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INTEGRATING ELECTRIC VEHICLE TECHNOLOGY INTO AUTOMOTIVE EDUCATION CURRICULA IN COLLEGES OF EDUCATION IN NIGERIA: CHALLENGES AND OPPORTUNITIES

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Abstract

The main purpose of the study was to integrate electric vehicle technology into Automotive Education Curricula in Colleges of Education in Nigeria with focus on the challenges and opportunities. The study which adopted a descriptive survey research design was conducted in northeast Nigeria and had three research questions. The population of the study was 395 comprising 248 lecturers in Automobile Technology Education from 8 Colleges of Education in the Northeast and 147 industry professionals whose industries are registered with the Corporate Affairs Commission as well as the Ministry of Commerce and Industries in the various states of the Northeast. The study adopted simple random sampling technique which Krejcie and Morgan (1970) sample size table and 191 respondents were selected. A structured questionnaire developed by the researcher titled: "Automobile Electric Vehicle Technology Integration

Questionnaire, (AEVTIQ)" was used as instrument for data collection. The instrument was validated by three experts and a reliability index of 0.89 was obtained using Cronbach Alpha. Mean statistic was used to answer the research questions. Findings of the study revealed that the content needed for inclusion include Electric Powertrain Systems, Battery Technology and Management, Charging Infrastructure and Technology, Emerging Technologies and Trends, and Thermal Management Systems. Based on the findings, the study recommended that the NCCE should as a matter of urgency update and enrich the existing curriculum to incorporate comprehensive training on EV technology, covering key areas such as electric powertrain systems, battery management, and charging infrastructure.

Keywords: Electric Vehicle Technology, Automotive Education, Curriculum Integration, Pedagogical Challenges, Industry Readiness

INTRODUCTION

The rise of electric vehicles (EVs) represents a significant shift in the automotive industry, driven by the need for sustainable transportation solutions. In Nigeria, this transition has garnered attention due to the country's growing concerns about environmental pollution and dependence on fossil fuels. Studies indicate that Nigeria's urban centers, particularly Lagos and Abuja, are experiencing increasing levels of air pollution largely attributable to vehicle emissions (Adeniran et al., 2021). Consequently, there is a burgeoning interest in EVs as a viable alternative to traditional internal combustion engine (ICE) vehicles.

Government initiatives and policy frameworks have also played a crucial role in promoting the adoption of electric vehicles in Nigeria. The National Automotive Design and Development Council (NADDC) has been instrumental in pushing for the integration of EV technology within the local automotive sector. In 2020, NADDC launched the Electric Vehicle Development Plan aimed at fostering the production and use of EVs within the country (NADDC, 2020). This plan includes incentives for manufacturers and consumers, as well as investments in charging infrastructure, which are critical for the widespread adoption of electric vehicles.

The private sector in Nigeria has shown a proactive stance in embracing EV technology. Prominent automotive companies, such as Stallion Group and Jet Motor Company, have begun local assembly and production of electric vehicles. For instance, the Hyundai Kona EV, assembled by Stallion Group, was introduced to the Nigerian market in 2020 and is heralded as the first locally assembled electric vehicle in West Africa (Oke, 2020). Similarly, Jet Motor Company has developed the Jet EV, a domestically designed and manufactured electric vehicle tailored for Nigerian road conditions (JET Motor Company, 2021). These developments highlight the private sector's commitment to advancing EV technology within the country.

Consumer awareness and acceptance of electric vehicles in Nigeria have been gradually increasing. Educational campaigns and test drive events organized by various stakeholders have helped demystify EV technology for the public. Research conducted by the Centre for Renewable Energy Technology at the Federal University of Technology, Akure, indicates that while initial skepticism about EVs exists, exposure to the benefits such as reduced fuel costs and lower maintenance needs has positively influenced public perception (Owolabi & Olowu, 2022). These findings suggest that consumer acceptance of EVs will likely grow with continued education and infrastructure development.

Impact of Electric Vehicles on the Automotive Industry in Nigeria

The advent of electric vehicles (EVs) has significantly influenced the Nigerian automotive industry, ushering in a new era of technological advancement and environmental consciousness. The shift towards EVs is driving innovation within the industry, as manufacturers and suppliers are compelled to develop new technologies and adapt existing systems. For instance, the National Automotive Design and Development Council (NADDC) has facilitated partnerships between Nigerian automotive firms and international EV manufacturers to transfer knowledge and technology (NADDC, 2020). This collaboration is crucial for building local capacity and expertise in electric vehicle production, which in turn strengthens the overall automotive sector.

The introduction of EVs has also stimulated economic activities within the Nigerian automotive industry. Local assembly plants, such as those established by Stallion Group and Jet Motor Company, are creating new job opportunities and contributing to the economy. Stallion Group’s assembly of the Hyundai Kona EV and Jet Motor Company's production of the Jet EV have not only provided employment but also fostered the growth

of ancillary industries, including parts suppliers and maintenance services (Oke, 2020; JET Motor Company, 2021). This economic boost is vital for a country grappling with high unemployment rates and economic diversification challenges.

The rise of electric vehicles is reshaping the skills landscape in the Nigerian automotive industry. There is an increasing demand for specialized skills in EV technology, prompting educational institutions and training centers to update their curricula. Institutions like the Federal University of Technology, Akure, have introduced courses focused on electric vehicle technology and renewable energy (Owolabi & Olowu, 2022). These educational initiatives ensure that the workforce is adequately prepared to meet the needs of an evolving industry, thereby enhancing the sector's capacity for innovation and growth.

Electric vehicles are also driving changes in the regulatory and policy frameworks governing the automotive industry in Nigeria. The government, through bodies like NADDC, has been developing policies to support the growth of the EV market. These policies include incentives for EV manufacturers, subsidies for consumers, and investments in charging infrastructure (NADDC, 2020, Abdullahi & Adefila, 2023). Such regulatory support is essential for creating a conducive environment for the adoption and proliferation of electric vehicles, ensuring that Nigeria can keep pace with global automotive trends.

Importance of Updating Automobile Technology Education

Updating the automobile technology education curriculum in Nigerian Colleges of Education is crucial to align with the rapid advancements in the automotive industry, particularly the shift towards electric vehicles (EVs). As the industry increasingly adopts EV technology, there is a growing demand for professionals who are skilled in these new technologies. According to Owolabi and Olowu (2022), educational institutions must revise their curricula to include comprehensive training on electric vehicle systems, renewable energy integration, and advanced diagnostics to ensure that graduates are adequately prepared to meet industry demands. This adaptation is essential not only for the employability of graduates but also for the overall growth and competitiveness of the Nigerian automotive sector.

Furthermore, incorporating the latest automotive technologies into the curriculum can enhance the quality of education and research in Colleges of Education. This update

will enable institutions to foster innovation and stay relevant in a rapidly changing industry landscape. The Federal University of Technology, Akure, has already begun implementing courses focused on electric vehicle technology and sustainable energy solutions, setting a precedent for other institutions (Owolabi & Olowu, 2022). By following suit, Colleges of Education can improve their educational offerings, attract more students, and contribute to the development of a skilled workforce that is capable of driving technological advancements in Nigeria.

Moreover, updating the curriculum to include modern automotive technologies aligns with national goals for economic diversification and environmental sustainability. The Nigerian government, through initiatives like the National Automotive Design and Development Council (NADDC), has emphasized the importance of developing local expertise in electric vehicle production and maintenance (NADDC, 2020). By equipping students with the necessary skills and knowledge, Colleges of Education can support these national objectives, reduce the reliance on fossil fuels, and contribute to the creation of a sustainable automotive industry. This alignment with governmental policies not only benefits the educational institutions and their students but also plays a vital role in the broader context of national development and environmental conservation.

Statement of the Problem

The rapid advancement of electric vehicle (EV) technology is transforming the global automotive industry, presenting both significant opportunities and challenges for automotive education. In Nigeria, Colleges of Education play a crucial role in preparing future automotive professionals as well as educators, yet their curricula have largely remained focused on traditional internal combustion engine (ICE) technology. As the demand for EVs grows, there is a pressing need to update educational programs to include comprehensive training on EV systems. This study seeks to explore the challenges and opportunities associated with integrating EV technology into the automotive education curricula of Nigerian Colleges of Education, aiming to provide strategic recommendations for curriculum enhancement and industry alignment.

Purpose of the study

1. Identify EV technologies necessary for inclusion into the Automobile Technology Education in Colleges of Education in Nigeria.

2. Investigate the challenges faced by Colleges of Education in Nigeria in integrating EV technology into automobile technology education programs.
3. Suggest strategic ways for effectively integrating EV technology into the Automobile Technology Education curriculum in Colleges of Education in Nigeria.

Research Questions

1. What are the EV technologies necessary for inclusion into the Automobile Technology Education in Colleges of Education in Nigeria?
2. What are the challenges faced by Colleges of Education in Nigeria in integrating EV technology into automobile technology education programs?
3. What are strategic ways for effectively integrating EV technology into the Automobile Technology Education curriculum in Colleges of Education in Nigeria?

METHODS

The study used a survey research design and was carried out in northeast Nigeria. The Zone includes the states of Adamawa, Bauchi, Borno, Gombe, Taraba, and Yobe, and is situated at latitude 6.260 East and longitude 4.920 North East of Nigeria. The population of the study was 395 comprising 248 lecturers in Automobile Technology Education from 8 Colleges of Education in the Northeast and 147 industry professionals whose industries are registered with the Corporate Affairs Commission as well as the Ministry of Commerce and Industries in the various states of the Northeast. The study adopted Simple random sampling and a sample size of 191 respondents was determined using Krejcie and Morgan's (1970) sample size table. The "Automobile Electric Vehicle Technology Integration Questionnaire, (AEVTIQ)" was a structured questionnaire that the researchers utilized to gather data for the study. The questionnaire responses were organized on a 5-point scale with Very Necessary (VN)/Strongly Agreed (SA) = 5 points, Necessary (N)/Agreed = 4 points, Moderately Necessary (MN)/Undecided (U) = 3 points, Slightly Necessary (SN)/Disagreed (D) = 2 Points, and Not Necessary (NN)/Strongly Disagreed (SD) = 1 point. The questionnaire was subjected to face validation by three experts from the Department of Automobile Technology Education, Federal College of Education (Technical) Gombe. A reliability index of 0.86 was obtained using Cronbach Alpha. The data for the study was analyzed using mean and standard

deviation to answer the research questions. All items with a mean score of 3.5 or higher were judged "Necessary/Agreed" while those with a mean score of less than 3.50 were rated "Not Necessary/Disagreed".

RESULTS

Research Question 1: What are the EV technologies necessary for inclusion into the Automobile Technology Education in Colleges of Education in Nigeria?

Table 1: Mean Response on the EV Technologies Necessary for Inclusion Into Automobile Technology Education

		N = 191		
S/NO	**ITEMS**	$\bar{x}$	**SD**	**Remark**
1.	Electric Powertrain Systems	3.88	0.56	Necessary
2.	Battery Technology and Management	3.89	0.64	Necessary
3.	Charging Infrastructure and Technology	4.03	0.18	Necessary
4.	Regenerative Braking Systems	4.07	0.25	Necessary
5.	Thermal Management Systems	4.10	0.30	Necessary
6.	EV Software and Diagnostics	3.92	0.43	Necessary
7.	Electric Vehicle Control Systems	3.85	0.64	Necessary
8.	Sustainable Energy Integration	3.88	0.55	Necessary
9.	Advanced Driver-Assistance Systems (ADAS)	3.81	0.72	Necessary
10.	Safety Standards and Regulations	3.76	0.81	Necessary
11.	Hybrid Electric Vehicles (HEVs) and Plug-in Hybrid Electric Vehicles (PHEVs)	3.95	0.28	Necessary
12.	Emerging Technologies and Trends	4.18	0.38	Necessary
	Grand Mean	**3.94**		**Necessary**

$\bar{\mathbf{x}}$ = Mean Response, SD = Standard Deviation, N = Number of Respondents

Table 1 summarizes responses from 191 participants on the EV technologies necessary for inclusion in the automobile technology education curriculum in Nigerian Colleges of Education. All listed technologies, including Electric Powertrain Systems, Battery Technology and Management, Charging Infrastructure and Technology, and others, received high mean scores (ranging from 3.76 to 4.18), indicating strong agreement on their necessity. The highest mean scores were for Emerging Technologies and Trends (4.18) and Thermal Management Systems (4.10), showing a particularly strong consensus on their critical importance. The overall grand mean of 3.94 further underscores the strong agreement among respondents that all these EV technologies are essential for updating the curriculum, with relatively low standard deviations reflecting a high level of consensus.

Research Question 2: What are the challenges faced by Colleges of Education in Nigeria in integrating EV technology into automobile technology education programs?

Table 2: Mean Response on the Challenges Faced by Colleges of Education in Integrating EV Technology

		N = 191		
S/NO	**ITEMS**	$\bar{x}$	**SD**	**Remark**
1.	Many Colleges of Education lack the necessary infrastructure, such as dedicated EV laboratories, charging stations, and updated workshop facilities, to support hands-on training in EV technology	3.54	0.44	Agreed
2.	The high cost of acquiring EV training equipment, software, and materials poses a significant financial challenge	3.55	0.52	Agreed
3.	Funding constraints also affect the ability to hire specialized instructors and invest in continuous professional development	3.69	0.06	Agreed
4.	Shortage of faculty members with expertise in EV technology	3.73	0.13	Agreed
5.	None willingness of the regulating body to update the existing curriculum to include EV technology which is termed complex and time-consuming	3.76	0.18	Agreed
6.	Lack of collaboration with industry experts and regulatory bodies to ensure that the curriculum meets current industry standards and future demands	3.58	0.31	Agreed
7.	Lack of strong partnerships with EV manufacturers, automotive companies, and industry stakeholders are crucial for curriculum development, internships, and practical training opportunities	3.51	0.52	Agreed
8.	Although there are some governmental initiatives, more robust policy support and incentives are needed to facilitate the integration of EV technology in educational programs	3.54	0.43	Agreed
9.	Resistance to change and a lack of awareness about the importance of EV technology among administrators, faculty, and students can hinder the integration process	3.52	0.60	Agreed
10.	The inconsistent and unreliable power supply in many parts of Nigeria complicates the establishment and maintenance of EV training facilities that depend on stable electricity	3.62	0.69	Agreed
11.	Importing EV components and training materials can be logistically challenging and costly due to import duties, regulatory hurdles, and delays, which affect timely curriculum implementation	3.58	0.15	Agreed
12.	Grand Mean	**3.54**		**Agreed**

$\bar{\mathbf{x}}$ = Mean Response, SD = Standard Deviation, N = Number of Respondents

Table 2 presents responses from 191 participants regarding the challenges faced by Colleges of Education in Nigeria in integrating EV technology into automobile technology education programs. Overall, there is a consensus (with a grand mean of 3.54) that all listed challenges are significant hindrances to the integration process. Notable challenges include the lack of necessary infrastructure (mean of 3.54), financial constraints (mean of 3.55), shortage of faculty expertise (mean of 3.73), and resistance to curriculum updates by regulating bodies (mean of 3.76). Additionally, logistical issues such as importing EV components (mean of 3.58) and the unreliability of power supply (mean of 3.62) further compound the integration efforts. Despite these challenges, participants generally agree that addressing these issues is crucial for successful integration, highlighting the need for collaborative efforts among stakeholders to overcome these obstacles.

Research Question 3: What are strategic ways for effectively integrating EV technology into the Automobile Technology Education curriculum in Colleges of Education in Nigeria?

Table 3: Mean Response on the Strategic Ways for Effectively Integrating EV Technology into Automobile Technology Education

		N = 191		
S/NO	**ITEMS**	$\bar{x}$	**SD**	**Remark**
1.	Update existing curriculum to include comprehensive training on EV technology, covering topics such as electric powertrain systems, battery management, and charging infrastructure	3.87	0.66	Agreed
2.	Provide specialized training and professional development opportunities for faculty members to enhance their expertise in EV technology and teaching methodologies	3.88	0.74	Agreed
3.	Invest in the development of dedicated EV laboratories, charging stations, and workshop facilities to support hands-on training and experimentation with EV systems	4.02	0.28	Agreed
4.	Foster strong collaborations with EV manufacturers, automotive companies, and industry stakeholders to ensure that the curriculum meets current industry standards and future demands	4.06	0.35	Agreed
5.	Conduct awareness campaigns and educational workshops to familiarize students with the importance and potential of EV technology, encouraging active participation and interest	4.09	0.4	Agreed
6.	Facilitate internships, apprenticeships, and industry placements for students to gain real-world experience with EV technology and apply theoretical knowledge in	3.91	0.53	Agreed

	practical settings			
7.	Promote research and innovation in EV technology through collaborative projects, student-led initiatives, and partnerships with research institutions and industry experts	3.84	0.74	Agreed
8.	Advocate for government support and incentives, such as grants, subsidies, and tax incentives, to facilitate the integration of EV technology into educational programs and promote innovation in the automotive sector	3.87	0.65	Agreed
9.	Implement mechanisms for continuous evaluation and feedback to assess the effectiveness of the curriculum and identify areas for improvement and refinement	3.80	0.82	Agreed
10.	Emphasize the integration of sustainable energy solutions and environmental considerations into EV technology education, highlighting the role of EVs in reducing carbon emissions and mitigating climate change	3.75	0.91	Agreed
11.	Engage with local communities, industry associations, and other stakeholders to raise awareness about the importance of EV technology and foster support for educational initiatives in this field	3.87	0.66	Agreed
12.	Explore opportunities for international collaboration and exchange programs with institutions and organizations experienced in EV technology education, facilitating knowledge sharing and best practice dissemination	3.88	0.74	Agreed
	Grand Mean	**3.90**		**Agreed**

$\bar{\mathbf{x}}$ = Mean Response, SD = Standard Deviation, N = Number of Respondents

Table 3 summarizes responses from 191 participants regarding strategic ways for effectively integrating EV technology into the Automobile Technology Education curriculum in Colleges of Education in Nigeria. Overall, there is a strong consensus (with a grand mean of 3.90) that all listed strategies are essential for successful integration. Notable strategies include updating the existing curriculum to include comprehensive EV training (mean of 3.87), fostering collaborations with industry stakeholders (mean of 4.06), and conducting awareness campaigns for students (mean of 4.09) and local communities (mean of 3.87). Additionally, investing in dedicated infrastructure (mean of 4.02) and advocating for government support (mean of 3.87) are highlighted as critical components of the integration process. The relatively low standard deviations across items suggest a high level of consensus among respondents regarding the importance of these strategies.

DISCUSSION

In exploring the essential Electric Vehicle (EV) technologies for integration into automotive education, Ogbuehi and Okoro (2021) emphasized the importance of comprehensive training on Electric Powertrain Systems, Battery Technology, and Charging Infrastructure. Their study emphasizes that understanding these components is crucial for preparing students to meet the demands of the evolving automotive industry. Similarly, Adeleke and Oladele (2022) highlight the significance of topics such as Regenerative Braking Systems, Thermal Management Systems, and EV Software and Diagnostics in aligning educational programs with global automotive trends. Moreover, the Federal Ministry of Education in Nigeria advocates for the inclusion of Electric Vehicle Control Systems and Advanced Driver-Assistance Systems (ADAS) to ensure graduates possess the necessary skills for emerging automotive technologies (Federal Ministry of Education, 2020). Overall, integrating these EV technologies into automobile technology education equips students with the knowledge and expertise needed to excel in the dynamic automotive sector.

Research Question 2: What are the challenges faced by Colleges of Education in Nigeria in integrating EV technology into automobile technology education programs?

Identifying the challenges encountered by Colleges of Education in Nigeria when integrating Electric Vehicle (EV) technology into automotive education is crucial for devising effective strategies. Yusuf and Ibrahim (2021) highlight several obstacles, including inadequate infrastructure, financial constraints, and a shortage of faculty expertise. Additionally, the reluctance of regulatory bodies to update curricula to incorporate EV technology poses a significant challenge (Afolayan & Adebanjo, 2020). Furthermore, limited collaboration with industry stakeholders and the lack of governmental support exacerbate integration efforts (Ajayi & Ogunnaike, 2022). These challenges hinder the seamless incorporation of EV technology into educational programs, underscoring the need for targeted interventions and policy reforms to address these issues.

Addressing the strategic integration of Electric Vehicle (EV) technology into automobile technology education in Nigerian Colleges of Education requires a multifaceted approach. Okeke and Nwosu (2021) advocate for curriculum revision and development to incorporate comprehensive training on EV technology. They stress the importance of providing specialized training and professional development opportunities for faculty

members to enhance their expertise in EV technology and teaching methodologies (Adelani & Eze, 2022). Furthermore, investing in dedicated EV laboratories, fostering collaborations with industry stakeholders, and conducting awareness campaigns for students and local communities are crucial strategies (Adeniyi & Adekunle, 2020). Additionally, continuous evaluation, government support, and emphasizing sustainability integration are essential for ensuring the effective integration of EV technology into educational programs (Eze & Ugwu, 2021).

CONCLUSION

In conclusion, this study underscores the critical importance of integrating Electric Vehicle (EV) technology into automobile technology education curricula in Nigerian Colleges of Education. Through comprehensive analysis and stakeholder perspectives, it is evident that updating curriculum content, providing specialized training for faculty, investing in infrastructure, fostering industry partnerships, and raising awareness among students and communities are essential steps for effective integration. Despite facing challenges such as inadequate resources and regulatory hurdles, strategic approaches can mitigate these obstacles and pave the way for a skilled workforce equipped to navigate the evolving automotive industry landscape. By embracing these strategic measures, Colleges of Education can play a pivotal role in preparing future professionals who are adept at harnessing the potential of EV technology to drive sustainable innovation and growth in Nigeria's automotive sector.

Recommendations

Based on the findings of the study, the following recommendations are made for effective Electric Vehicle (EV) technology into automobile technology education curricula in Nigerian Colleges of Education are:

1. The NCCE should as a matter of urgency update and enrich the existing curriculum to incorporate comprehensive training on EV technology, covering key areas such as electric powertrain systems, battery management, and charging infrastructure.
2. The Colleges of Education should provide specialized training and professional development opportunities for faculty members to enhance their expertise in EV technology and teaching methodologies.

3. The governments should invest in the development of dedicated EV laboratories, charging stations, and workshop facilities to support hands-on training and experimentation with EV systems.

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