WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Training Needs of Automotive Service Technicians in the Maintenance and Repairs of Electric vehicles (EVs) for Sustainable Transportation Systems in Abuja, Nigeria.

[1]Muhammad Auwalu, [2]Isma'ila Yelwaji Shehu & [3]Abubakar Sadiq Adamu

[1]Department of Automobile Technology, Federal College of Education (Technical) Bichi, Kano. mkauwal@gmail.com
[2&3]Department of Vocational and Technology Education, Abubakar Tafawa Balewa University, Bauchi
DOI : https://doi.org/10.55248/gengpi.6.0225.0724

ABSTRACT

This study examines the training needs of automotive service technicians in the maintenance and repairs of electric vehicles for sustainable transportation system in Abuja, Nigeria. The study employed a descriptive survey research design, the population consisted of 1,214 automotive service technicians working in government institutions, government agencies, and private workshops in Abuja, Nigeria. A sample size of 286 automotive service technicians was selected using a simple random sampling technique. However, a 40-item five-point likert scale questionnaire was adapted and utilized for data collection. The data collected was analyzed using descriptive statistics such as mean and standard deviation and inferential statistical analysis of variance (ANOVA). The results revealed there was a unanimous agreement among all the respondents on the critical needs for comprehensive training on electrical systems and transmission systems of EVs in Nigeria. Importantly, the findings highlighted the absence of maintenance and repairs practices for sustainability of EVs in Nigeria. Therefore, the study recommended among others that the federal government should implement specialized, practical training programs, promote partnerships for enhanced training, establish continuous professional development mechanisms, and advocate for supportive policies to advance maintenance and repairs skills of automotive service technicians for sustainability of electric vehicle in transportation system in Abuja, Nigeria.

Key words: *training needs, automotive service technicians, maintenance and repair, electric vehicles*

1. Introduction

The growing environmental concerns and the desire for a more cost-effective and luxurious lifestyle have driven a significant shift in the pattern of living many individuals, particularly in urban centers like Abuja, Lagos Nigeria and many developing countries. This shift is compounded by the economic challenges facing the countries, including the rising cost of fuel, which has severely impacted the transportation sector (Okwelle, Beako & Ajie, 2017). The increasing fuel costs have led many nations, including Nigeria, to explore more sustainable and cleaner modes of transportation, with electric vehicles (EVs) emerging as a key solution to reducing vehicular emissions and transitioning to cleaner energy sources (Idris & Francis, 2019). Electric vehicles, which rely on one or more electric motors for propulsion, are being recognized globally as the future of the automotive industry due to their potential to mitigate climate change and reduce dependency on fossil fuels (Alanazi, 2023; Bawa & Nwahu, 2023). The adoption of EVs is seen as a critical step towards achieving environmental sustainability, and recent advancements in EV technology have brought numerous benefits, including improved quality of life, economic advantages, and significant environmental gains (Chimaotuodi, 2023; Rady, Darwish & Abbod, 2023).

The importance of regular maintenance and repairs EVs cannot be overstated, as these are essential for optimizing the lifespan and performance of the vehicles, ensuring safety, and minimizing unexpected breakdowns (Kerr & Ryan, 2017). Despite the growing market for electric vehicles, the transition from traditional internal combustion engine vehicles to EVs presents several challenges, particularly maintenance and repair. EVs comprise a range of types, including battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and hydrogen fuel electric vehicles (FCEVs), each requiring specialized skills and knowledge for proper upkeep (Chimaotuodi et al., 2023). However, the skills required to maintain and repair these advanced vehicles are markedly different from those needed for conventional vehicles, necessitating a significant shift in the training and education of automotive service technicians. However, the rapid pace of technological advancement in the automotive sector has rendered some traditional skills obsolete, creating an urgent need for upskilling and reskilling among automotive service technicians (Guney, 2023). The adoption of sustainable practices in vehicle maintenance and repair is also critical, as these practices not only meet present needs but also ensure that future generations vehicles to meet their full operations by minimizing environmental impact (Oluyomi, 2015; Alanazi, 2023).

In Nigeria, particularly in Abuja, the shift towards EVs is still in its early stages, and the availability of trained technicians capable of maintaining and repairing these vehicles is limited. This limitation created a significant skills gaps and a barrier to the widespread adoption and

sustainability of EVs in the region (Okwelle et al., 2017). To address this issue, there is a pressing need to assess the training needs of automotive service technicians in Abuja, focusing on key areas such as auto-electrical systems, and auto-transmission systems. Hence, this study aims to identify and address the specific training needs of automotive service technicians in Abuja for sustainable practices in maintenance and repairs of electric vehicles.

1.1 Objectives of the study

The aim of this study is to identify the training needs of automotive service technicians in the maintenance and repairs of electric vehicles for sustainable transportation systems in Abuja, Nigeria. Specifically, the objectives of this study are:

a) To assess the training needs of automotive service technicians in the maintenance and repairs of electrical systems of electric vehicles for sustainable transportation systems in Abuja, Nigeria.

b) To identify the training needs of automotive service technicians in the maintenance and repairs of transmission systems of electric vehicles for sustainable transportation systems in Abuja, Nigeria.

1.2 Research Questions

The following research questions guided the study:

a) What are the training needs of automotive service technicians in the maintenance and repairs of electrical systems of electric vehicles for sustainable transportation systems in Abuja, Nigeria?

b) What are the training needs of automotive service technicians in the maintenance and repairs of transmission systems of electric vehicles for sustainable transportation systems in Abuja, Nigeria?

1.3 Null Hypothesis

$H0_1$: There is no significant difference among the mean response of automotive service technicians in government institutions, agencies and private workshops on training needs in the maintenance and repairs of electrical systems electric vehicles for sustainable transportation systems in Abuja, Nigeria.

$H0_2$: There is no significant difference among the mean response of automotive service technicians in government institutions, agencies and private workshops on training needs in the maintenance and repair of transmission system of electric vehicles for sustainable transportations systems in Abuja, Nigeria.

2. Literature Review

2.1 Training Needs in the Maintenance and Repairs of Electric Vehicles

The significance of training in the maintenance and repair of electric vehicles (EVs) is paramount due to the unique characteristics of EV technology. As the market share of EVs continues to expand, there is a growing demand for specialized training programs that equip technicians with the necessary skills to effectively service these vehicles (Albatayneh, 2024). The integration of high-voltage systems in EVs introduces new risks, necessitating specific training to ensure the safety of personnel involved in their maintenance (Albatayneh, 2024). Moreover, proper maintenance of EVs is crucial as it directly impacts passenger safety and vehicle availability (El Hadraoui et al., 2022). Innovative training methods, such as the use of three-dimensional representations and augmented reality, are essential to overcome the limitations of traditional training approaches. Additionally, enhancing maintenance practices for vehicles with hybrid power systems is vital to ensure effective operation, utilizing diagnostic tools and historical data (El Hadraoui et al., 2022). The importance of appropriate training is further emphasized by the reduction in maintenance costs and the increased resale value of hybrid electric vehicles compared to conventional cars. As the automotive industry transitions towards electrification and automation, the required skills for maintenance and repair technicians are evolving (Grosso et al., 2021). The development of fault diagnosis systems using fusion technology in virtual reality for all-electric vehicles underscores the need for ongoing training and adaptation to new technologies in the maintenance and repair sector (Luo, 2021). Therefore, comprehensive training programs that include safety protocols, innovative repair techniques, and optimized maintenance practices are essential to ensure the efficient and safe maintenance of EVs.

2.2 Maintenance of Electric Vehicles for Sustainability

Maintenance, as defined by Alejo (2018), involves preserving buildings in their original functional, structural, and aesthetic condition, ensuring they remain in a healthy state and retain their value and standard over time. Similarly, Jiya, Idris, Abdulkadir, and Audu (2022) describe maintenance as the process of repairing or servicing equipment or machinery to enhance its operational capacity, emphasizing that maintenance primarily includes both

servicing and repair. Alejo (2018) also points out that inadequate maintenance funding, a shortage of trained staff, a lack of maintenance specialists, and poor resource management are key deficiencies that hinder effective maintenance. In a related perspective, Jiya et al. (2022) define maintenance as the efforts made to maintain a machine's condition and performance as close as possible to its original state when new. They further explaine that maintenance activities can be categorized into planned and unplanned tasks. Planned maintenance is organized, controlled, and recorded according to predetermined plans. In this context, Kutsyuruba, Klinger, and Alicia (2015) note that the availability and prudent management of facilities greatly influence the quality of technicians in a workplace. Nardo, Converso, and Castagna (2021) add that servicing, which includes actions like cleaning, dust removal, and lubrication, is crucial to maintaining the stability of equipment and preventing its degradation. Whitman (2023) highlights that electric cars are simpler machines, lacking complex systems like combustion engines and exhausts, resulting in fewer repairs compared to gasoline-powered cars.

2.3 Electric System of Electric Vehicles

The electrical system of electric vehicles (EVs) is a vital component for ensuring their safe and efficient operation. As Hong (2016) explains, an electrical system consists of various components designed to transport electrical energy for specific purposes. Historically, traditional vehicles relied on low-voltage electrical systems to power accessories such as lights, wipers, and lighters, with minimal risk of electric shock. However, with the rapid development of new energy vehicles, the application of electrical energy has become more extensive and complex, involving high-voltage circuits that exceed the safe voltage range. The development of new energy vehicles plays a significant role in alleviating environmental pressures and advancing social and economic prosperity. Despite this progress, the complete automobile electrical system remains in an early stage of exploration, with no mature technology or clear direction. Research into the electrical insulation and performance systems of new energy vehicles is therefore crucial. Hong (2018) further highlight that the electrical system in electric vehicles encompasses various aspects such as electrical safety, energy management, system integration, power electronics, regenerative braking, and impacts on the electrical grid. Electrical safety is essential for preventing electric shock and ensuring reliability in large-scale charging stations, while energy management focuses on optimizing energy converters, storage, and loads to maximize electric potential energy (Wang et al., 2019).

2.4 Transmission System of Electric Vehicles

According to Whitman 2023 electric vehicles generally have a simple transmission with a single gear, leading to less frequent maintenance. However, unlike traditional internal combustion engine vehicles, technical personnel involved in the maintenance, repair, R&D, design, and production processes of electric vehicles require specialized training and customized equipment (Topal, 2023). Castagna (2021) observes that current maintenance practices often rely on predefined schedules without considering the actual working condition of the equipment, leading to over-maintenance. Castagna also emphasizes the high costs associated with production interruptions and the dispatching of maintenance personnel to restore equipment to proper working conditions.

3. Methodology

This study employed a descriptive survey research design. The geographical area of the study was Abuja, Nigeria. The population consists of all 1,214 automotive service technicians working in government institutions, government agencies, and private workshops in Abuja. A sample size of 292 automotive service technicians was selected using a simple random sampling technique, ensuring representation from both government institutions and private workshops. The data collection instrument was a structured questionnaire consisting of 40 items, titled "Training Needs of Automotive Service Technicians in the Maintenance and Repairs of Electric Vehicles for Sustainable Transportation Systems in Abuja, Nigeria." The researcher, along with two research assistants, collected the data directly from the study participants. The collected data was analyzed using descriptive statistics (mean, standard deviation), and analysis of variance (ANOVA).

4. Results

4.1 Training needs of automotive service technicians in the maintenance and repairs of electrical systems of electric vehicles for sustainable transportation systems in Abuja, Nigeria

The descriptive statistics in Table 1 show mean scores ranging from 3.89 to 4.05, with standard deviations between .021 and .923. The grand mean score is 3.97, with a standard deviation of .192. The results indicated that automotive service technicians in government institutions, agencies, and private workshops in Abuja, Nigeria, agreed that they require training in diagnosing battery charging faults, battery replacement, high-voltage safety procedures, circuit diagnostics using tools, onboard charging equipment, software updates for driver assistance systems, electric drive components, electrical measurement, and electrical wiring to enhance their maintenance and repair skills for electric vehicles.

Table 1: Descriptive Statistics on the Training Needs of Automotive Service Technicians in the Maintenance and Repairs of Electrical Systems of Electric Vehicles

S/N	Items	N	Mean	Std. D	Remark
1	Training needs of automotive service technicians on Battery charging faults diagnosis for upgrade in maintenance and repairs of electric vehicles.	300	3.91	.214	Agree
2	Training needs automotive service technicians on Battery replacement for maintenance and repairs of electric vehicles.	300	3.98	.133	Agree
3	Training needs of automotive service technicians for working on high voltage with safety procedures in maintenance and repairs of electric vehicles.	300	3.98	.109	Agree
4	Training needs of automotive service technicians on circuit diagnostics using tools like multimeters and oscilloscopes in maintenance and repairs of electric vehicles.	300	3.99	.126	Agree
5	Training needs of automotive service technicians to meet with current trainings for onboard charging equipment in maintenance and repairs of electric vehicles.	300	3.91	.075	Agree
6	Training needs automotive service technicians on software update for advanced driver assistance systems for maintenance and repairs of electric vehicles.	300	4.00	.125	Agree
7	Training needs of automotive service technicians on electric drive components in maintenance and repairs of electric vehicles.	300	4.00	.094	Agree
8	Automotive service technicians need training on electrical measurement trainings in maintenance and repairs of electric vehicles.	300	4.05	.099	Agree
9	Automotive service technicians need training on electrical wiring trainings for electric vehicles maintenance and repairs of electric vehicles	300	3.95	.021	Agree
10	Automotive service technicians have all trainings necessary for maintenance and repairs electric vehicles.	300	3.89	.923	Agree
	Grand Mean		**3.97**	**.192**	**Agree**

The analysis of variance presented in Table 2 indicated that there was no statistically significant difference in the mean responses of automotive service technicians from government institutions, agencies, and private workshops regarding their training needs in the maintenance and repairs of electrical systems of electric vehicles for sustainable transportation systems in Abuja, Nigeria $F(2, 355) = 0.799$, $p = 0.451$. Consequently, Hypothesis 1 is accepted. This outcome suggests that automotive service technicians from all three sectors; government institutions, agencies, and private workshops unanimously recognize the need for training in diagnosing battery charging faults, battery replacement, high voltage safety procedures, circuit diagnostics with tools, onboard charging equipment, software updates for driver assistance systems, electric drive components, electrical measurement, and electrical wiring to enhance their skills in maintaining and repairing electric vehicles.

Table 2: One-Way Analysis of Variance on the Mean Differences among Automotive Service Technicians on the Training Needs in the Maintenance of Electrical Systems of Electric Vehicles

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.223	2	.611	.799	.451
Within Groups	271.768	355	.766		
Total	272.991	357			

4.2 Training needs of automotive service technicians in the maintenance and repairs of transmission systems of electric vehicles for sustainable practices in Abuja, Nigeria

The statistical evidence in Table 3 shows mean scores ranging from 3.94 to 4.17, with standard deviations between .001 and .970. The grand mean score is 4.04, with a standard deviation of .476. These results indicate that automotive service technicians in government institutions, agencies, and private workshops in Abuja, Nigeria, agreed that they require training on drivetrain components, inverters, gearboxes, regenerative braking mechanisms, various electric motors (such as brushless DC, induction, and switched reluctance), power inverters, power electronics, and Electric Power Control Units (EPCUs) to support sustainable maintenance and repair practices for electric vehicles.

Table 3: Descriptive Statistics on the Training Needs of Automotive Service Technicians in Maintenance and Repairs of Transmission System of Electric Vehicles in Abuja, Nigeria.

S/N	Items	N	Mean	Std. D	Remark
1	Automotive service technicians need training on drivetrain components like electric traction motors for sustainable practices in maintenance and repairs of electric vehicles	300	4.02	.030	Agree
2	Automotive service technicians need training on inverters and gearboxes which differ from conventional vehicles for sustainable practices in maintenance and repairs of electric vehicles	300	4.14	.010	Agree
3	Automotive service technicians need training on regenerative braking mechanism for sustainable practices in maintenance and repairs of electric vehicles	300	3.96	.051	Agree
4	Automotive service technicians need training on brushless DC motor for sustainable practices in maintenance and repairs of electric vehicles	300	4.07	.950	Agree
5	Automotive service technicians need training on induction motor for sustainable practices in maintenance and repairs of electric vehicles	300	4.02	.970	Agree
6	Automotive service technicians need training on switched reluctance motor for sustainable practices in maintenance and repairs of electric vehicles	300	4.10	.934	Agree
7	Automotive service technicians need training on power inverter for sustainable practices in maintenance and repairs of electric vehicles.	300	4.17	.836	Agree
8	Automotive service technicians need training on power electronics for sustainable practices in maintenance and repairs of electric vehicles	300	3.99	.001	Agree
9	Automotive service technicians need no any training on sustainable practices in maintenance and repairs of electric vehicles.	300	4.00	.061	Agree
10	Automotive service technicians need training on Electric Power Control Unit (EPCU) for sustainable practices in maintenance and repairs of electric vehicles	300	3.94	.918	Agree
	Grand Mean		**4.04**	**.476**	**Agree**

The analysis of variance results presented in Table 4 shows that there was no statistically significant difference in the mean responses of automotive service technicians from government institutions, agencies, and private workshops regarding their training needs in transmission systems for sustainable maintenance and repair of electric vehicles in Abuja, Nigeria $F(2, 355) = 1.200$, $p = .302$. Consequently, Hypothesis 2 is accepted. This finding indicates that automotive service technicians across government institutions, agencies, and private workshops in Abuja collectively agree on the need for training in drivetrain components, inverters, gearboxes, regenerative braking mechanisms, various types of electric motors (brushless DC, induction, switched reluctance), power inverters, power electronics, and Electric Power Control Units (EPCUs) to support sustainable maintenance and repair practices for electric vehicles.

Table 4: One-way analysis of variance on the mean differences on training needs for transmission systems among automotive service technicians in government institutions, agencies, and private workshops for sustainable maintenance and repair of electric vehicles in Abuja, Nigeria.

	Sum of Squares	df	Mean Square	f	Sig.
Between Groups	1.208	2	.604	1.200	.302
Within Groups	178.620	355	.503		
Total	179.828	357			

5. Discussion

The findings from research question one, supported by the corresponding null hypothesis test, revealed that automotive service technicians from government institutions, agencies, and private workshops unanimously agree on the need for training in diagnosing battery charging faults, battery replacement, high voltage safety procedures, circuit diagnostics with tools, onboard charging equipment, software updates for driver assistance systems, electric drive components, electrical measurement, and electrical wiring to enhance their maintenance and repair skills for electric vehicles. This conclusion is further reinforced by the results of Hypothesis 1, which showed no statistically significant difference in the mean responses of automotive service technicians across these sectors regarding their training needs in electrical systems for sustainable practices in the maintenance and repair of electric vehicles in Abuja, Nigeria. These findings align with previous research, such as the study by Nardo et al. (2021), which emphasizes the growing complexity of EV systems and the corresponding need for advanced diagnostic skills and specialized training in battery management, high voltage safety, and circuit diagnostics. As EV technology evolves, technicians must stay updated with the latest tools and techniques to ensure effective maintenance and repair practices. The results also concur with Smith et al. (2023), who underscore the importance of continuous professional development for automotive technicians, particularly in the context of new and emerging technologies. Their study found that technicians who receive regular training in areas such as software updates, electric drive components, and electrical wiring are better equipped to address the unique challenges posed by EVs. The authors argue that such training is essential for maintaining the safety and efficiency of EVs, thereby supporting sustainable practices in the automotive industry.

The results from research question two, along with the test of its corresponding hypothesis, revealed that automotive service technicians from government institutions, agencies, and private workshops agree on the need for training in drivetrain components, inverters, gearboxes, regenerative braking mechanisms, various electric motors (such as brushless DC, induction, and switched reluctance), power inverters, power electronics, and Electric Power Control Units (EPCUs) to support sustainable maintenance and repair practices for electric vehicles. Additionally, the analysis showed no statistically significant difference in the mean responses of these technicians across the different sectors regarding their training needs in transmission systems for sustainable maintenance and repair of electric vehicles in Abuja, Nigeria. These findings are consistent with broader research on electric vehicles, including studies by Vasiljevic et al (2023), which highlight the increasing complexity of EV drivetrain systems. This includes critical components such as inverters, gearboxes, and various types of electric motors. Jones et al. emphasize that specialized training is essential for technicians to effectively diagnose and repair these advanced components, ensuring the sustainability and efficiency of EV operations. The authors argue that without such training, technicians may face challenges in maintaining the performance and reliability of EVs, thereby hindering the adoption of sustainable transportation solutions. Similarly, research by Khan et al. (2017) underscores the importance of training in power electronics and EPCUs, which are crucial for the efficient functioning of EVs. Their study found that technicians who receive training in these areas are better prepared to manage the unique challenges posed by EV technologies, including regenerative braking mechanisms and power inverters. Miller and Thompson stress that as EV technology continues to evolve, ongoing education and skill development are vital for technicians to keep pace with technological advancements and ensure sustainable maintenance practices.

6. Conclusion

This study has systematically addressed the training needs of automotive service technicians in Abuja, Nigeria, focusing on sustainable practices in electric vehicle maintenance and repair. The research identified unanimous agreement among technicians from government institutions, agencies, and private workshops on the critical necessity for comprehensive training in areas such electrical systems and transmission systems. Importantly, the findings highlight the absence of significant differences in training needs across different sectors. This study represents a pioneering effort in assessing these training requirements in Abuja, Nigeria, highlighting the importance of providing educational programs to enhance the capabilities of technicians in supporting the sustainable development of electric vehicle technology.

6.1 Recommendations

1. The Federal Government should design and implement specialized training programs tailored to the specific needs identified in the study, such as battery chemistry, drivetrain components, cooling systems, and advanced diagnostic tools. These programs should be both comprehensive and practical, combining theoretical knowledge with hands-on experience.
2. The Federal Government should encourage partnerships between government agencies, educational institutions, private workshops, and industry stakeholders to strengthen training initiatives. Such collaboration can provide access to resources, expertise, and cutting-edge technologies essential for effective training in electric vehicle maintenance and repair.

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