

Enhancing Malaysian Polytechnic Graduates' Employability in the ASEAN Workforce through Work-Based Learning for Industry 4.0

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Abstract: *The emergence of the Fourth Industrial Revolution (IR4.0) has altered global workforce requirements, requiring a fundamental change in Technical and Vocational Education and Training (TVET) institutions. This study examines the strategic development of IR4.0-ready talent at Malaysian polytechnics via the deployment of Work-Based Learning (WBL) frameworks. The paper presents the IR4.0 Talent Excellence Framework as a multidimensional roadmap for talent development, grounded in a theoretical model that incorporates Emotional Intelligence, Multiple Intelligences, Cultural Intelligence, and Tech Talent. It rigorously assesses national policies, institutional reforms, and industry collaborations that have influenced Malaysia's polytechnic transformation program. This study employs a systematic literature review and case analysis of Malaysian Work-Based Learning models (2u2i, 3u1i) to illustrate how polytechnics integrate academic theory with industrial practice to cultivate graduates prepared for the future. Notwithstanding these achievements, obstacles endure, including fragmented governance, skill mismatches, and public misconceptions regarding TVET. The report finishes by advocating for coherent governance, increased industry involvement, and strategic investments to improve the scalability and efficacy of WBL as a tool for national and regional workforce development.*

Keywords: Work-Based Learning; TVET; Talent; Industry 4.0

1. Introduction

The Fourth Industrial Revolution (IR4.0), propelled by rapid advancements in automation, artificial intelligence (AI), the Internet of Things (IoT), and big data analytics, is fundamentally altering global industries and reshaping the future of work (Schwab, 2017; Liao et al., 2017; World Economic Forum, 2020; Mazlan et al., 2025a). These technological disruptions are reshaping industrial processes and modifying the competencies demanded of the modern worker. Modern economies necessitate personnel with technological expertise, digital literacy, emotional intelligence, and the capacity to tackle intricate transdisciplinary challenges (McKinsey & Company, 2022; Brunello & Wruuck, 2021; UNESCO-UNEVOC, 2020).

In response to these changes, worldwide educational institutions are enacting systemic reforms to develop future-ready personnel. Technical and Vocational Education and Training (TVET) has emerged as a crucial method for reconciling industrial demands with graduate skills. Unlike traditional academic frameworks, TVET is based on experiential learning, industry collaboration, and competency-based assessment components that are increasingly aligned with the demands of IR4.0 (Paryono, 2022; Pavlova, 2019; Varma & Malik, 2024). Countries such as Germany, South Korea, and Singapore have reformed their TVET systems to integrate dual training models, advanced learning environments, and ongoing learning pathways to ensure talent alignment and economic resilience (OECD, 2023; Lee et al., 2022; Brown et al., 2021).

Malaysia, recognising the imperative to sustain competitiveness in a digital global economy, has implemented many governmental initiatives to reform and improve its TVET sector. Polytechnic institutions in Malaysia are crucial to this transformation, acting as vital enablers of skilled human capital development through initiatives such as the Dasar TVET Negara 2030 and Transformasi Politeknik 2023-2030 (Adnan, 2022; JPPKK, 2023; Mustapha & Hussain, 2022; National TVET Council, 2024). These policies emphasise curriculum reform, improved academia-industry partnerships, and the integration of digital competencies to ensure polytechnic graduates are equipped to thrive in the IR4.0 labour market.

Despite this positive trend, inconsistencies remain in translating policy objectives into practical applications, particularly in aligning educational methodologies with the diverse talent demands of IR4.0. Furthermore, while polytechnic systems are progressing, there is a lack of research investigating how structured approaches such as Work-Based Learning (WBL) could systematically develop the emotional, cultural, and digital intelligence necessary for the workforce of the Association of Southeast Asian Nations (ASEAN).

2. Justification: The Need for IR4.0 Talent in TVET

IR4.0 is significantly transforming the global skills landscape, necessitating those states rapidly re-evaluate their educational frameworks and workforce development approaches. In IR4.0 contexts, personnel must not just utilise developing technology but also exhibit the agility to adapt to technological disruptions, tackle difficult issues, and commit to lifelong learning (World Economic Forum, 2020; Schwab, 2017; Pavlova, 2019). These requirements extend beyond conventional technical expertise to include digital literacy, emotional intelligence, creativity, and problem-solving abilities qualities frequently insufficiently cultivated in traditional educational frameworks (Frankiewicz & Chamorro-Premuzic, 2020; Gupta, 2021; Goleman & Fernandez-Berrocal, 2021). Fostering IR4.0 talent is no longer a marginal endeavour; it is a national necessity that supports economic resilience and future competitiveness.

Malaysia has officially acknowledged this urgency in significant strategic papers, including the Twelfth Malaysia Plan (2021–2025) and the National 4IR Policy. These frameworks necessitate extensive upskilling and reskilling programs, as well as the reform of education to align with the changing requirements of high-technology businesses (Economic Planning Unit [EPU], 2021; Malaysia Ministry of Education, 2015; National TVET Council, 2024). At the core of these initiatives is the cultivation of a digitally proficient, innovation-oriented workforce adept in essential fields such as smart manufacturing, robotics, data analytics, and sustainable technology. Nonetheless, despite these aspirational objectives, a continual disparity exists between the skills of graduates especially those from technical and vocational school

tracks and the expectations of employers (Ngatiman et al., 2022; Mustapha & Hussain, 2021; Sanusi & Puteh, 2023). This disconnection underscores the necessity for pedagogical frameworks that transcend theoretical alignment and actively integrate future-ready abilities into educational and training institutions.

TVET institutions, particularly polytechnics, are distinctly positioned to tackle this challenge due to their fundamental focus on practical, work-integrated education. Their delivery methodologies, encompassing practical training, industry-relevant curriculum, and competency-based evaluations, establish a robust framework for the integration of IR4.0-aligned skill sets (UNESCO-UNEVOC, 2020; Paryono, 2022; Lee et al., 2022). To properly leverage this strategic position, TVET must transition from its conventional function as a provider of technical skills to a catalyst for comprehensive talent development. This involves integrating multidimensional frameworks that foster technical skills, emotional intelligence, cultural adaptability, and technological agility.

Incorporating these traits into curriculum design, learner assessment, and WBL models is crucial for futureproofing TVET and maintaining its relevance in a swiftly changing digital economy. Only through such transformation can TVET systems evolve from reactive skill providers to proactive catalysts of national and regional innovation.

3. Role of Polytechnics in Human Capital Development

Polytechnics hold a crucial role in Malaysia's educational framework, functioning as the foundational support of the national TVET system. Since its inception in 1969, Politeknik Ungku Omar (PUO) has played a crucial role in providing mid-level technical personnel to further the nation's industrialisation objectives (JPPKK, 2023; Nalathambi et al., 2023; Yaakob, 2017). In the last fifty years, polytechnics have experienced significant modifications, evolving from diploma-awarding schools to suppliers of bachelor's degrees with curricula integrated with industrial practice. This transformation signifies an expanded institutional mandate: to cultivate graduates who are not just technically adept but also digitally literate, professionally versatile, and globally competitive (Yusuf & Ahmad, 2018; Ibrahim et al., 2019; Kipli & Khairani, 2020).

Recent national frameworks, particularly the *Transformasi Politeknik 2023–2030* and *Dasar TVET Negara 2030*, have redefined polytechnics as catalysts for workforce modernisation. These policies prioritise curriculum reform, digital integration, and global collaboration to improve the quality and relevance of education (National TVET Council, 2024; JPPKK, 2023; Nalathambi et al., 2023). The curriculum frameworks now incorporate components of IR4.0, including artificial intelligence (AI), data analytics, and the IoT, in conjunction with vital soft skill modules such as entrepreneurship, communication, and emotional intelligence (Yaakob, 2017; Hanafi et al., 2023; Sanusi & Puteh, 2023). This integrative strategy demonstrates a systemic commitment to preparing graduates with the transdisciplinary skills required to succeed in complex, technology-driven job situations.

A crucial technique for actualising this transition is the integration of WBL throughout polytechnic programs. Nationally endorsed models like 2u2i and 3u1i provide students with structured exposure to industrial environments, thereby enhancing their technical skills, workplace adaptability, and professional identity (Ramli et al., 2023; Mohd Yusof et al., 2020; Fergusson, 2022). These activities are bolstered by collaborative partnerships with industry stakeholders in areas such as curriculum co-development, industrial mentoring, and dual-mode

evaluation systems. These synergies enhance significant talent growth and augment institutional reputation and global visibility, as demonstrated by the Asia Pacific Accreditation and Certification Commission (APACC) Platinum Award granted to esteemed institutions like PUO and Politeknik Port Dickson (JPPKK, 2023).

Malaysian polytechnics are essential in promoting the nation's human capital objectives. Their achievement in cultivating IR4.0-ready graduates will influence the direction of national initiatives aimed at establishing a knowledge-based and innovation-driven economy. Realising this potential, however, requires continuous investment in three major domains: curriculum innovation, enhancement of TVET instructors' skills, and strengthened partnership between industry and academics. These elements constitute the basis for the next talks in this paper.

4. Theoretical Framework: IR4.0 Talent Excellence

Malaysian polytechnics must transcend traditional technical training methods to cultivate graduates who are authentically prepared for the dynamic ASEAN workforce in the context of IR4.0. The changing requirements of the digital economy necessitate a new type of talent individuals that possess not only technical proficiency but also emotional resilience, cultural adaptability, and technological agility. The cultivation of IR4.0 talent requires a theoretical framework that encompasses emotional, cognitive, cultural, and technical dimensions. Technical qualifications alone are insufficient to guarantee graduate employability or adaptability, especially in volatile, unpredictable, complex, and ambiguous (VUCA) work situations (Frankiewicz & Chamorro-Premuzic, 2020; Choi, 2021; Gupta, 2021).

This study employs a composite theoretical framework that integrates four fundamental constructs Emotional Intelligence (EI), Multiple Intelligences (MI), Cultural Intelligence (CQ), and Tech Talent to formulate the IR4.0 Talent Excellence Framework for polytechnic education. This framework establishes the intellectual basis for the design, implementation, and evaluation of WBL experiences that may comprehensively cultivate IR4.0 competencies in students.

EI as defined by Goleman (1995), denotes the capacity to recognise, control, and manage emotions to improve personal and professional effectiveness. It includes five domains: self-awareness, self-regulation, motivation, empathy, and social skills (Goleman, 1995; Brackett et al., 2011; Karimi et al., 2021). Within the framework of IR4.0, where collaboration, ethical decision-making, and emotional resilience are paramount, emotional intelligence emerges as a vital characteristic for polytechnic graduates (Goleman & Fernandez-Berrocal, 2021; Dai, 2017; Legault, 2017).

MI as proposed by Gardner (1983), broadens the traditional concept of intelligence to encompass other modalities, including interpersonal, bodily-kinesthetic, and spatial intelligences dimensions particularly pertinent in experiential, skills-oriented learning contexts. In the polytechnic environment, characterised by varied student learning profiles and abilities, MI theory provides an inclusive pedagogical framework that facilitates differentiated instruction and enhances learner engagement (Alshahrani & Almutairi, 2021; Yavich & Rotnitsky, 2020; Cavas & Cavas, 2020).

CQ as formulated by Ang and Van Dyne (2008), refers to an individual's capacity to operate proficiently in culturally varied environments. CQ encompasses four essential dimensions metacognitive, cognitive, motivational, and behavioural enabling individuals to engage in

cross-cultural interactions and global work settings with enhanced sensitivity and efficacy (Ang & Van Dyne, 2008; Semenov & Randrianasolo, 2024, 2021; Ng et al., 2022). For polytechnic graduates joining global sectors including manufacturing, logistics, and digital services, CQ is widely regarded as vital for promoting inclusive innovation and international collaboration.

Tech Talent, although not based on a particular theoretical framework, denotes expertise in digital tools, programming, data analytics, and emerging technologies, including AI, cloud computing, and the IoT (Bondarouk et al., 2017; Morrison-Love, 2022; Yang & Gu, 2021). In organisations influenced by IR4.0, Tech Talent embodies both a skill set, and a mindset characterised by continual learning and flexibility (Chubb et al., 2022; Tansley et al., 2013; Sanusi & Puteh, 2023). Polytechnic colleges cultivate Tech Talent by integrating curricula and providing exposure to practical digital tools via organised WBL.

The integration of these four components establishes the IR4.0 Talent Excellence Framework, which supports the strategic design of polytechnic education in Malaysia. This framework directs curriculum creation, learner evaluation, and industry collaboration ensuring that WBL programs function not only as training placements, but as platforms for comprehensive talent development. The conceptual model (Figure 1) demonstrates how the framework integrates academic domains with practical workplace contexts, equipping graduates to thrive in both domestic and regional (ASEAN) labour markets as emotionally intelligent, culturally adept, and technologically proficient professionals.

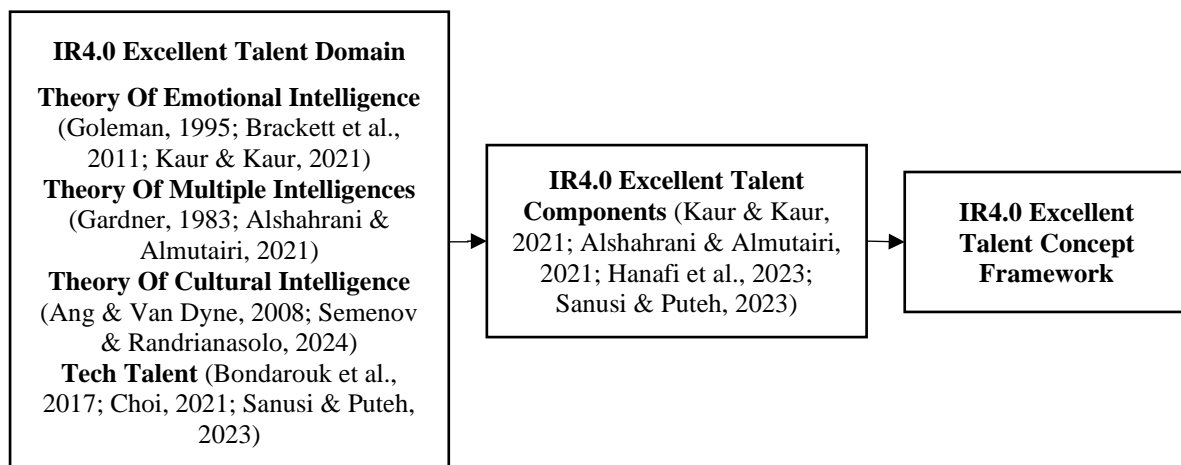


Figure 1: Example of Figure

The IR4.0 Talent Excellence Framework offers a comprehensive theoretical foundation for revolutionising talent development strategies at TVET institutions, especially polytechnics. By anchoring WBL practices within this multifaceted framework, polytechnics can innovate their educational strategies to develop future-ready graduates that fulfil the transdisciplinary and human-centred requirements of IR4.0 industries throughout Malaysia and the ASEAN region.

5. Transformation of TVET and Polytechnics in Malaysia

The evolution of Malaysia's TVET system signifies a calculated reaction to the simultaneous demands of national advancement and global technological transformation. Prompted by the increasing requirements of IR4.0, the progression of TVET from its origins in the First Malaysia Plan to its current transformation under the Twelfth Malaysia Plan (2021–2025) has shifted the sector from a peripheral function to a vital component in enhancing national

competitiveness, innovation, and inclusive human capital development (Malaysia Ministry of Education, 2015; EPU, 2021; Suib et al., 2021). The polytechnic sector is crucial to this systemic transformation, substantially addressing the skills disparity between educational outcomes and the changing requirements of the labour market (Mustapha & Hussain, 2021; JPPKK, 2023; Sanusi & Puteh, 2023).

Table 1 presents a comprehensive assessment of governmental policies, initiatives, and reform frameworks that have impacted Malaysia's polytechnic and TVET agenda during the past two decades, summarising the extent and focus of this transformation. The report outlines critical documents, objectives, theme areas, and implementation strategies, serving as a thorough reference that illustrates the policy evolution from institutional coordination to IR4.0 readiness and workforce transformation.

Table 1: Systematic Literature Review (SLR) of Key Policies and Initiatives in Malaysian TVET Transformation

Policy/Initiative	Year	Key Objectives	Focus Area(s)	Reference(s)
National Skills Development Act	2006	Establish quality assurance and national coordination	Certification, accreditation	Ibrahim, M. S., et al. (2019); Mustapha & Hussain, (2022)
TVET Master Plan	2007-2010	Create integrated national TVET system	Governance, institutional alignment	Ibrahim, M. S., et al. (2019); Abdul Aziz and Subramaniam (2023)
Malaysia Education Blueprint	2015-2025	Elevate TVET image, enhance WBL, strengthen industry linkages	WBL, industry engagement, inclusivity	Malaysia Ministry of Education (2015); Yunos, (2023)
<i>Dasar TVET Negara</i>	2022-2030	Develop resilient, inclusive, and IR4.0-ready workforce	Curriculum digitalisation, governance, branding	UNESCO-UNEVOC (2020); National TVET Council, (2024)
<i>Transformasi Politeknik Framework</i>	2023-2030	Future-proof polytechnics via strategic institutional transformation	IR4.0 technologies, entrepreneurship, inclusivity	JPPKK (2023); Nalathambi et al. (2023)

These policy changes jointly strengthen the transformation of Malaysian polytechnics into adaptable, industry-relevant, and globally competitive institutions. The Malaysia Education Blueprint (2015-2025) and the National TVET Policy 2030 have driven reforms by advancing WBL, enhancing industry connections, and digitising curricula (Yusof et al., 2022; National TVET Council, 2024). *Dasar TVET Negara* has six strategic thrusts: governance, lifelong learning, industry partnership, curriculum digitisation, TVET branding, and inclusivity, each aimed at cultivating a workforce prepared for the demands of IR4.0.

Malaysian polytechnics have implemented these aims through innovative programs and enhanced institutional roles. Since 2013, leading colleges have launched industry-integrated bachelor's degree programs that merge academic education with experiential elements, including industrial placements, simulation laboratories, and multidisciplinary capstone projects (Yusuf & Ahmad, 2018; Hanafi et al., 2023; JPPKK, 2023). This transformation signifies a movement from generating just employable graduates to fostering transformative, innovation-oriented talent.

The *Transformasi Politeknik 2023-2030* plan advances this initiative by emphasising curricular innovation, industry collaboration, entrepreneurship, and inclusivity (Nalathambi et al., 2023; JPPKK, 2023). Current curricula integrate IR4.0 competences, including artificial intelligence, robotics, and the Internet of Things, in conjunction with soft skill courses focused on emotional intelligence, entrepreneurship, and ethics (Yaakob, 2017; Hanafi et al., 2023; Sanusi & Puteh, 2023). Simultaneously, socially responsive initiatives such as TVET-Tahfiz illustrate the system's ability to accommodate Malaysia's spiritual and cultural diversity (JPPKK, 2023).

Partnerships with companies like Siemens and Intel have enhanced polytechnic programs via co-created curricula, industry mentorship, and certification opportunities (Sanusi & Puteh, 2023). These collaborations enhance institutional recognition, as demonstrated by international standards like the APACC Platinum Award. Nevertheless, obstacles remain. Disjointed governance among ministries, erratic industrial involvement, and persistent public stigma about TVET hinder comprehensive transformation (Ngatiman et al., 2022; Salleh, 2020). In the absence of united leadership and enhanced collaboration, the polytechnic reform agenda's full potential may remain unfulfilled.

In summary, the reform of Malaysia's TVET and polytechnic framework is not solely institutional; it has pedagogical, structural, and ideological dimensions. The analysed policy landscape, as depicted in Table 1, distinctly demonstrates a trend of escalating complexity and ambition. With continuous investment and robust stakeholder alignment, Malaysia's polytechnics are poised to emerge as regional leaders in applied education and workforce development. The subsequent part will examine how WBL serves as a strategic instrument for achieving the IR4.0 Talent Excellence agenda stated in this reform trajectory.

6. Work-Based Learning as a Talent Development Strategy

In the comprehensive initiative to convert Malaysia's polytechnic system into a driver for IR4.0-compliant human capital, WBL has surfaced as a fundamental educational approach that connects academic theory with practical industrial application (Mazlan et al., 2025b; Mohd Yusoff et al., 2025). Within polytechnic institutions, WBL facilitates the shift from conventional classroom education to experiential, industry-integrated learning that develops both technical and interpersonal skills required by the digital economy. WBL fundamentally denotes organised, purposeful learning experiences integrated into genuine business environments and connected with academic curricula to enhance graduate employability and readiness for IR4.0 (Grant, 2021; Fergusson, 2022; Nouwen et al., 2022).

The theoretical foundation of WBL is based on constructivist learning theory, which posits that information is actively generated through involvement with the environment, rather than passively absorbed. Constructivism emphasises the significance of contextualised and experiential learning in cultivating cognitive, practical, and reflective skills exactly the holistic learning necessary for the development of IR4.0 talent (Seagraves et al., 1996; Stones, 1994; Zajda, 2021). Consequently, WBL offers both a pedagogical framework and a philosophical congruence with the IR4.0 Talent Excellence Framework previously discussed in this study.

To support this position, a review of key literature on WBL and IR4.0 skill development is presented in Table 2. The findings summarised illustrate how prior studies have collectively informed the role of WBL in building the multidimensional competencies needed for IR4.0.

Table 2: Summary of Key Literature Supporting Work-Based Learning in IR4.0 Context

Author(s) & Year	Focus Area	Key Contributions to WBL and IR4.0 Talent
Grant (2021); Fergusson (2022); Nouwen et al. (2022)	WBL structure and design	Define WBL as structured, intentional learning in real-world settings; strengthen employability through industry exposure.
Seagraves et al. (1996); Stones (1994); Zajda (2021)	Learning theory	Emphasise constructivist learning theory in experiential skill acquisition relevant to IR4.0 domains.
Mohd Yusof et al. (2020); Hanafi et al. (2023); Ramli et al. (2023)	Malaysian WBL models (2u2i, 3u1i)	Document implementation in Malaysian polytechnics; show benefits and integration with national frameworks.
Choi (2021); Morrison-Love (2022)	Industrial tech exposure	Identify WBL's role in familiarising students with IR4.0 tools: CNC, ERP, robotics, AI.
Frankiewicz & Chamorro-Premuzic (2020); Karimi et al. (2021); Anthony et al. (2022)	Soft skills development	Demonstrate the role of WBL in enhancing communication, collaboration, emotional intelligence, and adaptability.
Cheok & Ran (2023); O'Dwyer et al. (2023); Fergusson (2022)	WBL quality and assessment	Discuss assessment rubrics, dual-supervision, and institutional standards for evaluating WBL.

The Malaysian Ministry of Higher Education (MOHE) has formalised many WBL models within its educational reform agenda, particularly the 2u2i and 3u1i frameworks. The 2u2i approach entails two years of academic teaching succeeded by two years of industry-based training, whereas the 3u1i model designates three years for academic study and one year for workplace immersion (Mohd Yusof et al., 2020; Hanafi et al., 2023; Ramli et al., 2023). These models are currently integrated into diploma and bachelor's degree programs in polytechnics and are regulated by the Malaysian Qualifications Agency (MQA) in accordance with its Good Practices: Work-Based Learning (GGP:WBL) guideline, thereby ensuring standardised quality and learning outcomes (MQA, 2016; O'Dwyer et al., 2023; Cheok & Ran, 2023).

The advantages of WBL are numerous and clearly correspond to the IR4.0 talent goal. Students acquire practical experience with sophisticated industrial systems, including CNC machines, ERP software, and industrial robotics, which are essential in the realms of smart manufacturing and automation (Choi, 2021; Morrison-Love, 2022). Concurrently, WBL cultivates vital soft skills communication, collaboration, time management, and conflict resolution which employers often see as deficient in recent graduates (Frankiewicz & Chamorro-Premuzic, 2020; Karimi et al., 2021; Anthony et al., 2022). The competencies are evaluated using collaboratively designed rubrics by academic professors and industry mentors, guaranteeing a holistic and contextual assessment of student performance.

Malaysian polytechnics have exhibited leadership in integrating scalable WBL programmes. Esteemed institutions like PUO and Politeknik Ibrahim Sultan engage in active collaboration with over 60 industry partners spanning the manufacturing, logistics, digital services, and medical technology sectors to provide semester- and year-long placements (JPPKK, 2023; Mustapha & Hussain, 2021; Hanafi et al., 2023). These collaborations are generally formalised via Memorandums of Understanding (MOUs) and encompass explicitly delineated training parameters, mentorship frameworks, and dual oversight systems. These WBL experiences effectively implement the IR4.0 Talent Excellence Framework by enhancing students' emotional intelligence, cultural adaptation, and technological skills in practical environments. Nonetheless, although WBL presents transformative potential, its successful implementation is fraught with challenges. Critical concerns encompass the absence of standardised assessment instruments across institutions, insufficient pedagogical training for industry mentors, and

disparate degrees of industry engagement, especially among small and medium firms (Fergusson, 2022; Ramli et al., 2023; Zajda, 2021). These deficiencies can compromise the quality and uniformity of learning across polytechnic programs. Addressing these challenges necessitates a unified national initiative that includes consistent stakeholder engagement, stringent policy directives, and effective institutional frameworks for the monitoring, assessment, and ongoing improvement of WBL implementation.

Ultimately, WBL serves as both a pragmatic tool and a strategic facilitator for cultivating IR4.0 talent in Malaysian polytechnics. It functions to connect theory with practice and to expedite the development of comprehensive graduate profiles individuals who possess technical expertise, emotional maturity, digital fluency, and global competence. As Malaysia progresses towards its goal of becoming a regional centre for innovation and talent, WBL will continue to serve as a fundamental pillar in achieving an inclusive and sustainable TVET ecosystem.

7. Issues and Challenges

Despite considerable progress in the integration of WBL models and IR4.0-aligned curriculum in Malaysian polytechnics, various persistent challenges remain, hindering the full realisation of national targets for IR4.0 talent excellence. These issues involve structural, operational, and sociocultural factors, highlighting the gap between policy aims and how they are actually carried out. To help polytechnics accomplish their revolutionary mission and make a big difference in the ASEAN IR4.0-ready workforce, these problems need to be fixed.

A major problem is that graduates' skills don't match what employers want. Even though TVET schools, especially polytechnics, want to give students both technical and soft skills, many employers still say that students lack critical thinking, communication, and innovation skills (Mustapha & Hussain, 2021; Hanafi et al., 2023; Ngatiman et al., 2022). A national survey conducted by TalentCorp Malaysia (2021) indicated that just 58% of employers saw TVET graduates as job-ready, citing inadequate digital literacy and poor interpersonal skills as contributing factors. This difference shows that adding IR4.0 content to the curriculum, training, and evaluation methods may not be enough to help students achieve the many skills listed in the IR4.0 Talent Excellence Framework.

A major worry is that polytechnics are not doing WBL programs the same way. National models such as 2u2i and 3u1i provide a structured framework; however, their effectiveness is contingent upon several operational factors, including the involvement of industry partners, clearly defined learning objectives, and coordinated oversight (Fergusson, 2022; Ramli et al., 2023; O'Dwyer et al., 2023). In some instances, students are placed in organisations that do not offer substantial or curriculum-related learning opportunities. Furthermore, many industrial mentors lack adequate professional qualifications in pedagogy or educational supervision, undermining the consistency and depth of experiential learning (Anthony et al., 2022; Cheok & Ran, 2023). These shortcomings limit WBL's capacity to serve as a reliable catalyst for practical skill enhancement.

At the governance level, lack of coordination between ministries, agencies, and organisations continues to make it hard to make changes that work together. The simultaneous operations of entities such as the Ministry of Higher Education (MOHE), the Ministry of Human Resources (MOHR), and the Majlis Amanah Rakyat (MARA) can lead to superfluous initiatives, ambiguous duties, and contradictory policy goals (Salleh, 2020; Ibrahim et al., 2019; Pavlova, 2019). For example, one agency may put more focus on entrepreneurship while another may

put more emphasis on digitisation. This can cause strategic mismatch at the institutional level. The absence of a unified governance structure impedes national planning efforts and obstructs sustainable partnerships with industry stakeholders (Suib et al., 2021; Lee et al., 2022).

Cultural and societal perceptions of TVET consistently undermine its legitimacy and attractiveness. Even after years of struggle and progress, some people in Malaysia still think that TVET is not as good as academic paths (A. Aziz & Subramaniam, 2023; Brown et al., 2021). This stigma has real effects: it affects how many students enrol, discourages high-achieving pupils, reduces government funding, and may make companies less likely to work with schools. Until this image changes, efforts to improve polytechnic education will continue to be hampered by societal bias and limited appeal to those who want to succeed.

Ultimately, institutional capacity constraints present a significant impediment to the integration of IR4.0. While top polytechnics have made strides in incorporating cutting-edge technologies such as AI, cloud computing, and robotics, many institutions still struggle with outdated infrastructure, limited access to smart tools, and insufficient digital training for teachers (Morrison-Love, 2022; Yaakob, 2017). These differences lead to unequal educational quality and could make the gap between urban and rural schools even bigger, which would make it harder for everyone to get an education that is in line with IR4.0.

Even while Malaysian polytechnics have made a lot of headway in making education more relevant to the needs of IR4.0, full talent development is still a long way off because of long-lasting structural problems. To fix these differences, we need big changes, better cooperation between sectors, and a change in how we think about and use TVET. Finding and dealing with these problems is very important for making polytechnics into respected and welcoming places that prepare graduates for IR4.0, not just for the country's progress but also for Malaysia's leadership in the expanding ASEAN education and skills framework.

8. Conclusion and Recommendations

Polytechnic education in the TVET system is becoming increasingly strategic and influential as Malaysia transitions to a digitally linked and innovation-driven economy. This article investigates the process by which Malaysian polytechnics cultivate IR4.0 Talent Excellence through WBL, which employs emotive, multidimensional, cultural, and technical intelligence. This integration of multidimensional skills demonstrates the heterogeneity and adaptability of contemporary workplaces, underscoring the necessity of a technical education approach that is more comprehensive, learner-centred, and industry-relevant. According to literature and policy evaluations, WBL is a scalable and potent framework for connecting theoretical knowledge with industrial demands. Malaysian polytechnics have enhanced graduate preparation by integrating classroom instruction with immersive practical experiences, as demonstrated by 2u2i and 3u1i. The sector is unable to realise its revolutionary potential due to skill mismatches, fragmented governance, unequal industry engagement, and institutional capacity issues. Empirical research in a variety of polytechnic contexts is required to further refine and validate the IR4.0 Talent Excellence Framework in the wake of this study. Graduate outcomes and longitudinal studies demonstrate the influence of attributes such as technical aptitude and cultural intelligence on employment and performance (Goleman & Fernandez-Berrocal, 2021; Ng et al., 2022). Stakeholder participation and policy endorsement are indispensable for the alignment of learning outcomes, mentorship methods, and evaluation frameworks through industry and academic collaboration (Cheok & Ran, 2023; Fergusson, 2022). Professional development and strategic infrastructure investments are required to effectively implement

IR4.0-oriented curricula (Morrison-Love, 2022). The governance of TVET must be consistent and significant. The efficiency of policy, the clarification of institutional roles, and the national response to workforce developments can all be enhanced by monitoring and coordinating ministry objectives (Salleh, 2020; Lee et al., 2022). It is imperative to rectify the unfavourable public perception of TVET. National marketing, industry-aligned branding, and success stories of polytechnic graduates have the potential to re-establish TVET as a forward-thinking and prominent educational option (A. Aziz & Subramaniam, 2023). Ultimately, the production of IR4.0-ready graduates necessitates the implementation of integrated strategies, multidisciplinary teaching, and robust industry-institutional connections. The IR4.0 Talent Excellence Framework enables Malaysian polytechnics to establish a workforce that is internationally competitive, intelligent, and adaptable, and to lead regional applied education developments.

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Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this study.

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