Integrating Electric Vehicle Technology into Automotive TVET Programmes in Malaysia: A Review of Curriculum Readiness

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DOI: https://dx.doi.org/10.47772/IJRISS.2025.910000512

Received: 02 November 2025; Accepted: 08 November 2025; Published: 17 November 2025

ABSTRACT

The transition from internal combustion engine (ICE) vehicles to electric vehicles (EVs) globally is transforming the automotive sector and the necessary expertise for workers. The National Automotive Policy (NAP 2020) of Malaysia aims to establish the nation as a regional centre for sustainable mobility. It is essential for the Technical and Vocational Education and Training (TVET) curricula to be prepared for electric vehicle (EV) integration. This research paper provides a conceptual and narrative assessment of the curricular readiness of Malaysia's automotive Technical and Vocational Education and Training (TVET) programs for electric vehicle (EV) technology. The paper employs Fullan's Educational Change Theory and Rogers' Diffusion of Innovation Theory to outline preparation across four dimensions: policy direction, institutional capacity, human capability, and curricular alignment. The study integrates research, policy documents, and institutional reports published from 2015 to 2025. The findings indicate that despite national programs such as NAP 2020 and the Low Carbon Mobility Blueprint (2021–2030) promoting the proliferation of electric vehicles (EVs), their adoption at the institutional level remains constrained. Numerous automotive TVET programs continue to emphasise conventional internal combustion engine technologies. This is due to inadequate infrastructure, insufficiently qualified educators, and a lack of effective collaboration within the business. The study proposes a cohesive framework for enhancing EV curriculum readiness through policy alignment, professional development, and strengthened industry partnerships. It posits that the integration of EV technology into Malaysia's automotive TVET signifies not only a curricular reform but also a strategic progression towards ecological industrial transformation and sustainable workforce development.

Keywords: electric vehicles (EVs); TVET; curriculum readiness; educational change; diffusion of innovation; green skills

INTRODUCTION

The worldwide automobile industry is undergoing significant transformation as a result of the shift from internal combustion engine (ICE) vehicles to electric vehicles (EVs). Environmental concerns, rapid technological advancements, and international pledges to reduce greenhouse gas emissions are driving this shift. Governments and corporations worldwide are investing heavily in electric mobility as part of broader initiatives to lower carbon emissions and improve the sustainability of the planet. According to the International Energy Agency [1], over 14 million electric cars (EVs) were sold globally in 2023, accounting for around 18% of all automobile sales. Over the next ten years, this number is anticipated to rapidly increase [1], [2]. The automotive sector is evolving as a result of this type of stimulus, which is also altering the knowledge and abilities required of technical staff.

Technical and Vocational Education and Training (TVET) institutions are facing increasing pressure to produce graduates capable of designing, maintaining, and servicing new electric vehicle (EV) systems as the need for green technology increases [3]. As a result, integrating electric vehicle technology into technical and vocational education and training (TVET) curricula has emerged as a crucial strategic necessity for nations seeking to uphold their economic competitiveness and fulfil their commitments to global sustainability, including the Sustainable Development Goals (SDGs 4, 8, 9, and 13) of the UN. TVET, which has previously focused on satisfying the needs of the industrial workforce, must now adjust to this disruptive shift by including new

elements of green skills, modern teaching techniques, and technical knowledge into its current training programs [4], [5]

One of the most significant sectors of Malaysia's industrialisation and economic expansion remains the automobile sector [6]. According to the government's National Automotive Policy (NAP 2020), next-generation vehicles (NxGVs), energy-efficient vehicles (EEVs), and electric mobility are all critical to enhancing the sustainability of industry and transportation. This policy aims to establish Malaysia as a hub for local technology development and the production of electric vehicles [7]. A workforce that is capable and prepared for the future is crucial to achieving this objective. To prepare the workforce for the EV ecosystem, institutions under the jurisdiction of the Department of Polytechnic and Community College Education (DPCCE), the Department of Skills Development (Jabatan Pembangunan Kemahiran, or JPK), and a number of additional TVET providers are crucial. Motor Vehicle Mechanics, Auto-Electricity, and Mechatronics are among the automotive-related courses taught at these institutions. Many curriculum revisions are now required in the programs to educate students for EV-related abilities.

However, many of Malaysia's automotive TVET programs still concentrate on conventional ICE technologies, despite the fact that national legislation emphasises electric mobility. Workshop techniques, training curricula, and evaluation criteria often use mechanical and electrical systems that are rapidly becoming obsolete in modern automotive settings [8], [9]. Important questions concerning the curriculum's preparedness and the extent to which current curricula, instructional materials, and institutional capacities can manage the knowledge and skills required for EV technology are raised by this misalignment. Curriculum content is only one aspect of preparation; other factors include instructor skill, industry partnerships, the availability of specialised training tools, and the institution's adaptability. Malaysia's objectives for technology and green economic growth might suffer if students are not prepared, as there may be a greater skills gap between TVET graduates and the demands of the sector as it develops [10], [11].

Additionally, the integration of EV technology into TVET education is impeded by a variety of factors. Schools are confronted with the high cost of new training equipment, the fact that teachers lack sufficient experience with EV systems, and the absence of defined competency criteria that align with the National Occupational Skills criteria (NOSS) in addition to the curriculum design. Additionally, it is imperative that regulatory authorities, EV manufacturers, and TVET providers collaborate more closely to guarantee that the curriculum is current and that knowledge is effectively transmitted [5], [12], [13]. In order to address these issues, it is imperative that we have a comprehensive and evidence-based understanding of the current state of our preparedness and the systemic issues that are impeding the implementation of curricular reform.

This paper evaluates the preparedness of automotive TVET programs in Malaysia for the integration of EV technology by conducting a critical narrative analysis of current literature, policy papers, and institutional reports in light of these circumstances. The review integrates data from research conducted in the United States and other countries regarding the incorporation of green skills, the development of EV-related curricula, and the transformation of TVET. It highlights critical trends, deficits, and opportunities. The study aims to improve academic understanding and policy discourse regarding the successful adaptation of Malaysia's TVET system to the increasing demands of technology by highlighting the importance of curriculum preparedness. Malaysian automotive TVET courses are evaluated to ascertain their suitability for the integration of electric car technologies. What are the curriculum's primary strengths, limitations, and opportunities for improvement in order to facilitate the integration of EV technology?

It is crucial to achieve these objectives in order to ensure that Malaysia's automotive TVET sector is in alignment with the evolving mobility industry. The review does not intend to empirically evaluate specific institutions; rather, it provides a synthesis of current knowledge and policy trajectories. The insights obtained are intended to provide guidance to curriculum creators, policymakers, and educators on the structural and pedagogical modifications that are required to modernise automotive TVET programs. Furthermore, Malaysia's TVET system must be updated in order to accommodate the country's transition to a more environmentally favourable and technology-driven automotive future. It is not merely a matter of educational reform to ensure that the curriculum is prepared for EV technology; it is also a strategic necessity for the long-term health of the national economy and the competitiveness of the workforce.

Conceptual And Theoretical Framework

The integration of electric vehicle (EV) technology into automotive Technical and Vocational Education and Training (TVET) curricula represents a systemic transformation and an educational advancement. To comprehend this process, it is essential to possess a fundamental comprehension of the manner in which schools, teachers, and curricula address new technologies and policy requirements. In this segment, the conceptual framework of curriculum readiness is introduced, and the factors that influence curriculum adaptation in Malaysia's automotive TVET sector are analysed using Fullan's Educational Change Theory and Rogers' Diffusion of Innovation Theory.

Concept of Curriculum Readiness

Curriculum readiness is the extent to which an educational system, institution, or program is prepared to effectively implement and integrate new content, pedagogies, or technology [14], [15]. There are four interconnected components in the realm of TVET. Curriculum Content Readiness is the initial metric, which assesses the extent to which syllabi, learning outcomes, and competency standards incorporate emerging technologies such as EV propulsion systems, battery management, and power electronics. Secondly, Teacher and Instructor Readiness, which entails that educators are motivated to teach and test new areas of technology, versatile in their teaching methods, and technically proficient. Third, Infrastructure Readiness, which refers to the availability of appropriate safety facilities, simulation tools, workshops, and training instruments for EV-related education. Lastly, institutional and policy readiness refers to the existence of policies, financial sources, regulatory frameworks, and collaborations that are designed to facilitate and sustain curricular reform.

Therefore, curriculum preparedness encompasses more than merely altering the syllabi; it also involves ensuring that the content, capacity, and context are all in alignment [16], [17]. In Malaysia, TVET schools have updated their National Occupational Skills Standards (NOSS), incorporated EV diagnostic tools into their laboratories, trained their teachers, and established strong relationships with businesses to ensure that students have access to real-world experience in preparation for EV integration [12], [13], [18], [19]. Adnan et al. (2021) assert that the curriculum can be exceedingly challenging to implement and maintain when any of these components are lacking [10]..

Fullan’s Educational Change Theory

Fullan's Educational Change Theory provides a substantial framework for understanding curriculum transformation in the context of technological disruption [20], [21]. Fullan posits that the successful implementation of educational transformation requires the collaboration of three essential elements: innovative materials and resources, such as EV-related content and tools; novel pedagogical methods, such as project-based and experiential learning; and revised beliefs and understandings among educators, administrators, and stakeholders.

The concept asserts that genuine transformation is distinguished by a focus on individuals and processes, rather than being driven by policies. Educators' professional competence, institutional leadership, a collective vision, and systemic coherence across governance levels are all essential for successful implementation [20], [21], [22].

The discrepancy between the outcomes desired by policymakers and the actual outcomes in the Malaysian automotive TVET environment is illustrated by Fullan's model. National policies such as the National Automotive Policy (NAP 2020) and the Low Carbon Mobility Blueprint (2021–2030) establish objectives for electric vehicles (EVs). However, in order for TVET institutions to effectively incorporate these objectives into their curricula, they must develop their own capabilities, provide assistance to their leaders, and modify their instructional procedures [7], [23]. Teachers must possess the technical and pedagogical skills necessary to effectively implement policy objectives and understand the rationale behind EV integration. Without this type of alignment, curriculum modifications may be more symbolic than substantive [11], [24]. In summary, Fullan's paradigm regards curricular preparedness as a collaborative endeavour that entails the collaboration of individuals and organisations, the acquisition of knowledge from one another, and the establishment of a shared understanding. This implies that an ongoing investment in teacher training, participatory curriculum design,

and leadership involvement at both the institutional and national levels is necessary for the preparation of the EV curriculum in Malaysia.

Rogers' Diffusion of Innovation Theory

Fullan's concept is furthered by Rogers' (2003) Diffusion of Innovation Theory, which demonstrates the dissemination of new ideas, technology, and methods within a social or organisational system. The concept outlines five innovative characteristics that influence the adoption rate: compatibility, relative advantage, complexity, trialability, and observability. In the context of automotive TVET, "innovation" refers to the integration of electric vehicle-related skills, instruments, and teaching methods into existing curricula [25]. Relative Advantage pertains to the perceived advantages of EV integration, including improved job prospects, alignment with green industry standards, and institutional prestige [18], [19], [26]. Compatibility assesses the extent to which EV programs are consistent with the institution's national skill frameworks, instructional methods, and values. Mansor et al. (2024) define complexity as the technical and pedagogical challenges that educators face when implementing advanced EV systems, particularly in contexts where they have not previously encountered such systems. Trialability emphasises the potential for institutions to test modules or brief courses before comprehensive implementation, thereby facilitating experiential learning and risk reduction. Observability pertains to the ease with which positive results, such as improved student performance or successful collaboration between industries, can be observed, which can motivate additional individuals to utilise the system [27].

Rogers' model enables us to comprehend the reasons why certain Malaysian TVET institutions are more prepared than others. The adoption process is typically expedited by institutions that are characterised by strong industry collaborations, supportive leadership, and access to contemporary infrastructure, which recognise a greater relative benefit and reduced complexity. Adnan et al. (2021), JPK (2022), and MANZOR (2023) all address the challenges of institutional inertia, delayed reform cycles, and restricted diffusion in colleges with limited resources.

Integrating the Frameworks: A Conceptual Model of Curriculum Readiness

By integrating the concepts of Fullan and Rogers, we can conceptualise curriculum preparedness for EV technology as a dynamic, multi-level process that is influenced by four interdependent variables, as illustrated in Figure 1.

1) *Policy Direction:* This involves the establishment of strategic frameworks and standards (NAP 2020, TVET Empowerment Plan) that establish the legitimacy, resource distribution, and performance metrics for the innovation of EV curricula [23], [28]. However, policies may be symbolically adopted without substantial changes in practice if other aspects are not sufficiently developed [21].

2) Institutional Capacity: This encompasses leadership within the organisation, funds, infrastructure (such as digital tools, EV equipment, and workshops), and partnerships with other enterprises that facilitate implementation [17]. Leadership must cultivate cultures of innovation and encourage partnerships within the sector, while boundary-spanning networks facilitate the exchange of knowledge [11], [29].

3) *Human Capacity*: The technical proficiency of educators in electric vehicle (EV) systems, their teaching abilities, and their readiness to adopt innovation [27]. Teachers interpret and reconstruct the curriculum through experience, rather than merely adhering to it [21]. This implies that they must continue to acquire knowledge through their employment rather than attending one-time seminars [30].

4) *Curriculum alignment*: In accordance with industry-defined EV competences, the intended, implemented, and evaluated curricula must be coherent [19]. This includes a genuine evaluation that accurately represents occupational competencies, suitable pedagogical approaches (such as simulation and project-based learning), and logical material sequencing [16], [18].

These elements are mutually constitutive: when robust policy is combined with insufficient institutional capacity,

it results in a mere symbolic adoption. Conversely, capacity devoid of human competence leads to unrealised potential. Interventions must be comprehensive, not incremental [21]. Figure 1 visually illustrates this model, which serves as the analytical framework that directs the collection and comprehension of data.

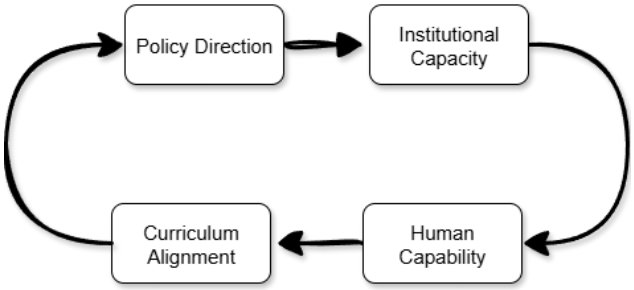

Fig 1 Conceptual Model of Curriculum Readiness For EV Integration in Automotive TVET (Malaysia)

In order to demonstrate the readiness of Malaysia's automotive TVET system for electric vehicle (EV) technology, this model integrates Rogers' Diffusion of Innovation Theory and Fullan's Educational Change Theory. The framework defines readiness as a multifaceted construct that is influenced by policy direction, institutional capacity, human capability, and curriculum alignment. This construct is situated within a broader context that is shaped by the National Automotive Policy (NAP 2020), the Green Technology Agenda, and Industry 4.0 initiatives.

The systematic evaluation of the interactions among various variables that either promote or hinder reform is facilitated by the integrated theoretical framework. It illustrates critical issues—such as inadequate infrastructure, inadequate teacher training, and inadequate industry collaboration—that impede the dissemination of novel concepts. This framing demonstrates that the curriculum's preparation for EV integration is not merely a design exercise; it is a comprehensive process that necessitates ongoing collaboration among legislators, institutions, educators, and industry partners. In order for curriculum transformation to be effective, it must be consistent with Malaysia's overarching objective of fostering sustainable mobility and green skills development at all levels of the education system.

METHODOLOGY

In order to consolidate and analyse the current literature, policy documents, and curriculum frameworks concerning the integration of electric vehicle (EV) technology into automotive Technical and Vocational Education and Training (TVET) programs in Malaysia, this paper implements a narrative review methodology. In contrast to systematic reviews, which prioritise precise inclusion criteria, the narrative approach enables the examination of the context and the exploration of more complex concepts. This is particularly beneficial in emerging disciplines, such as electric vehicle education, where there is a dearth of research. The sources included curriculum documents from agencies such as the Department of Polytechnic and Community College Education (DPCCE), the Department of Skills Development (JPK), and the Malaysia Automotive, Robotics, and IoT Institute (MARii), as well as international publications from the ILO and UNESCO-UNEVOC. Additionally, peer-reviewed journal articles were consulted. Utilising keywords such as "electric vehicle technology," "automotive TVET," "curriculum readiness," and "Malaysia," we identified resources in databases such as Scopus, ScienceDirect, and Google Scholar. We exclusively examined works that were published between 2015 and 2025.

Thematic synthesis methodology was employed in the analysis, which was informed by Rogers' Diffusion of Innovation Theory and Fullan's Educational Change Theory. The review involved the identification, classification, and interpretation of literature that addressed topics such as curriculum content, teacher preparedness, institutional capability, and policy support. We examined each document to determine whether there was any evidence that national policies, such as the National Automotive Policy (NAP 2020), were consistent with the manner in which the curriculum was being taught at the school level. Thematic coding facilitated the identification of Malaysia's assets, weaknesses, and opportunities for enhancing its preparedness for the integration of EVs into the curriculum. This interpretive method provided us with a comprehensive

understanding of the collaborative efforts of policy orientations, institutional structures, and human capacities to prepare Malaysia's automotive TVET landscape for the integration of EV technology into the curriculum.

THEMATIC REVIEW AND DISCUSSION

The Table 1 below summarises key findings from studies, policy reports, and institutional documents (2015–2025) related to curriculum readiness for integrating electric vehicle (EV) technology into Malaysia's automotive TVET programs. The review themes are categorised under policy readiness, curriculum content, teacher/institutional readiness, and industry collaboration.

Table I Summary Review of Key Findings

Theme	Key Findings	Sources
Policy Readiness	• Malaysia's National Automotive Policy (NAP 2020) highlights Next-Generation Vehicles (NxGVs) and emphasises human capital development for EVs. However, implementation in TVET curricula remains slow, with limited policy translation into course design. • Alignment with the Low Carbon Mobility Blueprint (2021–2030) and TVET Empowerment Plan (2021–2025) supports green skills development, but coordination across agencies (MOHE, JPK, MARii) remains fragmented.	[28][24], [31] [5], [12], [32]
Curriculum Content Readiness	• Automotive curricula in most Malaysian polytechnics and community colleges remain focused on Internal Combustion Engine (ICE) systems, with minimal inclusion of EV modules such as battery management or high-voltage safety. • Slow revision of National Occupational Skills Standards (NOSS) delays integration of EV competencies into accredited courses.	[12], [26], [33] [18], [19]
Teacher and Institutional Readiness	• Many instructors lack exposure to EV systems, as most were trained in mechanical-based programs. Existing train-the-trainer workshops are limited in scope and coverage. • Institutional readiness varies widely: few polytechnics have EV labs and diagnostic tools. Funding constraints hinder infrastructure upgrades.	[11] [27] [23], [34] [35]
Industry Collaboration	• Partnerships between TVET institutions and automotive firms (e.g., Proton, Perodua, MARii) are emerging but largely pilot-based. Industry involvement in curriculum co-design remains weak. • Absence of structured apprenticeship models specific to EV technology limits hands-on exposure for students and teachers.	[10] [15], [16], [17]

DISCUSSION

The theme assessment suggests that Malaysia's initiatives to integrate electric vehicle (EV) technology into automotive technical and vocational education and training (TVET) are guided by explicit policy; however, they are impeded by inconsistent curriculum and practice. The reasons why policy intent alone has failed to achieve consistent curriculum preparation across institutions are elucidated by utilising Fullan's Educational Change Theory and Rogers' Diffusion of Innovation as analytical frameworks.

Malaysia's policy framework, which encompasses the National Automotive Policy 2020, the Low Carbon Mobility Blueprint 2021–2030, and associated TVET initiatives, provides substantial strategic momentum for the adoption of electric vehicles and the development of skills [28], [32]. These documents engage institutional stakeholders and convey national significance, both of which enhance the external environment [18], [19]. However, the evaluation indicates that there is still a discrepancy between policy and practice. Although regulations establish EV objectives, operational instruments, such as new competency standards (NOSS), specific financing sources, and explicit curriculum guidance, are still lacking [12], [13], [24]. Fullan's methodology postulates that these gaps arise when policy modifications are implemented without concurrent capacity development, cohesive leadership, and resources that enable stakeholders to implement innovation rather than passively supporting it [20]. There is a lack of micro-level enablers, including unambiguous NOSS updates, institutional financial allocations, and cross-agency coordination, in Malaysia, which reduces the likelihood of uniform curricular reform throughout the TVET system. Nevertheless, policy consistency is demonstrated at the macro level.

The findings suggest that the majority of automotive curricula continue to prioritise internal combustion engines (ICE) and fail to adequately incorporate electric vehicle (EV)-specific capabilities, such as high-voltage safety, power electronics, and battery management systems [26]. It is not sufficient to merely incorporate new modules into the curriculum; rather, it is necessary to modify the learning objectives, evaluation methods, and sequencing of lessons to illustrate the multifaceted nature of electric vehicles (EVs), which encompass electrical, electronic, software, and mechanical components. UNESCO-UNEVOC (2023) and ILO (2022) emphasise that modular curricula and competency-based approaches are effective in industries that experience rapid technological advancements. The review suggests that Malaysia has been slow to implement modular or competency-based micro-credentials, which would facilitate the incremental integration of electric vehicles and accelerate industry adoption [12], [18], [19]. Rogers' diffusion attributes assert that the perceived relative advantage of EV curricula will only accelerate adoption if schools are able to test small, visible successes (pilot modules, micro-credentials) that demonstrate the employability of students and the satisfaction of employers [10], [25] .

The primary impediment is the competence of the teacher. Many automotive educators were educated in mechanical disciplines and lack formal certifications or practical experience with electric vehicle (EV) systems [11], [27]. According to Fullan (2007), educational reform is effective when educators continue to collaborate and acquire new knowledge. The evaluation reveals that there are currently programs in place to assist individuals in acquiring new skills, including the DPCCE and MARii seminars. Nevertheless, the system often struggles to expand its capacity due to the short-lived, limited-scope, and small-scale nature of these programs [23]. Without a planned, ongoing professional development (CPD) path that encompasses accredited instructor certifications, industry secondments, and communities of practice, the transition to problem-based, simulation-led learning will be slow and teacher readiness will remain uneven [27], [35].

Specific instruments, such as insulated workshops, battery testing benches, high-voltage safety gear, and diagnostic software, are required to train individuals to work on electric vehicles. According to the 2023 MOHE audit, these facilities are present in only a small number of polytechnics. Numerous educational institutions encounter challenges in terms of purchasing, maintaining, and adhering to safety regulations [23]. Institutional governance and financing models exacerbate these issues: TVET providers frequently operate with restricted budgets and dispersed responsibilities in the areas of curriculum modification, procurement, and industry collaboration. This point is further emphasised by Fullan's emphasis on cohesive leadership: institutional leaders must possess the authority and resources to prioritise the integration of electric vehicles, coordinate planning across departments, and manage the risks associated with high-voltage systems [20]. Rogers' concept of trialability posits that flagship investments, such as well-resourced pilot laboratories and centres of excellence, can demonstrate feasibility. Nevertheless, a significant number of institutions will demonstrate reluctance in adopting these models unless their benefits are apparent and they are scaled [10], [18], [19].

For the acquisition of equipment, apprenticeships, collaborative design, and current technical expertise, industry collaborations are indispensable [10]. MARii's CoE-FM and certain OEM-TVET partnerships are promising examples of practice, as they offer pilot training, common infrastructure, and competency frameworks [18], [19]. Nevertheless, the review demonstrates that these partnerships are primarily between a limited number of model

institutions and have not been incorporated into statewide apprenticeship or dual-training programs [5], [15], [16], [17]. Dissemination is significantly impeded by proprietary concerns, coordination complexity, and insufficient incentives for small and medium enterprises (SMEs) to partake in formal training partnerships. Rogers' observability dimension implies that the key to fostering broader adoption within the TVET network will be the promotion and expansion of successful collaborations between industry and TVET [25].

A few patterns are common to all of them. Initially, curriculum preparation is a scaled process: while some schools are early adopters due to their strong leadership, linkages to the business, and pilot laboratories, others are lagging behind due to a lack of resources or instructors. Secondly, policy signals establish a mandate, but they lack sufficient practical clarity. Integrating NOSS with EV competency taxonomies would significantly enhance curricular work [12].Third, professional development for teachers and organised industry affiliations are interdependent: partnerships with businesses provide teachers with real-world examples to learn from, and teachers who are proficient in their field make working with businesses more productive. Finally, equity is crucial: institutions located in metropolitan or affluent regions are more likely to benefit from investments in electric vehicles. This could result in an inconsistent national distribution of EV capabilities if legislation fails to specifically address the distribution of resources.

The irregular path is elucidated by Fullan and Rogers: when employers provide positive feedback and policy grants certain institutions an advantage, while others are able to experiment with EV modules, as in the MARii experiments, adoption accelerates. However, diffusion is halted when there is a high level of complexity (e.g., high cost, technological risk) and low compatibility (e.g., outdated ICE curricula, limited staff competency). This suggests that the most effective strategy is a hybrid approach, which includes national policy and funding to support infrastructure and NOSS updates, focused CPD and secondments to simplify teacher workloads, and incentivised industry co-investment to enhance trialability and observability [18], [19], [20], [25]

RECOMMENDATIONS

The following recommendations are suggested to improve curriculum readiness and guarantee the effective integration of EV technology into Malaysia's automotive TVET programs, as per the review.

Curriculum Reform and Standardisation

The National Occupational Skills Standards (NOSS) and related competency frameworks should be updated by the Department of Skills Development (JPK) to encompass EV systems, battery management, and power electronics in order to facilitate curriculum reform and standardisation. Furthermore, it is imperative to create modular and adaptable curricula that incorporate EV-related competencies into existing automotive programs to facilitate a more seamless transition. Another critical area that necessitates attention is teacher upskilling and professional development. In collaboration with MARii, PERODUA, and Proton EV initiatives, this entails the implementation of national-scale train-the-trainer programs that concentrate on EV maintenance, diagnostics, and safety systems. Additionally, instructors' capacity to deliver high-quality training would be enhanced by offering incentives to pursue industry attachments and certifications in EV technology.

Resource Development and Infrastructure

In order to facilitate the effective administration of EV training, it is imperative to prioritise the development of infrastructure and resources. This encompasses the prioritisation of investment in EV laboratories, simulators, and diagnostic tools through public-private partnerships or federal grants. The optimisation of limited resources and the provision of broader access to high-quality training facilities could also be achieved by establishing shared training centres among technical institutions.

Industry Collaboration and Work-Based Learning

Curriculum relevance necessitates the enhancement of industry collaboration and work-based learning. It is recommended that TVET institutions enhance their connections with industry by incorporating apprenticeship programs with EV manufacturers, charging station developers, and service providers. The establishment of

curriculum advisory committees that include automotive industry experts would further guarantee the relevance of the content and the alignment with the labour market.

Policy and Governance Enhancement

The improvement of policy and governance necessitates the coordination of efforts across numerous agencies. It is imperative to promote interagency coordination among MOHE, JPK, DPCCE, and MARii in order to harmonise the implementation of policies. The implementation of monitoring and evaluation frameworks to monitor the adoption of EV curriculum and the competency of instructors would facilitate continuous improvement and evidence-based decision-making.

Research and Continuous Improvement

The reform process should be founded on continuous development and research. Action research on EV pedagogy, curriculum innovation, and learner outcomes should be promoted by TVET institutions and universities. Curriculum design and workforce planning would be informed by the development of national databases on the demand for EV-related skills, thereby ensuring that programs remain responsive to industry requirements.

The strategic alignment of policy, people, and practice is essential for the successful integration of EV technology into Malaysia's automotive TVET ecosystem. A comprehensive approach is necessary to establish curriculum readiness, which involves the integration of visionary policy frameworks, institutional capability, and human resource development. These recommendations have the potential to expedite Malaysia's transition to a TVET system that is future-ready, green, and innovation-driven, and is in alignment with the national sustainability and industrial transformation objectives, provided that they are implemented consistently and collaboratively.

CONCLUSION

The incorporation of electric vehicle (EV) technology into Malaysia's automotive TVET curricula is a national imperative and an educational transformation. Malaysia's efficacy within the regional EV ecosystem will be determined by its ability to produce technically competent graduates as the global automotive industry transitions towards electrification and sustainability. This review demonstrates that, despite the robust policy intent expressed in frameworks such as the National Automotive Policy (NAP 2020), Green Technology Master Plan, and TVET Empowerment Plan, curriculum preparedness at the institutional level remains inconsistent.

The results indicate that the majority of automotive TVET programs continue to prioritise internal combustion engine (ICE) competencies, with only a limited integration of EV-specific modules, diagnostic systems, or energy storage technologies. The diffusion of innovation as envisioned by Rogers (2003) is impeded by the persistence of gaps in teacher capability, infrastructure adequacy, and industry linkage [25]. The application of Fullan's (2007, 2020) Educational Change Theory further emphasises the necessity of systemic coherence, leadership support, and professional learning among teachers in order to implement meaningful curriculum reform [20], [21]. Therefore, Malaysia's preparedness is imperfect and changing, as it reflects both progress and persistent obstacles in the alignment of policy vision with institutional capacity and human capital development. In general, the review deduces that the preparation of the curriculum for the integration of electric vehicles (EVs) in Malaysian automotive TVET is not solely a technical adjustment, but a systemic change process that necessitates ongoing collaboration between government, industry, and education stakeholders

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