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# Integrating Electric Vehicle (EV) Technology into Teaching & Learning Among TVET Institutions in Malaysia

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## ABSTRACT

Malaysian Technical and Vocational Education and Training (TVET) institutions must align their educational frameworks with national goals of 15% electric vehicle penetration by 2030 and 80% by 2050 to transition to electric vehicles. This study uses Socio-Technical Systems (STS) theory to examine Malaysian TVET institutions' integration of electric vehicle technology, finding major gaps between the present curriculum centred on internal combustion engines and growing electric vehicle skills. This study uses narrative review and thematic synthesis to identify five critical misalignments: technical infrastructure and social capacity, policy-practice integration, industry-academia collaboration, sustainability and adaptation, and accreditation integration. The research shows that Malaysian TVET institutions have systemic issues beyond equipment acquisition, including technological infrastructure and human resource skills. This study uses STS theory to propose a comprehensive integration framework that optimizes technical and social subsystems across five key domains: technical infrastructure advancement and social capacity enhancement, policy-practice alignment mechanisms, integrated industry collaboration systems, adaptive sustainability frameworks, and accreditation-compliant integration. The framework recommends a gradual implementation plan based on organisational change management since effective electric vehicle teaching involves synchronous technological and social changes in TVET institutions.

**Keywords**— Electric vehicles Technology, TVET, socio-technical systems, workforce development, technical education

## INTRODUCTION

The global migration to electric vehicles is a significant development that will necessitate extensive labour planning. The Malaysian government aims to accelerate the usage of electric vehicles (EVs) in Malaysia, following a global trend. The target is to achieve 15% of total industry volume (TIV) by 2030 and 80% by 2050 [1]. However, for policies to be effective, the country's Technical and Vocational Education and Training (TVET) institutions must overcome significant challenges in preparing students for this advancement in technology. The majority of Malaysian TVET automotive programs now focus on internal combustion engine technology, leaving insufficient capacity for electric vehicle-specific competencies such as high-voltage safety, battery diagnostics, and smart charging systems. This technology divide is more than just an equipment issue; it is a fundamental misalignment between evolving technological needs and current educational frameworks [2], [3].

This paper aims to use Socio-Technical Systems (STS) theory to investigate the integration of electric vehicle technology into Malaysian Technical and Vocational Education and Training (TVET) institutions, thereby addressing substantial gaps in the current framework. STS theory provides a comprehensive framework for understanding the importance of matching technological advancements with social systems to achieve optimum performance. This study looks into how TVET institutions can efficiently synchronise their technical infrastructure with human resource capabilities, institutional rules, and sector-wide collaborative frameworks to help Malaysia achieve its electric mobility ambitions.

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# LITERATURE REVIEW

The global transition to electric vehicles (EVs) is a critical component of climate change mitigation and sustainable transportation. Many people understand that electric vehicles (EVs) can reduce carbon emissions, increase energy efficiency, and reduce our reliance on fossil fuels[1]. Their integration to transport systems has helped to reduce air pollution in major cities while also opening up new avenues for technological advancement. However, the rate of change varies by area. Developed countries are adopting electric vehicles (EVs) more quickly than developing countries, which are still lagging due to financial, technical, and institutional constraints [2].

Even though technology is rapidly evolving, the literature demonstrates that there are significant gaps between the technical and social subsystems in Malaysian TVET institutions attempting to use EV technology. These gaps manifest in five key ways:

### Technical Infrastructure-Social Capacity Misalignment

The market requires electric vehicle infrastructure, particularly public charging networks, to expand and people to learn how to use them. The scarcity of fast chargers and standard connectors reduces people's confidence and slows the adoption of electric vehicle education programs[3]. Most Malaysian TVET schools have technology infrastructure designed only for internal combustion engines. They lack high-voltage infrastructure, battery modelling equipment, and smart charging stations—all of which are required for EV training. At the same time, the social subsystem lacks any teachers who have been educated to teach electric vehicles, exacerbating the problem. Even when schools have modern EV equipment, teachers are not equipped to use it effectively [4], [5].

### Policy-Practice Integration Gaps

Malaysia's national policies (NETR, LCMB) establish clear goals for EV adoption (15% penetration of electric vehicles (EVs) by 2030 and 80% penetration by 2050), but TVET institutions have difficulty translating these lofty objectives into practical educational programs [6], [7]. The technical subsystem must follow safety standards and equipment specifications; however, the social subsystem lacks mechanisms for interpreting and implementing policy requirements at the institutional level. The speed with which education adjusts does not correspond to the urgency of national decarbonisation goals [8].

### Industry-Academia Collaboration Deficiencies

To make EV education effective, TVET institutions and automotive industry partners must collaborate on a continuous basis. However, the existing social subsystems in Malaysian TVET colleges do not provide organized opportunities for companies to participate in curriculum development, equipment selection, and graduate placement[9]. Institutions frequently acquire EV training methodologies through internal academic decision-making rather than direct involvement with manufacturers or energy industry partners [10]. This reduces the value of technical infrastructure investments and makes it more difficult for graduates to find work.

### Sustainability and Adaptation Limitations

Because EV technology is rapidly changing, both the technological infrastructure and the social framework must be adaptable. Many Malaysian TVET schools lack modular equipment designs (a technical issue) and initiatives that encourage teachers to continue studying (a social issue). According to research, approximately 20% of topics require frequent revisions[11], [12]. This revision is hampered by the lack of modular design in existing laboratory settings, which would allow for flexible alterations and iterative enhancements to fit changing training needs and evolving technology [13]. Furthermore, many laboratories have cost-efficiency problems due to the high costs associated with obtaining and maintaining contemporary EV components and physical infrastructure[14]. This double restriction prevents institutions from keeping up with technological advancements.

**Accreditation Integration Challenges**

The Engineering Accreditation Council (EAC) and the Engineering Technology Accreditation Council (ETAC) set standards for Malaysian TVET programs that prioritise outcome-based learning. Nonetheless, institutions struggle to reconcile EV-specific technical talents with certification norms, demonstrating a disconnect between technical skills and social-institutional frameworks. This creates a mismatch between graduates' abilities and the sector's changing needs[15], [16] .

## SOCIO-TECHNICAL SYSTEMS THEORETICAL FRAMEWORK:

The Socio-Technical Systems theory, first proposed by Trist and Bamforth (1951), states that an organisation's efficacy is dependent on the simultaneous optimisation of its technical and social subsystems. This theory provides critical insights into how educational systems must address both technological infrastructure and human factors in the context of EV integration in TVET institutions[17]. The technical subsystem encompasses the lab equipment, safety systems, diagnostic tools, charging infrastructure, and simulation software required for EV teaching. The social subsystem includes teacher abilities, curriculum design, school policies, business partnerships, and student learning styles. STS theory emphasises that these subsystems are interdependent and should be improved collectively rather than independently.

The STS theory approach has been widely applied in domains such as health information management and engineering education to improve system performance through stakeholder involvement and participatory design. The importance of human-system integration was highlighted by Kemp et al. (2023), who used STS to investigate how staff interaction with health information systems affects institutional efficiency[18]. Herrmann et al. (2009) maintained socio-technical walkthroughs, which are participatory lab design techniques that adjust to changing educational needs and technological advancements[19].

To successfully integrate EV technology into Malaysian TVET institutions, it is critical to comprehend how advanced technical components and existing social frameworks interact with one another. Using modern EV technology without the necessary changes to educator training, curriculum frameworks, and industry partnerships will produce unsatisfactory results. Furthermore, enhancing social processes in the absence of adequate technical infrastructure reduces the effectiveness of education.

STS theory is relevant in Malaysia's educational system, as schools must adhere to government policy frameworks (NETR, LCMB), safety guidelines (EVCS Guidelines), and industry requirements while providing high-quality instruction. The theory's emphasis on participatory design and stakeholder involvement is consistent with the need for a collaborative approach that integrates the perspectives of students, educators, industry partners, and legislators.

## METHODOLOGY

This study used a narrative review methodology supplemented by thematic synthesis to evaluate the challenges of integrating EV technology into Malaysian TVET institutions. The narrative review approach was chosen since the subject is interdisciplinary, encompassing engineering education, workforce development, policy implementation, and technological innovation.

From 2010 to 2025, literature was acquired from peer-reviewed journals, technical education reports, policy documents, and industry publications. This research searched academic databases such as Scopus, IEEE Xplore, and SpringerLink using keywords related to EV education, TVET development, socio-technical systems, and Malaysian technical education. There was also a look into NETR, LCMB, and the EV Charging System Guidelines to understand the national rules.

The thematic synthesis approach used STS theory as an analytical framework, categorizing literature by technical subsystem elements (infrastructure, equipment, safety systems) and social subsystem components (human resources, institutional procedures, collaborative mechanisms). This method identified systemic misalignments and opportunities for sociotechnical reform.

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## INTEGRATION FRAMEWORK BASED ON STS

This study suggests a Socio-Technical Systems framework for integrating EV technology in Malaysian TVET institutions, based on the discovered misalignments. The framework stresses the need to optimize both technological and social subsystems together in five key areas. Fig. 1 shows the proposed STS framework

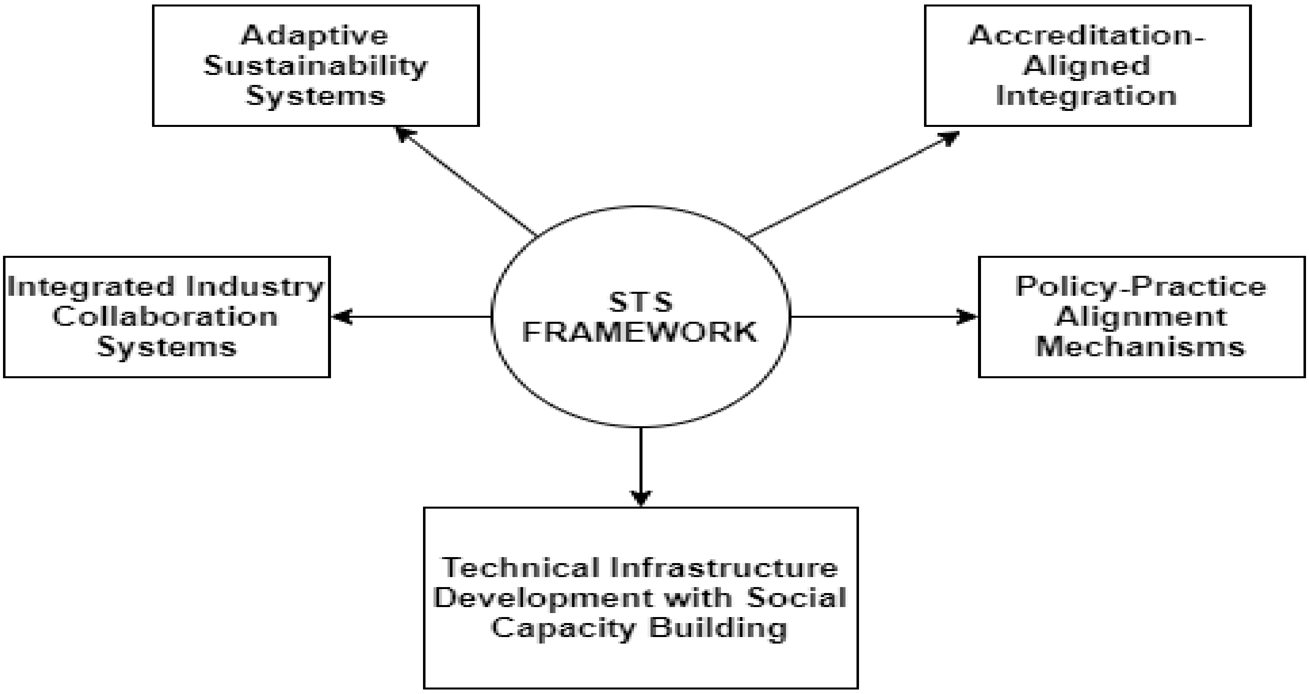


Fig 1 Proposed STS Framework for Integrating EV Technology in TVET in Malaysia

### Technical Infrastructure Development with Social Capacity Building

According to the STS Framework, social subsystem development has to align with technological subsystem improvements. To teach students how to use electric drivetrains, maintain batteries, apply regenerative braking, and work with high-voltage isolation, modern EV labs require complex infrastructure. Along with infrastructural development, thorough educator training programs should be conducted concurrently. The method ensures that human competences are in line with technology capabilities.

### Policy-Practice Alignment Mechanisms

The STS integration framework requires institutions to establish social subsystem procedures for converting national EV policies, such as the Low Carbon Mobility Blueprint (LCMB) and the National Energy Transition Roadmap (NETR), into specific technical requirements, such as the establishment and management of electric vehicle laboratories. This includes assembling policy interpretation committees, developing implementation plans, and establishing compliance monitoring systems that link institutional activities to macro-level goals. This includes adhering to technical and safety criteria such as MS IEC 61851, MS IEC 62196, and the EV Charging System (EVCS) criteria. This advances national goals while ensuring safety and well-being [6], [20]

### Integrated Industry Collaboration Systems

Structured industry-academic collaborations that address both technical and social issues are required for effective EV education. Government agencies, charging infrastructure vendors, and electric car manufacturers work together to build lab equipment. Social collaboration encompasses joint curriculum creation, educator exchange programs, training programs, internships, and graduate placement activities.

### Adaptive Sustainability Systems

Both technical and social subsystems must be built to adapt throughout time. This addresses the issue of technology becoming outdated. For technical sustainability, modular equipment designs and flexible lab settings are required. For social sustainability, this includes ongoing professional development, collaboration with other institutions, and measures to keep the curriculum current. Institutions should prioritise the purchase of lab equipment that is easily replaceable and expandable. They should also pay for certification and immersion programs to help teachers master new skills.

**Accreditation-Aligned Integration**

The framework emphasises the need for social system adjustments to ensure that EV technical skills are compatible with present accreditation processes. Laboratory work must adhere to the graduate standards established by the Engineering Accreditation Council (EAC) and the Engineering Technology Accreditation Council (ETAC) in order for students to achieve the goals of formal engineering education. This includes developing methods to assess students, learning objectives, and quality control systems that blend EV-specific competencies with accrediting criteria. This will help graduates acquire jobs and be prepared for them.

## SUGGESTIONS FOR IMPLEMENTATION OF FRAMEWORK

The study proposes a phased implementation based on organisational change management frameworks by Kotter's (2012) 8-step technique for promoting change. Kotter's phase method addresses issues that organisations frequently encounter during transformation projects[21].

According to research on organisational transformation, around half of the benefits of the change are typically seen within 18 months[22] . According to study on change management, performance patterns often emerge within three months [23].

Different schools use instructional technology in different ways, depending on the institution, the available resources, and the stakeholders' readiness. The strategy should begin with a foundational development phase that includes evaluating the socio-technical system, soliciting stakeholder feedback, analysing policy requirements, and developing teacher abilities. IT should also include a second phase, termed integration development. This phase applies to the circumstances and entails establishing a coordinated technical infrastructure, creating social capacity, activating industrial contacts, developing a curricular framework, and running a pilot program. The third and last step should be optimisation and scaling. This is adaptable and includes comprehensive program implementation, performance monitoring, continuous improvement activation, sophisticated technology integration, adaptive capacity development, and inter-institutional collaboration.

## DISCUSSION

Using Socio-Technical Systems theory, Malaysian TVET institutions require more than simply new equipment and curriculum changes to successfully integrate EV technology. The systemic nature of the problems needs the coordinated optimisation of both technical infrastructure and human operations. This study demonstrates the practical relevance of STS theory to difficulties in educational technology integration, extending traditional industrial applications to educational contexts. The framework provides a structured approach for negotiating socio-technical complexity while maintaining educational quality.

The ongoing reliance on internal combustion engine technology in Malaysian TVET colleges shows what STS theory defines as system inertia, which occurs when established socio-technical configurations resist change. To break this inertia, both subsystems must be operated on simultaneously. If the social structure does not change in tandem with technological modernisation, the equipment will be used less frequently, and the educational impact will be restricted.

The framework's emphasis on collaboration within the sector is founded on an essential STS principle: the necessity for environmental alignment. TVET schools are part of a larger socio-technical system that includes energy providers, automobile manufacturers, and regulatory agencies. To make EV education effective, schools must develop their internal socio-technical systems while remaining consistent with these outside systems.

The constraints of matching policies highlight another key STS concept: the requirement for hierarchical integration. Malaysia's national electric vehicle (EV) policies are higher-level system goals that must be translated into practical needs at institutional level. This translation process needs both technical interpretation (understanding how to use the equipment and what safety standards to follow) and social adaptation (developing strategies to put the plan into action and engage others).

## CONCLUSION

This study indicates that Malaysian TVET institutions should adopt a socio-technical approach rather than a technology-centred approach for the effective integration of electric car technologies. The application of Socio-technological Systems theory indicates that current integration issues stem from systemic misalignments between technological and social subsystems, rather than solely from inadequate equipment or gaps in the curriculum. The identified five gaps—misalignment between technical infrastructure and social capacity, policy-practice integration, industry-academia collaboration, sustainability frameworks, and accreditation systems—constitute components of a broader socio-technical system requiring comprehensive enhancement.

The proposed STS-informed methodology provides Malaysian TVET institutions with a systematic approach to address these misalignments through phased implementation, acknowledging organisational realities while promoting national electric vehicle adoption goals.

The study's implications extend beyond Malaysia to other emerging countries undergoing technological transformations in their educational systems. The framework improves theoretical understanding of socio-technical systems in educational contexts and provides practical guidance for policymakers and institutional leaders aiming to align TVET education with national sustainable mobility objectives. Further research should experimentally validate this framework through case studies at Malaysian TVET institutions, examining specific socio-technical integration processes and assessing outcomes using both technical performance indicators and metrics of social system effectiveness.

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