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CAPACITY BUILDING NEEDS FOR ELECTRIC VEHICLE DIAGNOSTICS AND MAINTENANCE AMONG INFORMAL AUTOMOTIVE PRACTITIONERS IN NORTH CENTRAL NIGERIA

Onyilo Regina Igogbe[1], Daniel Terhemba Adim[2] & Dr Kwaghgba Victor Aho[3]
[1,2,3]*Department of Industrial Technology, Rev. Fr. Moses Orshio Adasu University, Makurdi, Benue State, Nigeria.*
adimdanielterhemba@gmail.com

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ABSTRACT
The transition to e-mobility in Nigeria exposes a serious operational readiness gap in the informal automotive sector, which accounts for over 80% of auto technicians and remains internal combustion engine-centric. This study assessed capacity-building needs for electric vehicle (EV) diagnostics and maintenance among informal practitioners in North Central Nigeria. Anchored on Situated Learning Theory, Human Capital Theory, and Diffusion of Innovations Theory, the study adopted a descriptive survey design. It covered Benue, Kogi, Kwara, Nasarawa, Niger, Plateau, and FCT-Abuja, with a focus on mechanic villages such as Apo and Zuba. The population of 1,124, comprising mechanics, workshop managers, and EV outlet owners, was sampled to 295 using Yamane's formula through purposive stratified random sampling. Data were collected with the Capacity Building Needs for EV Diagnostics Questionnaire and analyzed using mean, standard deviation, and independent-samples t-test at the 0.05 level. Findings revealed high technical competency needs (cluster M = 3.37), particularly in high-voltage safety, cable identification and isolation, and battery management systems. Institutional and infrastructural readiness was low (cluster M = 2.45), with inadequate access to EV diagnostic tools, BMS testing facilities, and charging infrastructure, while collaboration opportunities were limited (cluster M = 2.05). The hypothesis tests showed significant differences between practicing mechanics and managers/supervisors across the three areas. The study recommended modular upskilling within mechanic villages, establishment of cluster EV service hubs, and strengthened TVET-informal linkages through blended learning and NBTE Recognition of Prior Learning.

Keywords: Capacity building, EV diagnostics, informal apprenticeship, battery management system, North Central Nigeria

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Introduction

The automotive industry is experiencing a global shift from internal combustion engine (ICE) propulsion to electric mobility, driven by decarbonization and advancements in battery technology (IEA, 2023). In Nigeria, automotive service delivery is anchored on informal apprenticeship, where skills are transferred through observation and practice under master craftsmen (Adegbola & Dare, 2021). With the implementation of the National Automotive Industry Development Plan (NAIDP) 2023 and interventions by the National Automotive Design and Development Council (NADDC, 2023), electric, hybrid vehicles and electric motorcycles are increasingly entering the Nigerian market. North Central Nigeria, comprising Benue, Kogi, Kwara, Nasarawa, Niger, Plateau, and the Federal Capital Territory, with its concentration of mechanic villages, offers a strategic context for examining the readiness of informal automotive practitioners for EV diagnostics and maintenance.

Nigeria's automotive service delivery relies on informal apprenticeship. Despite their numerical dominance, accounting for over 80% of auto technicians, informal automotive practitioners in North Central Nigeria remain entirely ICE-centric, with competence limited to carburetors, fuel injection, and 12-volt systems (Osunwusi & Abatan, 2023). Recent assessments show specialized EV diagnostic tools are generally unavailable in workshops, and infrastructure readiness is rated inadequate (Ogunyemi et al., 2022). This is reinforced by wider evidence: 84% of TVET colleges in Africa were not aware of EV skill requirements, and almost 90% of trainers had no EV training (Handwerkskammer Erfurt & RMI, 2024). In Nigeria, while NADDC has developed EV-specific National Occupational Standards and 17 Automotive Training Centres (NADDC, 2023; 2024), informal mechanics remain excluded due to unaccredited apprenticeship models (Olawale & Omotosho, 2024). Consequently, the absence of technicians trained in high-voltage safety and battery management is slowing EV adoption and exposing users to safety and business risks (Onyema, 2025). Hence, there is an empirical need to assess the capacity-building needs of informal practitioners for EV diagnostics and maintenance in North Central Nigeria.

Purpose of the Study

This study assessed capacity-building needs for electric vehicle (EV) diagnostics and maintenance among informal automotive practitioners in North Central Nigeria. Specifically, the study:

1. Determined the technical competency needs of informal practitioners for EV service.
2. Examined the institutional and infrastructural readiness of informal mechanic shops for EV service delivery.
3. Assessed collaboration opportunities between informal shops and EV stakeholders for skills transfer.

Research Questions

1. What are the technical competency needs of practicing auto mechanics, managers of auto mechanic shops, and owners of electric vehicles/EV assembly in electric vehicle diagnostics and maintenance in North Central Nigeria?
2. What is the level of institutional and infrastructural readiness of practicing auto mechanics, managers of auto mechanic shops, and owners of electric vehicles/EV assembly outfits for electric vehicle service delivery in North Central Nigeria?
3. What are the collaboration opportunities between practicing auto mechanics, managers of auto mechanic shops, and owners of electric vehicles/EV assembly outfits for skills transfer and EV adoption in North Central Nigeria?

Hypotheses

HO1: There is no significant difference in the mean responses of practicing auto mechanics and managers of auto mechanic shops on the technical competency needs of informal automotive practitioners for electric vehicle diagnostics and maintenance in North Central Nigeria.

HO2: There is no significant difference in the mean responses of practicing auto mechanics and managers of auto mechanic shops on the level of institutional and infrastructural readiness of informal auto mechanic shops for electric vehicle service delivery in North Central Nigeria.

HO3: There is no significant difference in the mean responses of practicing auto mechanics and managers of auto mechanic shops on the collaboration opportunities for skills transfer and EV adoption in North Central Nigeria.

Review of Related Literature

Theoretical Review

Situated Learning Theory, as propounded by Lave and Wenger (1991) defines learning as legitimate peripheral participation in communities of practice where novices move from periphery to full participation through social interaction. Its importance to this study lies in explaining why informal mechanic villages function as learning communities and why they resist decontextualized formal EV curricula, as apprenticeship-based experiential learning and peer knowledge sharing shape competency acquisition (Shittu & Adeosun, 2021; Opeyemi, 2023).

Human Capital Theory, as postulated by Becker (1964) conceptualizes education and training as investments in human capital that yield returns in productivity and earnings. The theory justifies capacity building for EV technology as a strategic investment for employability and national competitiveness, particularly as labour markets reward multidimensional capital including technical know-how and adaptability (Deming, 2017; Caplan, 2018).

Diffusion of Innovations Theory by Rogers (2003) explains how, why, and at what rate new ideas spread through social systems via innovation characteristics of relative advantage, compatibility, complexity, trialability, and observability. Combined with the Technology Acceptance Model by Davis (1989), it illuminates why informal mechanics have not adopted modern diagnostic technology due to perceived complexity and low observability, as facilitating conditions and social influence significantly predict adoption (Ajao et al., 2024; Ismail, 2023).

Empirical Review

Empirical evidence indicates that automotive training and practice in Nigeria remain predominantly Internal Combustion Engine (ICE) focused, with emerging deficits in competencies required for electric mobility. In North Central Nigeria, Mamman and Auta (2020) appraised the Motor Vehicle Mechanics Work curriculum and found it was still ICE-based, with strategies inadequate for modern automotive technologies. This aligns with Ogbuanya and David (2020), who reported a lack of basic instructional facilities in 22 accredited technical colleges, limiting exposure to emerging technologies.

In the informal sector, Okwelle and Tombari (2017) studied 63 artisans in Ikoku mechanic village, Port Harcourt, and identified significant deficits in modern vehicle competencies required for standard enterprise. Similarly, Ezeama, Obe and Ede (2016) assessed capacity-building needs of motor vehicle mechanics trainers and reported a high need for auto-diagnostic competencies, a gap that becomes more critical with high-voltage EV systems. Shittu and Adeosun (2021) further showed that informal apprenticeship in Nigeria relies largely on tacit learning through observation, which leaves gaps in theoretical knowledge and safety standards essential for high-voltage work.

The challenge extends beyond skills to tools and infrastructure. Lemo (2025) found in Ogun State that trainees who had access to diagnostic and ECU servicing equipment performed better, yet most workshops lacked such tools, affecting sustainability. Okolie, Anolue and Adenuga (2021) also noted that many TVET institutions in rural settings lacked consistent electricity and internet, limiting engagement with modern equipment. Cross-national evidence reinforces this pattern. A needs analysis of 500 automotive companies and 35 TVET colleges across Africa by Handwerkskammer Erfurt and RMI (2024) revealed an acute shortage of qualified EV lecturers, with 84% of colleges unaware of EV skill requirements and almost 90% of trainers without EV training. The study identified five critical training areas, including battery technology, high-voltage safety, and EV diagnosis.

Taken together, existing studies have examined curriculum adequacy, general diagnostic needs, or infrastructural constraints in isolation, and mostly within formal TVET or single mechanic villages in the South-South and South-West. No known study has combined technical competency needs, institutional and infrastructural readiness, and collaboration pathways together, specifically for informal automotive practitioners in the context of EV diagnostics and maintenance in North Central Nigeria. It is this integrated gap that the present study seeks to close.

Conceptual Review

Capacity building for EV transition

Capacity building for EV transition is the deliberate process of equipping people, workshops and institutions with the competencies, resources and linkages required to support electric mobility. In this study, it requires alignment of human competencies, institutional resources and collaboration systems within both formal and informal automotive sectors (UNESCO-UNEVOC, 2022).

Informal apprenticeship in Nigeria

Informal apprenticeship in Nigeria is a practice-based TVET system in which master craftsmen mentor apprentices over a period without formal certification. It is a vibrant system accounting for over 65% of automotive employment (NBS, 2021; ILO, 2020), yet it remains largely focused on ICE repairs (Adegbola & Dare, 2021).

Electric vehicle diagnostics and maintenance

Electric vehicle diagnostics and maintenance is the systematic process of inspecting, testing, troubleshooting, and servicing the high-voltage systems that power an electric vehicle. It encompasses the battery management system (BMS) as the central control unit for cell balancing and temperature management (Theodoridis et al., 2025), the electric motor, which converts electrical energy to mechanical motion and enables regenerative braking (Szumska, 2025), and power electronics such as AC-DC and DC-DC converters for fast charging (Uddin & Rahman, 2022). Knowledge of dominant battery chemistries in 2023 - lithium iron phosphate, nickel manganese cobalt, and nickel cobalt aluminum (Wang & Li, 2024) - is essential for safe handling and forms the core of EV diagnostics and maintenance.

Institutional and infrastructural readiness

A collaboration and skills transfer model is a framework that links formal and informal actors to facilitate technology adoption. It emphasizes formal-informal linkages, industry immersion, and public-private partnerships as vehicles for technology adoption and resilience (UNESCO, 2022; ILO, 2020; Ejiofor & Ali, 2023).

Methodology

This study adopted a descriptive survey design, suitable for collecting opinions and competencies from a large, dispersed population without manipulation of variables (Osagie &

Okunade, 2024). The study area was North Central Nigeria: Benue, Kogi, Kwara, Nasarawa, Niger, Plateau, and FCT Abuja. The zone was chosen for its concentration of state transport garages, large mechanic villages like Apo Mechanic Village Abuja, emerging EV presence in Garki and Lokoja, and documented deficiencies in facilities and auto-electricity skills (Ogbuanya & David, 2020; Terwase et al., 2024).

The population was 1,124, comprising practicing auto mechanics, managers/supervisors/owners of auto shops, and owners/management staff of EV assembly/distribution outlets. A sample size of 295 was determined using Yamane's formula at a 5% error margin (Yamane, 1967; Israel, 1992). Proportional allocation gave 262 practicing mechanics, 27 shop managers/supervisors, and 6 EV assembly/distribution staff. The small figure of 6 for the third stratum reflects the actual accessible EV outlets in the zone at the time of the study, as EV penetration is still nascent in North Central.

Purposive stratified random sampling was used to ensure proportional representation of the three strata and to select workshops with traces of EV service (Creswell & Creswell, 2017; Saunders et al., 2019). The instrument was the Capacity Building Needs for Electric Vehicle Diagnostics Questionnaire (CBNEVDQ). It contained 30 items in three clusters of 10 each. Cluster A (Technical competency needs) was anchored on a 4-point Need scale: Highly Needed (HN)=4, Needed (N)=3, Slightly Needed (SN)=2, Not Needed (NN)=1. Clusters B and C (Readiness and Collaboration) were anchored on a 4-point Agreement scale: Strongly Agree (SA)=4, Agree (A)=3, Disagree (D)=2, Strongly Disagree (SD)=1 (Creswell & Creswell, 2017; Kumar, 2019).

For interpretation, real limits were used: 3.50-4.00 = Highly Needed/Strongly Agree, 2.50-3.49 = Needed/Agree, 1.50-2.49 = Slightly Needed/Disagree, 1.00-1.49 = Not Needed/Strongly Disagree. The criterion mean was 2.50; any item with a mean of 2.50 and above was regarded as Needed/Agree (Field, 2018; Pallant, 2020).

The instrument was face and content validated by four experts: two experts in Industrial Technology Education from Rev. Fr. Moses Orshio Adasu University, Makurdi; one expert in Automobile Technology from Federal University of Technology, Minna as an outside validator, and one Measurement and Evaluation expert from Benue State University, Makurdi (Taherdoost, 2016). Their corrections on clarity and relevance were incorporated.

A pilot test was conducted using 30 respondents - 15 informal mechanics and 15 shop supervisors - drawn from Mararaba mechanic village in Nasarawa State, which shares similar characteristics with the main study area but was not part of the main sample. The exercise helped to check the clarity of items, timing, and logistics. Data from the pilot yielded Cronbach's alpha coefficients of 0.88 for Cluster A, 0.83 for Cluster B, and 0.92 for Cluster C, with an overall coefficient of 0.87, above the 0.70 benchmark (Taber, 2018).

Data were collected in person and via Google Forms for distant locations. The mean and standard deviation were used to answer research questions. For hypotheses, an independent-samples t-test was used to compare the two major groups - 262 practicing mechanics and 27 shop managers/supervisors - at the 0.05 level of significance. Levene's test was used to check homogeneity of variance; where significant, Welch's t-test (equal variances not assumed) was reported. The third stratum of 6 EV assembly/distribution staff was not included in inferential analysis to avoid distortion of variance and power associated with a very small group. Its responses were retained as key informant insights and presented descriptively with mean and SD, interpreted with caution (Field, 2018; Pallant, 2020).

Research Question 1: What are the technical competency needs of practicing auto mechanics, managers of auto mechanic shops, and owners of electric vehicles/EV assembly outfits in electric vehicle diagnostics and maintenance in North Central Nigeria?

Table 1: The Mean and Standard Deviation of the technical competency needs of practicing auto mechanics, managers of auto mechanic shops, and owners of electric vehicles/EV assembly outfits in electric vehicle diagnostics and maintenance in North Central Nigeria. (N1 = 262, N2 = 27, N3 = 6)

ITEM NO.	ITEM DESCRIPTION	M1	SD1	M2	SD2	M3	SD3	CM	CSD	REM-ARKS
1	High-voltage safety protocols and use of insulated personal protective equipment.	3.07	0.55	3.41	0.75	3.83	0.41	3.44	0.57	Needed
2	Identification and handling of high-voltage cables, connectors and isolation procedures.	3.71	0.45	3.04	0.52	4.00	0.00	3.58	0.32	Needed
3	Diagnosing and maintaining Battery Management System (BMS).	3.32	0.47	2.85	0.36	3.00	0.00	3.06	0.28	Needed
4	Testing, balancing and replacement of EV battery modules and cells.	3.69	0.46	3.81	0.40	3.00	0.00	3.50	0.29	Needed
5	Understanding of EV thermal management system for battery and power electronics.	2.98	0.55	3.78	0.58	3.00	0.00	3.25	0.38	Needed
6	Use of EV-specific scan tools and interpretation of CAN-bus diagnostic trouble codes.	3.67	0.48	3.00	0.39	3.33	1.03	3.33	0.63	Needed
7	Diagnosing and repairing electric drive motor and inverter system.	2.87	0.85	3.78	0.42	3.00	0.00	3.22	0.43	Needed

8	Diagnosing and repairing EV charging system including on-board charger and charging port.	3.32	0.47	3.85	0.36	3.50	0.55	3.56	0.46	Needed
9	Understanding of regenerative braking system and its integration with friction brake.	3.04	0.57	3.00	0.39	3.00	0.00	3.01	0.32	Needed
10	Interpretation of EV wiring diagrams and digital service manuals.	3.67	0.47	3.85	0.36	3.67	0.52	3.73	0.45	Needed
	CLUSTER MEAN	**3.33**		**3.44**		**3.33**		**3.37**		

Key: M_1 = Mean of Practicing Auto Mechanics, M_2 = Mean of Managers of Auto Mechanic Shops, M_3 = Mean of Owners of Electric Vehicles/EV Assembly Outfits SD_1 = Standard deviation of Practicing Auto Mechanics, SD_2 = Standard Deviation of Auto Mechanic Shops, SD_3 = Standard Deviation of Owners of Electric Vehicles/EV Assembly Outfits, ***CM*** = Cumulative Mean, ***CSD*** = Cumulative Standard Deviation

Table 1 shows that the identified technical competencies in electric vehicle diagnostics and maintenance were generally considered needed, with a cluster mean of 3.37. Practicing auto mechanics recorded a cluster mean of 3.33, managers of auto mechanic shops 3.44, and EV owners/assembly-outfit owners 3.33. The highest-rated competency was the identification and handling of high-voltage cables, connectors, and isolation procedures (CM = 3.58), while understanding regenerative braking and its integration with friction braking had the lowest cluster mean (CM = 3.01). Overall, the findings indicate a clear need for EV-related technical competency development among the three respondent groups.

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Research Question 2: What is the level of institutional and infrastructural readiness of practicing auto mechanics, managers of auto mechanic shops, and owners of electric vehicles/EV assembly outfits for electric vehicle service delivery in North Central Nigeria?

Table 2: The Mean and Standard Deviation of the level of institutional and infrastructural readiness of practicing auto mechanics, managers of auto mechanic shops, and owners of electric vehicles/EV assembly outfits for electric vehicle service delivery in North Central Nigeria. (N1 = 262, N2 = 27, N3 = 6)

ITEM NO.	ITEM DESCRIPTION	M1	SD1	M2	SD2	M3	SD3	CM	CSD	REM-ARKS
11	Availability of insulated hand tools rated for 1000V for EV work in the workshop.	1.71	0.45	3.15	0.36	3.83	0.41	2.90	0.41	Agree
12	Availability of EV diagnostic scan tools and software update subscription.	1.33	0.47	2.15	0.36	2.67	0.52	2.05	0.45	Disagree
13	Availability of Battery Management System (BMS) testing and diagnostic bench.	2.04	0.57	1.93	0.27	3.00	0.00	2.32	0.28	Disagree
14	Availability of personal protective equipment for high-voltage work such as insulated gloves and face shield.	1.68	0.47	2.93	0.62	3.00	0.00	2.53	0.36	Agree
15	Availability of dedicated EV charging point and stable power supply in the workshop.	1.70	0.46	1.85	0.36	2.83	0.41	2.13	0.41	Disagree
16	Restructuring of workshop layout to include high-voltage safety demarcation and warning signs.	3.69	0.46	3.15	0.36	3.00	0.00	3.28	0.27	Agree
17	Availability of fire safety equipment suitable for lithium-ion battery fire.	1.68	0.47	3.22	0.42	3.83	0.41	2.91	0.43	Agree

18	Availability of structured curriculum or manual for EV training in the workshop.	1.69	0.46	1.78	0.42	3.33	0.52	2.27	0.47	Agree
19	Access to mobile EV simulation kits for apprentice training.	1.31	0.46	1.85	0.36	2.67	0.52	1.94	0.45	Disagree
20	Availability of internet access for accessing EV technical information and online diagnostics	1.68	0.47	1.78	0.42	3.00	0.00	2.15	0.30	Disagree
	CLUSTER MEAN	**1.85**		**2.38**		**3.12**		**2.45**		

Key: M_1 = Mean of Practicing Auto Mechanics, M_2 = Mean of Managers of Auto Mechanic Shops, M_3 = Mean of Owners of Electric Vehicles/EV Assembly Outfits SD_1 = Standard deviation of Practicing Auto Mechanics, SD_2 = Standard Deviation of Auto Mechanic Shops, SD_3 = Standard Deviation of Owners of Electric Vehicles/EV Assembly Outfits, ***CM*** = Cumulative Mean, ***CSD*** = Cumulative Standard Deviation

Table 2 indicates a mixed level of institutional and infrastructural readiness for EV service delivery, with an overall cluster mean of 2.45. Practicing auto mechanics recorded the lowest cluster mean (M = 1.85), compared with managers of auto mechanic shops (M = 2.38) and EV owners/assembly-outfit owners (M = 3.12). Readiness was reported for insulated hand tools, high-voltage safety demarcation, fire-safety equipment, and structured EV training materials, whereas access to EV diagnostic tools, BMS testing facilities, dedicated charging points, mobile simulation kits, and internet-based technical resources was generally rated inadequate.

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Research Question 3: What are the collaboration opportunities between practicing auto mechanics, managers of auto mechanic shops, and owners of electric vehicles/EV assembly outfits for skills transfer and EV adoption in North Central Nigeria?

Table 3: The Mean and Standard Deviation of the collaboration opportunities practicing auto mechanics, managers of auto mechanic shops, and owners of electric vehicles/EV assembly outfits for skills transfer and EV adoption in North Central Nigeria. (N1 = 262, N2 = 27, N3 = 6)

ITEM NO.	ITEM DESCRIPTION	M1	SD1	M2	SD2	M3	SD3	CM	CSD	REM-ARKS
21	Collaboration between informal mechanic villages and NADDC for EV upskilling programmes.	1.67	0.47	2.00	0.39	3.00	0.63	2.22	0.50	Disagree
22	Partnership between TVET institutions and informal shops for blended learning arrangement.	2.16	0.37	3.07	0.27	3.00	0.00	2.75	0.21	Agree
23	Linkage between EV assembly or sales companies and informal mechanics for after-sales service training.	1.72	0.45	1.85	0.36	2.17	0.75	1.91	0.52	Disagree
24	Organization of joint training workshops by ITF and auto mechanic associations on EV maintenance.	1.32	0.47	1.93	0.27	2.00	0.00	1.75	0.25	Disagree
25	Attachment of master craftsmen to EV assembly plants for industrial exposure.	2.00	0.00	3.15	0.36	2.00	0.00	2.38	0.12	Disagree
26	Inclusion of informal apprentices in NBTE Recognition of Prior Learning for EV certification.	2.00	0.57	3.15	0.36	3.00	0.00	2.72	0.31	Agree

27	Creation of WhatsApp or YouTube based EV micro-learning platform for informal practitioners.	1.21	0.41	1.78	0.42	1.33	0.52	1.44	0.45	Disagree
28	Establishment of EV service hubs within mechanic villages to serve as cluster training centres.	1.45	0.68	1.78	0.42	1.67	0.52	1.63	0.54	Disagree
29	Involvement of EV owners in providing feedback on service needs to informal workshops.	1.58	0.70	2.11	0.51	2.17	0.41	1.95	0.54	Disagree
30	Government grant or support for informal shops to procure EV diagnostic tools through cooperative societies.	1.21	0.41	2.00	0.55	2.00	0.00	1.74	0.32	Disagree
	CLUSTER MEAN	**1.63**		**2.28**		**2.23**		**2.05**		

Key: M_1 = Mean of Practicing Auto Mechanics, M_2 = Mean of Managers of Auto Mechanic Shops, M_3 = Mean of Owners of Electric Vehicles/EV Assembly Outfits SD_1 = Standard deviation of Practicing Auto Mechanics, SD_2 = Standard Deviation of Auto Mechanic Shops, SD_3 = Standard Deviation of Owners of Electric Vehicles/EV Assembly Outfits, ***CM*** = Cumulative Mean, ***CSD*** = Cumulative Standard Deviation.

Table 3 shows that collaboration opportunities for skills transfer and EV adoption were generally limited, with an overall cluster mean of 2.05. Practicing auto mechanics recorded a cluster mean of 1.63, while managers of auto mechanic shops and EV owners/assembly-outfit owners recorded 2.28 and 2.23, respectively. The highest-rated opportunity was partnership between TVET institutions and informal shops for blended learning (CM = 2.75), followed by inclusion of informal apprentices in NBTE Recognition of Prior Learning for EV certification (CM = 2.72). Most other proposed collaboration mechanisms were rated Disagree, indicating limited existing opportunities for structured collaboration among the stakeholder groups.

Hypotheses testing

N1 = 262 practicing auto mechanics, N2 = 27 managers/supervisors. The third stratum, N3 = 6 EV outlets, was excluded from the inferential test and retained as key informant descriptive insight. This explains why an independent-samples t-test (df = 287) is used instead of ANOVA.

HO_1: There is no significant difference in the mean responses of practicing auto mechanics and managers of auto mechanic shops on the technical competency needs of informal automotive practitioners for electric vehicle diagnostics and maintenance in North Central Nigeria.

Table 4

Group Statistics for Technical Competency Needs

	Respondents Description	N	Mean	Std. Deviation	Std. Error Mean
TECH_COMP_NEEDS	Practicing Auto Mechanics	262	3.3347	.17214	.01063
	Managers/Supervisors	27	3.4370	.16904	.03253

Table 5

Independent Samples t-test for Technical Competency Needs

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
TECH_COMP_NEEDS	Equal variances assumed	.050	.822	-2.945	287	.003
	Equal variances not assumed			-2.989	31.818	.005

Table 4 shows that managers/supervisors (M = 3.44, SD = 0.17) reported slightly higher technical competency needs than practicing mechanics (M = 3.33, SD = 0.17). Levene's test was not significant, $F(1, 287) = 0.05$, p = .822, indicating homogeneity of variance. The independent samples t-test was significant, $t(287) = -2.95$, p = .003, d = 0.60. Therefore, $H0_1$ is rejected. Although statistically significant, the absolute difference is small and both groups rated competency needs high (above the 3.25 cut-off), indicating consensus on need.

HO_2: There is no significant difference in the mean responses of practicing auto mechanics and managers of auto mechanic shops on the level of institutional and infrastructural readiness of informal auto mechanic shops for electric vehicle service delivery in North Central Nigeria.

Table 6: **Group Statistics for Institutional and Infrastructural Readiness**

	Recpondents Description	N	Mean	Std. Deviation	Std. Error Mean
LEVEL_INSTU_INFRASTRUCTURE	Practicing Auto Mechanics	262	1.8496	.16787	.01037
	Managers/Supervisors /Owners of Auto Shops	27	2.3778	.10500	.02021

Table 7: **Independent Samples t-test for Institutional and Infrastructural Readiness**

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
LEVEL_INSTU_INFRASTRUCTURE	Equal variances assumed	15.465	.000	-16.014	287	.000
	Equal variances not assumed			-23.253	41.215	.000

Levene's test was significant, $F(1, 287) = 15.47$, $p < .001$, therefore Welch's t-test was interpreted. There was a statistically significant large difference between groups, $t(41.22) = -23.25$, $p < .001$, $d = 3.24$. Practicing mechanics ($M = 1.85$) rated readiness lower than managers ($M = 2.38$). Both means are below the 2.50 criterion, indicating low readiness, but mechanics perceive more severe inadequacy. $H0_2$ is rejected.

HO_3: There is no significant difference in the mean responses of practicing auto mechanics and managers of auto mechanic shops on the collaboration opportunities for skills transfer and EV adoption in North Central Nigeria.

Table 8: **Group Statistics for Collaboration Opportunities**

	Recpondents Description	N	Mean	Std. Deviation	Std. Error Mean
COLLABORATION_OPPOR_BTW_INF	Practicing Auto Mechanics	262	1.6332	.17574	.01086
	Managers/Supervisors/ Owners of Auto Shops	27	2.2815	.11448	.02203

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Table 9: **Independent Samples t-test for Collaboration Opportunities**

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
COLLABORATION_OPPOR_BTW_INF	Equal variances assumed	5.230	.023	-18.745	287	.000
	Equal variances not assumed			-26.394	39.928	.000

Levene's test was significant, $F(1, 287) = 5.23$, $p = .023$, so Welch's correction was used. Results show a significant difference, $t(39.93) = -26.39$, $p < .001$, $d = 3.79$. Managers ($M = 2.28$) were more optimistic about collaboration than mechanics ($M = 1.63$). The overall mean (2.05) indicates collaboration opportunities are currently limited. $H0_3$ is rejected.

Discussion of Findings

The findings revealed high technical competency needs (cluster $M = 3.37$) with high-voltage cable identification and isolation rated highest ($M = 3.58$). The significant difference between mechanics and managers ($p = .003$) does not imply disagreement on need, but reflects managers' greater awareness of EV safety protocols due to closer contact with OEM documentation.

Institutional readiness was low ($M = 1.85$ - 2.38) with critical gaps in BMS test benches, 1000V rated tools, and charging infrastructure. The very large effect size ($d > 3.0$) between groups suggests stratified exposure to EV technology, with managers in urban centers having marginally better access.

Collaboration was rated lowest ($M = 2.05$). While TVET-informal workshop linkage and RPL were moderately supported, formal attachment to EV plants and access to online diagnostic resources were largely absent. The significant difference ($p < .001$) underscores perceptual divergence: managers foresee business opportunities in partnerships, while mechanics perceive systemic exclusion.

Conclusion

Capacity needs are high, but readiness is low. The informal sector, which services over 80% of Nigeria's vehicle parks, is currently unequipped for safe EV handling. The gap is more infrastructural than attitudinal.

Recommendations

Based on the findings of Research Question One and Hypothesis One which revealed high technical competency needs for EV diagnostics and maintenance among both groups of respondents, it is recommended that NADDC in collaboration with NBTE and ITF should develop short, competency-based micro-credentials focusing on high-voltage safety protocols, battery management system testing, and CAN-bus diagnostics. Since learning in the informal sector is situated within mechanic villages, delivery should be through mobile, hands-on clinics within mechanic villages rather than classroom-based approaches, with assessment leading to certification through Recognition of Prior Learning.

Based on the findings of Research Question Two and Hypothesis Two which showed low institutional and infrastructural readiness for EV service delivery, particularly among practicing mechanics, it is recommended that Government and development partners should upgrade selected mechanic villages in North Central Nigeria into cluster EV service hubs. Upgrading two villages per state with shared access to 1000V rated insulated tools, battery diagnostic benches, lithium-ion fire extinguishers, and dedicated charging points with stable power supply, managed through existing cooperative societies, will address the infrastructural inequality observed.

Based on the findings of Research Question Three and Hypothesis Three which indicated weak and uneven collaboration opportunities for skills transfer, it is recommended that a formal tripartite framework linking TVET institutions, the Nigerian Automobile Technicians Association (NATA), and similar bodies and EV assembly companies should be institutionalized by the Federal Government of Nigeria. This framework should provide for short-term industrial attachment of master craftsmen to EV plants and integration of informal apprentices into national skills qualification pathways.

Limitations

This study was limited to North Central Nigeria, so findings may not apply to some state outside of the zone or other EV hubs. The sample was uneven, with 262 mechanics, 27 managers and only 6 EV outlet owners, hence EV experts were treated as key informants and excluded from t-tests. The data were self-reported, so competency needs may be inflated and readiness under-rated, as no practical skills audit or physical workshop audit was conducted. The cross-sectional design also captures only a single point in time.

Contribution to Knowledge

The study provides first empirical evidence on EV skill gaps in Nigeria's informal sector, which services over 80% of vehicles but is excluded from EV discourse. It extends Human Capital and Diffusion of Innovations theories to show that learning in mechanic villages is situated and constrained by tools, not attitude. It further proposes a practical cluster-hub model with mobile micro-credentials and cooperative access to tools, offering a pathway for inclusive e-mobility transition in North Central Nigeria, Nigeria at large, and similar African contexts.

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