that no single engagement mechanism may be sufficient. Governance without authentic workplace learning may remain administrative; WBL without feedback may risk becoming mere placement provision; and employer feedback without curriculum authority may not close the loop. Depth, continuity, reciprocity, and feedback closure are analytically distinct properties, each observable in principle and measurable in practice. Table 5 maps its dimensions, core mechanisms, illustrative forms, and lead actors.

Figure 2. Proposed Ecosystem Industry Engagement Framework for Malaysian TVET

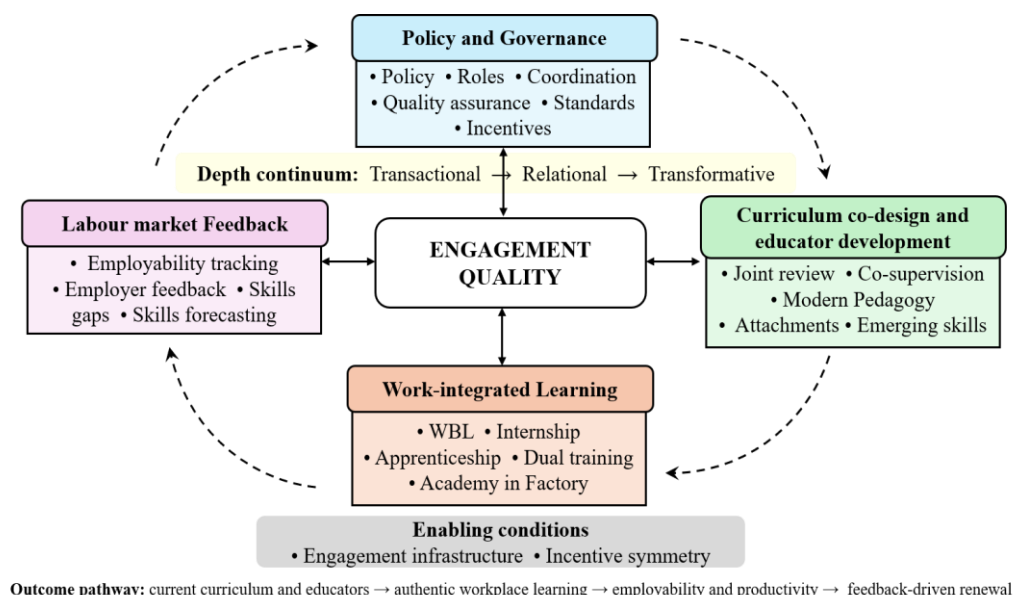


Table 5. Ecosystem Industry Engagement Framework: dimensions, mechanisms, and actors

Dimension	Core mechanism	Illustrative engagement form	Lead actors
Policy and governance	Institutionalises engagement as an expected function	Industry seats on governance boards; industry-led bodies;	Ministries, skills councils, industry associations

		integration of TVET and investment policy	
Curriculum co-design and educator development	Maintains curricular and pedagogical currency amid workplace change	Joint curriculum committees; industry co-supervision; lecturer industrial attachment; practitioner trainers	Institutions, employers, professional bodies
Work-integrated learning	Scales the transfer of learning into authentic work settings	Structured WBL, internships; dual training; apprenticeships; Academy in Factory	Institutions, employers, training agencies
Labour market feedback	Enables the detection and correction of alignment gaps	Tracer studies; employer panels; skills gap audits feeding curriculum review	Institutions, ministries, statistics agencies
Engagement infrastructure	Reduces the transaction costs associated with partnership formation	Industry liaison units; shared digital platforms; single coordination portals	Institutions, government
Incentive symmetry	Establishes reciprocal benefits from engagement	Co-financing; levy utilisation; tax incentives; recognition and awards	Government, employers

DISCUSSION

Insights from the synthesis

Read together, the reviewed evidence suggests three synthesis-level contributions, each of which is an interpretation advanced by this review rather than a finding reported by any single study. The first concerns reframing industry engagement as an ecosystem property rather than a discrete programme activity. This reframing reflects the evidence's dispersion. Marketability studies suggest that employer importance ratings diverge from the attributes graduates actually display, with knowledge emerging as a significant area of divergence [8]. Readiness assessments ask whether current capabilities will survive the transition to future work [22]. Programme-level analyses trace the same dissatisfaction to a mismatch between programme supply and labour-market demand [4], and surveys of WBL graduates compare their traits against industry requirements to expose the same divergence [50]. Although none of these studies was designed to examine engagement, each appears to attribute the observed gap, at least in part, to the thinness of the relationship between institutions and employers [57]. When the same diagnosis appears across instruments, sectors, and provider types, the engagement system, rather than any single programme, may therefore be treated as the object requiring change. No included study was designed to take the engagement system as its unit of analysis; the reframing is therefore an analytical consequence of the dispersion of the evidence, not a result the studies report.

The second contribution is the depth continuum, which supplies a vocabulary for distinguishing symbolic participation from embedded co-production. Malaysian policy discourse, with its emphasis on partnership targets, appears to have largely lacked this distinction, and the counting exercises in the literature expose why volume is a weak success metric. The NDTs, for example, had secured participation from only 1,028 of its 6,300 targeted industries by the end of 2010 [43], and the private sector's response to industrial training has repeatedly been described as tepid [12]. If participation rates were the whole story, these numbers would read simply as implementation failure. Read through the depth continuum, they may instead indicate that the engagement on offer was largely transactional. Employers were asked to host trainees or sit on committees without receiving a reciprocal stake in curriculum decisions, educator development, or assessment, and their participation consequently stayed shallow. The distinction therefore elucidates outcomes that volume metrics alone may not reflect. These participation figures are consistent with a predominantly transactional engagement model, while the depth continuum provides one possible explanation for the divergence between engagement volume and

quality. However, the reviewed sources do not empirically test this interpretation. It should therefore be regarded as a hypothesis concerning the volume–quality gap rather than as an established explanation for it.

Third, the framework links diagnosis to measurement by identifying candidate indicators for each functional domain and enabling condition, thereby providing a basis for systematically assessing alignment and performance across the framework. The resulting interpretation may be more demanding than the conventional recommendation to strengthen collaboration. It asks which actor holds decision rights, how often interaction occurs, whether costs and benefits are reciprocal, whether workplace learning is assessed, whether educators are renewed through industry exposure, and how quickly employer evidence changes programme standards. These questions may convert a broad policy aspiration into testable organisational properties. A convergent finding across the evidence warrants emphasis. Despite using different methods, the studies identify a similar set of skill gaps.

In a survey of 322 technical graduates and 43 employers, graduates rated themselves highest in social responsibility, environmental awareness, and ethical, moral, and professional conduct. Employers, however, prioritised social responsibility, leadership, and communication. The difference between the two sets of ratings was significant [46]. Employer assessments of trainees in industrial training programmes show a similar pattern, with the importance of soft skills exceeding graduates' demonstrated competency [39]. Communication deficits also recur in interviews with industry experts [3]. Skills-gap analyses in the electrical and electronic industry report similar findings [45], while manufacturing-focused reviews identify deficiencies in both technical and soft skills [51]. Evidence from Malaysia, Indonesia, and Brunei further indicates that students remain uncertain about the skills required for IR4.0 [56]. The consistency of these findings across sectors suggests that the feedback loop between employers and curriculum developers remains incomplete. Related uncertainty concerns the competency target itself, as the discourse shifts from IR4.0 to IR5.0 at the end of the review period [6]. The next section examines the implications of this shift for the engagement system.

Implications for TVET institutions and employers

For TVET providers, partnership counts should be treated as administrative descriptors rather than performance outcomes. Programme review can be strengthened by recurring industry validation, joint supervision, and authentic assessment, with practice-oriented, industry-engaged activities embedded into teaching and learning as part of curriculum development [29] and simulation-based learning developed jointly with industry [28]. The range of documented industry contributions suggests the breadth of these mechanisms. Industry experts appear to have identified the need for technical communication requirements, a necessary step in developing pedagogical models for vocational colleges [25], informed the teaching of specialised techniques such as non-destructive testing [23], and joined curriculum actors in validating simulation-based pedagogies [58]. Employers may also evaluate programme outcomes in the psychomotor and affective domains through industrial training [38]. Taken together, these examples suggest a consistent structure: industry evidence may enter the curriculum through defined mechanisms rather than ad hoc goodwill.

Educator capability may constitute the hinge determining whether such inputs reach students. Competency frameworks for TVET educators appear to stipulate relevant industry experience, making workplace knowledge a core rather than optional competency [30]. Studies of teacher education programmes identify the industry roles needed to sustain them and suggest that mutual understanding between institutions and industry may constitute a foundation [32]. Survey evidence links lecturers' industry experience to stronger experiential engagement and a job-readiness orientation among students [55]. Conversely, analyses at the instructor level document a mismatch between the competencies instructors possess and those their teaching requires, suggesting that industry-relevant instructor development warrants deliberate institutional design [31]. Institutional practice may respond through three mechanisms: structured industrial attachment, joint appointments, and practitioner trainers, which recur across these studies.

Work-integrated learning may produce substantive learning when it is structured, and the evidence appears consistent on this point. Industrial training in accredited engineering programmes is associated with non-technical skill development from the employers' perspective [35]. Employer ratings of civil engineering trainees suggest measurable gains in the psychomotor and affective domains [38], and studies of learning transfer from

skills institutes to the workplace show that transfer is shaped by workplace context, rather than solely by instructional content [34]. Self-efficacy develops when WBL programmes provide mentorship and support [36]. Yet the same body of evidence records persistent constraints: apprenticeship engagement is limited by employer-side issues and challenges [33]; the integration of experiential, work-based, and apprenticeship components functions as a workforce readiness mechanism only when deliberately designed [41]; and across much of Malaysian higher education the structures of WBL remain unclear and industry participation low [42]. Sectoral examples reinforce the conclusion. Preparation of vocational college graduates for the construction workforce appears most successful when classroom preparation and on-site learning are combined, and industry participates in both [44]. Developmental WBL may therefore be distinguished from mere placement provision by four conditions: explicit learning outcomes, trained supervision, joint assessment, and repeated coordination between providers and employers.

For employers, deeper engagement can provide earlier access to talent, reduce induction costs, and create a channel for influencing occupational preparation. Those benefits are likely to materialise only when corporations share the responsibility for human capital development [15]. The evidence cautions against assuming that employers will carry these costs unaided. The private sector's participation in training appears to have remained limited [12], and providers have struggled to secure sustained industrial commitment [33]. Engagement design should therefore institutionalise reciprocity within programme structures rather than relying on goodwill to emerge.

Implications for policy and governance

For policymakers, the evidence points to the need for stronger coordination between TVET institutions and industry. Fragmented responsibilities may increase employers' administrative burden and weaken accountability. Malaysian studies identify industry involvement as essential to TVET and suggest that employer participation is necessary to develop graduates who meet current workforce needs [15]. However, industry participation is unlikely to remain sustainable through informal cooperation alone; it requires clearly defined responsibilities, regular communication, and practical incentives.

The Malaysian evidence identifies several mechanisms for strengthening collaboration. Industry Centres of Excellence within MARA TVET are associated with critical success factors that can be managed systematically [18]. Vocational colleges have implemented student on-the-job training, joint programme quality assurance, human-capital development, and professional knowledge sharing as forms of industry collaboration [19]. Research on Malaysian TVET engineering institutions also examines ways to strengthen industry partnerships [20]. Nevertheless, TVET institution directors continue to report barriers related to resources, coordination, and maintaining industry commitment [5]. These findings suggest that policy should support formal partnership structures, shared planning, and sustained industry participation.

Industry involvement must extend beyond student placement and technical alignment because industry-defined competency requirements continue to evolve. Baharuddin et al.'s cases on Community Education 5.0 illustrate how institutions are beginning to align programmes with IR5.0 goals. However, curriculum modernisation has not kept pace, and misalignment and negative perceptions persist even in exemplary partnerships [7]. This contrasts with the IR4.0 approach, which largely frames industry engagement as a means of aligning graduates with technological efficiency and automated production [17], [26]. IR5.0 offers a broader framework centred on sustainability, human centricity, and resilience. It also emphasises socially sustainable work, lifelong learning, and developing a holistic, globally competitive workforce rather than automation readiness alone [6]. Consequently, policies designed solely to support IR4.0 alignment are no longer sufficient. Existing coordination bodies, curriculum authorities, and feedback mechanisms should also address human-centred outcomes.

A coherent Malaysian TVET system could create stable channels for industry participation, link incentives to training quality, and ensure that employer feedback informs programme standards. Industry engagement should encompass curriculum development, workplace learning, assessment, staff development, and the regular review of learning outcomes [15], [19]. However, stronger mandates alone will not guarantee meaningful collaboration. Engagement quality should be assessed according to the depth, continuity, and outcomes of industry

participation, including whether partnerships improve curriculum relevance and graduate readiness for Malaysian workplaces.

A measurement agenda for engagement quality

The next methodological step is to operationalise engagement quality. The candidate indicators in Table 6 constitute synthesis-derived proposals rather than validated measures; they are intended to support instrument development and comparative evaluation across provider types, sectors, and regions, drawing on established skills gap instruments. Malaysian research contains usable precedents for such measurement. Generic skills instruments have been applied to 322 graduates and 43 employers and appear to have detected statistically significant gaps [46]. Readiness scales have been administered to students in technical fields to benchmark progress towards the skills employers associate with IR4.0 [40]. Supply and demand comparisons have operationalised graduate traits against industry expectations [50], and importance-performance analysis has quantified alignment gaps in graduate attributes [8]. Manufacturing sector reviews provide sector-specific benchmarks of technical and soft skill deficits, and employer assessments of trainees offer a template for outcome-based measurement of workplace learning [39].

A Malaysian TVET Industry Engagement Index could measure the scope, depth, continuity, reciprocity, and outcomes of industry engagement. To support national benchmarking, its domains and indicators should be aligned with the National TVET Council's efforts to coordinate standards and reduce fragmentation across the TVET system [12]. To compare results across institutions, sectors, and regions, the index could use common definitions, data sources, and reporting procedures. However, its reliability, validity, feasibility, and sensitivity to institutional contexts would require testing before it is used for accountability. The proposed indicators may provide a useful starting point because each is linked to an existing instrument or data source.

Table 6. Candidate indicators for an engagement quality measurement agenda

Framework domain	Candidate indicator	Primary data source
Policy and governance	Proportion of industry seats on TVET governance; coordinating bodies; number of industry-led bodies with mandated advisory roles	Policy documents, council records
Curriculum co-design and educator development	Programmes with industry-validated standards; share of projects co-supervised by industry practitioners; educator industry exposure rate per cycle	Institutional records, programme accreditation files
Work-integrated learning	Programmes with structured WBL and assessed workplace curricula; workplace-to-institution time ratio; mentor training coverage	Provider records, programme standards
Labour market feedback	Tracer study coverage and response rate; employer satisfaction index; cycle time from tracer report to curriculum revision	Ministry surveys, institutional reports
Engagement infrastructure	Existence and utilisation of liaison units and shared platforms	Institutional self-reports
Incentive symmetry	Levy claim rates; co-financing volume; proportion of partnerships with formal cost-benefit sharing	Fund administration data

Future Directions

Five priorities follow from the evidence: The engagement depth continuum may require empirical validation through longitudinal or comparative designs. Employer-side costs, benefits, and participation decisions remain

less visible than institutional perspectives and consequently warrant dedicated investigation, including why industry participation fell short of NDTs targets [43] and why corporate participation remains limited [54]. Sectoral coverage should extend beyond engineering and manufacturing towards services, digital, and green economy occupations, building on construction sector work [44] and manufacturing-focused analyses [45], [51]. Equity in access to high-quality, WBL needs explicit examination across regions and learner groups, particularly given evidence that ASEAN TVET students remain uncertain about the skills required for IR4.0 and the associated need for upskilling and retraining [56], that graduate confidence is weakest in technology and adaptability skills [49], and that polytechnic curricula must specify digital competency domains to meet future industrial requirements [47]. Finally, the proposed indicators require reliability, validity, and feasibility testing, and that testing should track the paradigm itself: instruments calibrated to IR4.0 skills will need extension to IR5.0 competencies such as human-machine collaboration, sustainability, and holistic graduate attributes.

CONCLUSION

Industry engagement in Malaysian TVET is best understood as a continuous system of governance, curriculum co-design, workplace learning, and labour market feedback rather than as a set of isolated partnerships. The 44-source synthesis indicates that the main weaknesses occur when these functions are disconnected. Governance remains fragmented, and it is unclear how much the National TVET Council has reduced this fragmentation. Curriculum feedback is often episodic, educator exposure to industry is uneven, workplace learning varies in quality, and labour market evidence does not always lead to programme changes. The shift from IR4.0 to IR5.0 further highlights these weaknesses by changing the competencies that industry engagement must support. The proposed Ecosystem Industry Engagement Framework addresses this fragmentation by integrating four functional domains, two enabling conditions, and a continuum of transactional, relational, and transformative engagement. The framework is a synthesis of the reviewed evidence rather than a tested model; its contribution at this stage is analytical and its components remain to be validated empirically. Its main contribution is to position engagement quality, rather than participation alone, as the central unit of analysis.

Two caveats qualify these conclusions. First, the search was limited to English-language evidence indexed in Scopus, ScienceDirect, and Google Scholar, which may have excluded relevant Malaysian studies published in other languages or not indexed in these databases. Google Scholar results may also change over time because its rankings are relevance-based, limiting the search's reproducibility. Second, the evidence base is methodologically diverse and predominantly observational. Accordingly, this review identifies recurring patterns and plausible mechanisms of industry engagement rather than establishing causal effects. These limitations reinforce the need to treat the proposed framework as an analytically grounded basis for further testing, not as a definitive account of Malaysian TVET performance.

Future Malaysian TVET research could replicate and extend the search through transparent, regularly updated protocols; employ longitudinal and comparative designs to examine how engagement affects curriculum relevance, WBL quality, and graduate outcomes; and incorporate employers more systematically, including the costs and benefits of participation. Research could also cover a wider range of sectors, regions, provider types, and learner groups. Such evidence would allow the proposed indicators to be tested for reliability, validity, feasibility, and sensitivity to institutional context, thereby strengthening their value for both research and policy accountability.

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