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Towards an Industry-Responsive Instructional Framework in Automotive Technology Education: A Systematic Review of OJT Challenges and Opportunities Via the I-Cope Model

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ABSTRACT

Higher education institutions are heavily mandated to bridge the gap between academic innovation and grassroots development through structured training tracks. In technical-vocational automotive technology education, executing appropriate instructional frameworks is critical to facilitate electronic skill transmission and ensure career readiness. However, traditional training resources are frequently plagued by severe equipment scarcity, outdated mechanical hardware, and an reliance on text-dense manuals, causing heightened cognitive load and lower retention among student-trainees. This study implements a rigorous Systematic Literature Review (SLR) conforming to the PRISMA statement parameters to critically evaluate the pedagogical configurations, structural design challenges, and immersive workplace dynamics within automotive training tracks. By executing an explicit search protocol across databases including Scopus, Google Scholar, IEEE Xplore, and PhilJOL for literature published between 2020 and 2026, a curated matrix of peer-reviewed empirical research, national competency frameworks, and institutional audits was isolated. To systematically code and extract structural insights from this literature base, a novel analytical framework called the I-COPE Model (Industry, Challenges, Opportunities, and Pedagogical Evaluation) is proposed and deployed. The thematic synthesis indicates that developing a sustainable automotive workforce requires a multi-phase architecture: aligning on-campus simulators with hyper-automated vehicle diagnostics, leveraging On-the-Job Training (OJT) placements as a transformative pedagogical bridge to offset institutional deficits, and structuring industry-academic collaborations to build tool self-efficacy. Ultimately, this review offers curriculum designers a definitive roadmap to establish an Industry-Responsive Instructional Framework that aligns regional training spaces with modern industrial standards.

Keywords: Automotive Technology Education, Industry-Responsive Framework, On-the-Job Training, PRISMA Framework, Systematic Literature Review.

INTRODUCTION

The contemporary industrial landscape is experiencing a profound paradigm shift driven by the transition from localized mechanical systems to hyper-connected, automated, and software-defined networks (Miller, 2023; Thompson, 2022). This structural reorganization, accelerated by the global rise of Industry 4.0 and automotive electrification, has fundamentally altered the core competencies required of the technical workforce (Al-Emran & Granić, 2024; Han, 2023). Technical and Vocational Education and Training (TVET) systems face severe institutional pressures to modernize their instructional paradigms (Schneider, 2025). They must produce graduates who are not merely proficient in traditional mechanical installations, but highly capable of deploying, configuring, diagnosing, and repairing complex, interactive sensor-actuator configurations (Onwusa & Asuai, 2025). Consequently, the integration of specialized, smart instructional media into technical-vocational curricula has emerged as an existential economic necessity for developing nations striving to sustain workforce efficiency and satisfy evolving industrial criteria.

Within the architecture of technical-vocational tracks, the transport and automotive technology sectors serve as critical pillars of national infrastructure development (Adnan et al., 2021). National industrialization policies increasingly mandate that next-generation workforce capabilities incorporate energy-efficient systems, wireless diagnostic logic, and technical digital literacy to advance the sustainability of urban ecosystems (Albertz & Pilz, 2025; Thunqvist et al., 2023). Higher Education Institutions (HEIs) and regional polytechnic campuses are the frontline vehicles for operationalizing these skill sets (Yunus et al., 2024). Core competency modules require radical structural adaptations to match real-world industry tracks (Baharuddin et al., 2024), ensuring that institutional competencies directly match professional trade expectations and national certifications (Rose & Sorge, 2023).

However, a profound misalignment persists: a majority of public and provincial TVET programs remain tethered to conventional, text-dense instructional methodologies and static, isolated setups (Azman et al., 2025; Calago, 2023). Current laboratory workshops routinely rely on outdated layouts and rigid equipment that completely obscure the digital logic and data streams defining modern automotive systems (Gupta & Lee, 2023; Hoffman, 2024). This pedagogical friction raises critical questions regarding overall curriculum readiness and the structural capacity of current training tools to cultivate advanced technical literacy (Pascua & Lagunero Tagare, 2024). This integration barrier is further exacerbated by equipment scarcity in rural school clusters (Dela Cruz, 2024), uneven instructor mastery over modern circuit configurations (Andal et al., 2022), and a pervasive vocational mismatch that prevents graduates from meeting corporate hiring criteria (Springer, 2025).

To resolve these systemic failures, stakeholders require a granular, evidence-based assessment of institutional readiness and the pedagogical dynamics governing instructional technology acceptance. On-the-Job Training (OJT) serves as a critical pedagogical mechanism to bridge this theory-practice gap, where immersion exponentially boosts baseline career success and workforce readiness (Tran Ba Loc et al., 2025). Yet, ensuring that these experiential training programs remain aligned with a fast-evolving industry remains a persistent challenge for educators worldwide (Jerrim et al., 2020; Saragih & Sibuea, 2025). Actual trainee performance relies heavily on creating continuous industry-academic collaboration to ensure that classroom instruction matches real-world service center expectations (Arante, 2022), particularly when a lack of contemporary diagnostic tools during field training creates localized skill gaps (Fwah et al., 2024; Ramirez, 2024).

At Caraga State University Cabadbaran Campus (CSUCC) in Agusan del Norte, the Bachelor of Science in Industrial Technology (BSIT) major in Automotive Technology program strives to supply the region with competent industrial technicians. However, local realities expose an operational gap: student-trainees deployed in local automotive shops must grapple with highly advanced electronic engine management systems and computer-aided scan tools in the field using outdated on-campus equipment. Conversely, these local placements provide significant opportunities, allowing students to acquire specialized certifications and expose themselves to modern business operations (Aziz et al., 2024; Tovkanets, 2022).

This study implements a structured Systematic Literature Review (SLR) conforming to the PRISMA statement parameters to examine these user interaction paradigms, structural resource constraints, and behavioral intention models (Li et al., 2022). By synthesizing these localized insights, this paper establishes a strategic, data-driven, and Industry-Responsive Instructional Framework to ensure that technical training spaces are aligned with the digital evolution of the modern built environment (World Bank, 2024).

METHODOLOGY

To ensure absolute methodological transparency, minimize selection bias, and maximize research replication rigor, this study utilizes a structured Systematic Literature Review (SLR) design. The research architecture and operational workflow strictly conform to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement parameters. By employing an explicit, multi-stage search, screening, and selection strategy, this review ensures a replicable analytical workflow that maps contemporary empirical developments, global training trajectories, and regional workplace realities. Rather than presenting an unstructured descriptive summary, this systematic protocol filters the broader literature base to comprehensively isolate, evaluate, and map contemporary insights regarding On-the-Job Training (OJT) dynamics within Automotive Technology education.

Information Sources and Search Strategy

A comprehensive electronic search protocol was executed across major internationally and domestically indexed academic databases to harvest relevant empirical data. The investigated networks included Scopus, Google

Scholar, IEEE Xplore, and the Philippine Journals Online (PhilJOL) portal. To secure an exhaustive collection of primary research, the search strings were constructed using combinations of Boolean operators, wildcards, and specialized keywords targeting titles, abstracts, and index terms.

Specifically, the first exact search structure deployed across the database interfaces paired automotive training changes with curricular alignment by querying the intersection of "automotive technology education" or "industrial technology curriculum" and "industry-responsive" or "curricular alignment". To target field immersion dynamics, the second search query combined experiential frameworks with specific workforce outcomes, tracing the relationship between "On-the-Job Training" or "OJT challenges" or "workplace immersion" and "automotive industry" or "electronic troubleshooting" or "diagnostic tools". Finally, to isolate regional and national competency compliance, the third operational search block evaluated the intersection of "vocational mismatch" or "skill gaps" and "TESDA frameworks" or "industrial competencies".

Literature Selection: Inclusion and Exclusion Criteria

To filter the retrieved documents with high precision and eliminate arbitrary selection bias, an explicit matrix of eligibility boundaries was established prior to the data collection phase. To be included in the final qualitative synthesis pool, documents had to meet strict parameter thresholds:

Temporal and Language Parameters: Studies must be published in the English language within peer-reviewed journals, national development report registries, or authorized institutional repositories between 2020 and 2026 to capture the rapid post-pandemic shift toward electronic and electric vehicle (EV) automotive technologies.

Contextual Parameter: Materials must directly focus on higher education industrial technology tracks, specific automotive engineering technology programs, or workplace immersion setups.

Core Operational Parameter: Research must explicitly address the challenges (e.g., equipment scarcity, technological anxiety, diagnostic gaps) and opportunities (e.g., industry-academic collaborations, advanced tool exposure) encountered during student field placements.

Target Demographic Parameter: The empirical sample must focus heavily on undergraduate student-trainees, industry supervisors, and vocational curriculum designers within technical-vocational sectors.

Conversely, papers were systematically excluded if they focused exclusively on traditional, purely mechanical light-vehicle frameworks without analyzing electronic management systems or computerized diagnostics. These exclusion boundaries ensured that the final curated literature base remained highly applicable to the advanced technical benchmarks required by the modern automotive sector.

Screening, Selection, and PRISMA Flow Protocol

The systematic screening process was operationalized across four sequential phases in strict compliance with the PRISMA framework: identification, screening, eligibility assessment, and inclusion. During the *Identification Phase*, all citations generated by the electronic search strings were exported into reference management software, where automated algorithms and manual cross-checks located and eliminated duplicate records. During the *Screening Phase*, the titles and abstracts of the remaining unique records were independently audited against the inclusion and exclusion criteria by the researchers. Irrelevant papers, opinion pieces, editorial notes, and unverified abstracts were culled at this stage.

During the *Eligibility Phase*, the full-text manuscripts of all remaining potentially eligible studies were retrieved and subjected to deep diagnostic analysis. Any discrepancies regarding study eligibility between the primary reviewers were resolved through collaborative consensus or arbitration by an external academic panel. The quantitative reduction of records was carefully documented from the initial bulk identification down to the final selection of peer-reviewed articles, institutional policy papers, and empirical studies that met the absolute qualitative thresholds of this review.

The Analytical Framework: The I-COPE Model

To systematically process, categorize, and extract structural insights from the final pool of included literature, this study proposes and applies the **I-COPE Model (Industry, Challenges, Opportunities, and Pedagogical Evaluation)**. The I-COPE matrix serves as a multi-dimensional thematic lens to systematically code and synthesize the extracted literature base across four definitive filters:

Industry Standards (I): Reviewing literature that examines how digital tools, advanced computerized diagnostics, and rapid automotive transformations (such as EV and autonomous systems) dictate modern workplace expectations.

Challenges Encountered (C): Evaluating studies that detail severe instructional gaps, equipment scarcity, outdated campus laboratory infrastructure, and the resulting student anxiety during field tracking.

Opportunities Leveraged (O): Analyzing documentation regarding industry-academic collaborations, specialized certifications, and trainee exposure to advanced modern corporate service center operations.

Pedagogical Evaluation (P): Investigating empirical research on embedding constructive alignment, performance-gate metrics, and industry-responsive curriculum blueprints into formal institutional syllabi.

By passing the systematically selected literature through these four specific thematic filters, the review moves completely away from a narrative summary, instead building a cohesive, academically rigorous, and replicable structural framework regarding the definitive characteristics of an industry-responsive automotive curriculum.

RESULTS AND DISCUSSION

Study Selection and Characteristics

Following the execution of the PRISMA systematic filtration protocol, a final pool of peer-reviewed primary studies, academic audits, and national development registries published between 2020 and 2026 was isolated for structural synthesis. The curated literature represents a global and localized cross-section of automotive technology adoptions, industrial workforce readiness, and cooperative immersion frameworks. To establish a structured foundation for the qualitative synthesis, the included literature was systematically mapped across the analytical dimensions of the **I-COPE Model**, as outlined in Table 1.

Table 1: Methodological Matrix of Included Literature Categorized by I-COPE Core Vectors

I-COPE Domain	Structural Pedagogy Focus	Key Sample Citations (2020–2026)
Industry Standards (I)	Advanced computerized diagnostics, electronic troubleshooting, electric vehicle (EV) metrics, and industry benchmarks.	Al-Emran & Granić (2024); Han (2023); Miller (2023); Onwusa & Asuai (2025); Thompson (2022)
Challenges Encountered (C)	Outdated laboratory equipment, equipment scarcity, instructional poverty, vocational mismatches, and field-tracking anxiety.	Calago (2023); Jerrim et al. (2020); Pascua & Lagunero Tagare (2024); Saragih & Sibuea (2025); Springer (2025)
Opportunities Leveraged (O)	Industry-academic collaboration, specialized certifications, real-world workshop exposure, and regional corporate alignment.	Arante (2022); Aziz et al. (2024); Tovkanets (2022); Tran Ba Loc et al. (2025)
Pedagogical Evaluation (P)	Constructive curriculum alignment, TESDA standard frameworks, diagnostic scaffolding tools, and instructional engineering.	Fwah et al. (2024); Manayan et al. (2024); Ramirez (2024); Rose & Sorge (2023); Villanueva et al. (2021)

Thematic Synthesis

Theme 1: Global Industry Paradigms and Electronic Troubleshooting (I – Industry)

The systematically curated literature establishes that the global automotive landscape is experiencing an intense technological transformation, rendered by the swift transition from traditional, purely mechanical components to hyper-connected, software-defined networks (Miller, 2023; Thompson, 2022). This structural reorganization demands an entirely re-engineered approach to technical training as modern work environments evolve from basic mechanical adjustments to complex electronic engine management and digital circuit troubleshooting (Onwusa & Asuai (2025)).

As a result, next-generation workforce capabilities must incorporate energy-efficient system automation, wireless diagnostic logic, and high technical digital literacy (Han, 2023). International research proves that modern automotive technicians must be proficient in manipulating data streams and reading computerized sensor-actuator arrays rather than executing rote mechanical installation tasks (Al-Emran & Granić, 2024). Consequently, the integration of specialized diagnostic simulators into technical-vocational curricula has emerged as an existential economic necessity to satisfy modern industrial criteria.

Theme 2: Equipment Scarcity and the Theory-Practice Gap (C – Challenges)

A profound consensus emerging from the systematic synthesis highlights a widespread, critical disconnect between macro-policy expectations and real-world workshop environments in public and provincial programs (Calago, 2023). While national training policies emphasize advanced automated systems, localized school blocks frequently suffer from chronic instructional poverty and outdated laboratory equipment (Pascua & Lagunero Tagare, 2024). This structural mismatch forces institutions to rely on text-dense manuals and static, non-programmable setups that completely obscure the invisible digital logic defining contemporary vehicles.

When student-trainees are deployed into advanced industry tracks without proper on-campus laboratory preparation, they experience heightened technical anxiety and reduced self-efficacy (Springer, 2025). This pedagogical friction results in severe vocational mismatches, preventing graduates from meeting corporate hiring criteria (Jerrim et al., 2020; Saragih & Sibuea, 2025). The literature establishes that leaving student-trainees to grapple with advanced diagnostic scan tools in the field without prior school-based training degrades long-term retention and workforce readiness.

Theme 3: Industry-Academic Collaboration and Immersive Pathways (O – Opportunities)

Despite these severe resource gaps, the systematically reviewed literature identifies On-the-Job Training (OJT) placements as the ultimate proving ground and pedagogical mechanism to bridge the academic theory-practice gap. Through targeted field immersion, student-trainees gain direct access to advanced electronic engine management systems, automatic transmissions, and modern corporate service center operations (Tovkanets, 2022).

As demonstrated in this operational pipeline, real-world exposure does not merely enhance basic tool familiarity, but exponentially boosts graduate employment rates and long-term career success (Tran Ba Loc et al., 2025). Furthermore, empirical data confirm that creating continuous industry-academic collaboration allows educational institutions to leverage modern regional business operations to offset their internal infrastructure deficits (Arante, 2022). These cooperative arrangements give students a direct path toward acquiring specialized certifications and adjusting to industrial transport realities (Aziz et al., 2024).

Theme 4: Constructive Curriculum Alignment and Diagnostic Scaffolding (P – Pedagogical)

The final thematic dimension extracted from the literature emphasizes that sustainable technical competence relies on a comprehensive, industry-responsive instructional framework. Research filtered through the pedagogical lens demonstrates that modern curricula must be deliberately tailored to professional standards to validate whether institutional competencies match national trade certifications, such as TESDA regulations

(Rose & Sorge, 2023). To counteract field-tracking anxiety, instructional media must deploy localized, transparent, and open-layout trainer simulators that explicitly break down complex electronic logic into objective, measurable performance gates.

Empirical studies confirm that anchoring diagnostic exercises to real-world fault codes and computerized scanning procedures dramatically increases independent technical mastery among automotive trainees (Ramirez, 2024). By structuring lessons around an iterative cycle of physical measurement, diagnostic testing, and active code debugging, educators can transform an intimidating technical workflow into an approachable, self-paced livelihood tool (Fwah et al., 2024; Manayan et al., 2024; Villanueva et al., 2021). Ultimately, this systematic review highlights that a data-driven instructional framework is essential to transform technical training environments from symbolic compliance into highly aligned, market-ready centers of workforce excellence.

CONCLUSIONS

The systematic modernization of automotive technology education through industry-responsive pathways is an urgent socio-technical imperative. This systematic literature review, executed via the PRISMA protocol and analyzed through the **I-COPE Model (Industry, Challenges, Opportunities, and Pedagogical Evaluation)**, highlights a critical structural fracture within the technical education ecosystem. While macro-level national policy frameworks mandate student mastery over hyper-automated vehicle architectures and computerized diagnostics, actual field-level delivery remains severely bottlenecked by acute equipment scarcity, outdated campus laboratories, and an reliance on text-dense, non-interactive manual instruction. This instructional poverty creates a significant theory-practice gap, generating high cognitive load, learning friction, and technical anxiety among student-trainees when they enter modern industrial workshops for the first time.

To resolve these systemic mismatches, this study concludes that On-the-Job Training (OJT) placements serve as a vital, transformative pedagogical bridge that successfully offsets internal institutional deficits. Cooperative field immersion grants trainees direct, tactile access to advanced diagnostic scan tools and modern service center environments, shifting students from passive memorization to dynamic troubleshooting, specialized certification, and heightened tool self-efficacy. Transitioning to a sustainable workforce requires moving away from unaligned training frameworks toward a unified, Industry-Responsive Instructional Framework. When institutional curricula are intentionally tailored to match modern trade standards—reinforced by continuous industry-academic collaborations and output-based diagnostic assessment matrices—the technical readiness of the future workforce is secured, aligning classrooms with the evolving demands of the global industrial market.

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