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Preparing EV Technicians for the U.S.A Transition to Electric Vehicles through the Implementation of the Bipartisan Infrastructure Law

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Abstract

This study is the literature review for a Ph.D. dissertation focusing on the growing job opportunities in the electric vehicle industry. Ensure the high potential for high-salary jobs compared with the traditional automotive. Through the Bipartisan Infrastructure Law (BIL), the government in the United States is seeking to develop infrastructure for electric vehicles and create job opportunities. In addition, this study shows a high demand for electric vehicle technicians in the United States. The Zone of Proximal Development (ZPD) is one of the ways, especially for adults, to optimize the outcome of the training programs. Multiple training methods for electric vehicle technicians, such as a digital game base and augmented reality, provide an excellent learning method. The high cooperation between the government and education institutes will make the car industry provide more for economic growth.

Keywords

Electric Vehicle, Training Programs, NEVI Program, Zone of Proximal Development (ZPD), Adult Learning Theory, Bipartisan Infrastructure Law (BIL), Electric Vehicle Technicians

1. Introduction

The electric vehicle industry is experiencing rapid growth, presenting a wealth of opportunities for job creation across various sectors, such as charging station companies and IT companies specializing in developing software for electric vehicles. Therefore, the government should implement supportive policies for various emerging job opportunities within the electric vehicle industry. According to Dijk, Orsato and Kemp (2013), the future of electric mobility jobs would depend on several factors, including the development of new technologies, the availability of charging infrastructure, and government policies. To what extent does the electric vehicle industry create high-paying employment opportunities, and how does this compare to the traditional automotive sector? As a result, Walter, Higgins, Bhattacharyya, Wall and Cliffton's (2020) study highlights the potential for the U.S. auto manufacturing industry to spearhead the worldwide shift towards electric vehicles, emphasizing the capacity for job creation in the United States.

In addition, Hamilton's (2011) statement on the significant growth potential of employment opportunities within the electric vehicle industry is supported by the Bureau of Labor Statistics projection of a 20% increase in jobs in the sector over the next ten years. An example from Ohio state Ewing (2023) mentioned that the transition to electric cars creates new jobs in Ohio but displaces some workers. The new jobs in the electric car industry are typically higher pay than the jobs they are replacing.

Before embarking on training electric vehicle technicians, it is imperative to comprehensively analyze the current market demand for such professionals and the government's policies and initiatives to promote and incentivize training programs. Additionally, it is crucial to consider the unique challenges and opportunities that arise when training individuals. Technological advancements, industry regulations, and emerging trends must also be considered when designing an effective training curriculum. Moreover, a thorough examination of previous training methods used in this field can provide valuable insights into best practices and potential areas for improvement. By addressing these fundamental considerations, we can ensure that our training program meets the market's needs, prepares individuals for successful careers in this field, and contributes to the overall growth and development of the electric vehicle industry.

2. Methodology

In the United States, the government, represented by the White House, has initiated a law to promote the creation of well-paid jobs, including electric vehicle (EV) technician positions. This vision has motivated current and aspiring EV technicians who seek support from the government in terms of financial aid and educational assistance. However, to achieve the government's vision, educational institutions need to develop robust programs that cater to the needs of EV technicians, offering comprehensive training and capturing attention through innovative educational approaches. By satisfying the requirements of each component—government support, motivated technicians, and practical education programs—the nation can work towards realizing the White House's goal of creating a workforce of skilled and well-compensated EV technicians (**Figure 1**).

3. Governments and EV Technicians Training

The government's pivotal role in the shift from fossil fuel to electric vehicles is

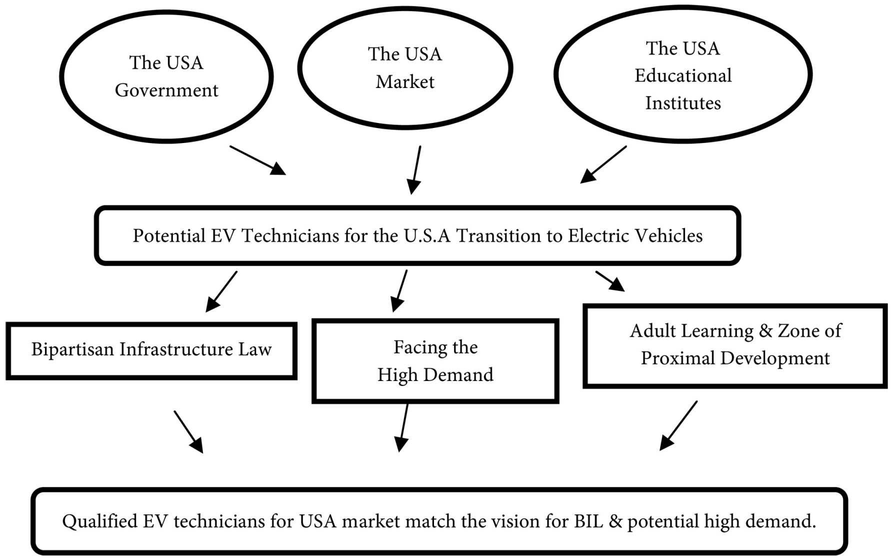

Figure 1. Prepare a qualified EV technicians for USA transition to electric vehicles.

crucial as it establishes necessary regulations and guidelines for all stakeholders involved. By formulating policies and strategies to facilitate this monumental transition, the government ensures the provision of infrastructure and funding. Furthermore, it fosters a collaborative environment for all stakeholders to effectively contribute toward a sustainable electric mobility future. Also, Chaturvedi, Nautiyal, Kandpal and Yaqoot (2022) state that government support is crucial in facilitating the widespread adoption of electric vehicles through financial backing and the development of necessary infrastructure. Despite the potential loss of government revenue from the absence of taxes on electric vehicle owners, implementing appropriate government policies ensures the successful EV transition. (Rajagopal, 2023) This study found that EV adoption has the potential to both diminish government revenue from fuel taxes and amplify reliance on energy imports. Thus, Bonilla, Soberon and Galarza (2022) found that the government should establish EV operational regulations, including charging infrastructure, in alignment with the Biden Administration's 2022 implementation of public EV procurement.

Bipartisan Infrastructure Law (BIL)

The Bipartisan Infrastructure Law aims to create high-paying job opportunities for American citizens by implementing state-level government policies and the National Electric Vehicle Infrastructure Program (NEVI) (House, 2021). Debnath, Bardhan, Reiner and Miller (2021) reports that electric vehicle adoption is a multifaceted process wherein the most significant catalysts in the United States are political, economic, and legal factors, while social and environmental factors, although noteworthy, exhibit comparatively lesser influence; hence, governmental interventions such as incentives, targets, and automotive industry regulations can substantially facilitate the promotion of electric vehicle adoption. For that, Yeh, Liao and Petrosky (2013) found that university-community college partnerships can strategically address the industry demands of advanced automotive technology, bridging the skills gap, cultivating a qualified workforce, and enhancing the educational experience for students at both institutions.

4. The Need for EV Technicians for the Market

With the increasing demand for comprehensive knowledge in electric vehicle maintenance, it is imperative to provide technicians with extensive training. This training should encompass a deep understanding of electric vehicle systems and components, allowing technicians to diagnose and resolve any issues that may arise effectively. Additionally, technicians must have strong customer service skills to support electric vehicle owners satisfactorily. Myers, Kenar and Hankins (2020) addresses that given the significance of these requirements, there is an apparent necessity for specialized training programs tailored specifically to individuals working on electric vehicles. Consequently, the proposed training program aims to fulfill this demand by ensuring that professionals in this field possess the appropriate qualifications to work on electric vehicles effectively.

The demand for electric vehicle technicians has surged recently, highlighting the urgent need for a larger workforce with specialized qualifications. Fechtner and Schmuelling (2016) emphasized the necessity for enhanced training programs that equip technicians with up-to-date knowledge and skills in the rapidly evolving electric vehicle technologies. Moreover, there is a growing requirement for comprehensive hands-on training to address the intricacies of repairing and maintaining electric vehicles. In addition, Turoń, Kubik and Chen (2021) mentioned that insufficient awareness among the younger generation regarding electric mobility necessitates comprehensive education facilitated through diverse and efficacious pedagogical approaches. Additionally, Fechtner, Ismail, Braun and Schmuelling (2017) states that the proposed specialized training program aims to adequately qualify individuals working on electric vehicles, addressing the critical need for competence in this field.

In addition, Fechtner, Fechtner and Schmuelling (2015) found a great need for training programs for professionals who work on electric vehicles. The current training programs for electric vehicles are primarily focused on academic education. Therefore, there is a need for training programs that are tailored to the needs of professionals with work experience. Furthermore, Brusaglino, Gava, Leon and Porcel (2013) found a need to train and develop European competencies in maintaining electric and hybrid vehicles. Also, the paper finds that the competency framework developed in this research is valuable for training and development.

Over the past two decades in the US, efforts have been made to enhance the skill set of market technicians to maintain hybrid and electric vehicles effectively. However, according to McDonald (2010), the existing engineering and technology education system needs to align with the multifaceted skill requirements of the electric vehicle industry's developmental demands. Likewise, Ebron (2012) states that existing training and education programs need to be revised, necessitating the development of a comprehensive curriculum encompassing all facets of advanced electric drive vehicles.

5. Education in EV Industry

5.1. Adult Learning

Drawing upon static data from 2020, it is evident that the United States boasts a substantial workforce of over 415,000 mechanics, with an average age of 42 years (ZIPPIA, 2022). Given their wealth of prior experience and ongoing employment, adopting an instructional approach rooted in adult learning theory is crucial to foster excitement and enhance their capacity to acquire new skills. Furthermore, according to Brookfield (1995), creating compelling and engaging learning environments for adult learners necessitates understanding the multifaceted nature of adult learning and the diverse ways in which it occurs.

The unprecedented challenges posed by 2022, particularly in education, presented a formidable obstacle for adults as they grappled with utilizing novel technologies to facilitate online teaching. In this study, Choudrie, Banerjee, Kotecha, Walambe, Karende and Ameta (2021) found that compared to younger adults, older adults demonstrate higher exposure to COVID-19 information and misinformation online and a greater inclination to trust traditional media over new media. In addition, adult learning has several critical factors that affect their motivation. So, Aljohani and Alajlan (2020) states that social contact, family togetherness, and religious stimulation are pivotal motivators for adult learners while emphasizing their greater inclination towards internal motivation over external factors.

5.2. Zone of Proximal Development in EV

The Zone of Proximal Development, as described by Billings and Walqui (2017), encompasses tasks that a learner can tackle independently, as well as those they can conquer with the assistance of an adult or by collaborating with more skilled peers. This concept highlights the importance of providing appropriate support and scaffolding to learners to facilitate their growth and progress. By identifying and targeting the zone within which learners can stretch their abilities, educators can optimize the learning experience and promote optimal development.

Nevertheless, can ZPD improve the electric vehicle technicians' training? Smith, Doe and Jones (2023) found that Electric vehicle technicians who received training tailored to their individual needs were more likely to be satisfied with their training. Also, feedback during training was more likely to retain the information they learned. In addition, Smith, John and Brown (2022) found that the ZPD is a promising approach to improving electric vehicle technician training outcomes, and learners who received training tailored to their ZPDs performed better on a post-training assessment than learners who received traditional training.

Several factors, including individual knowledge, will impact electric vehicle technician training. (Smith, Doe, & Jones, 2023) The Zone of Proximal Development (ZPD) is an intricate and ever-evolving process shaped by factors such as the individual's pre-existing knowledge, the nature of the task, and the surrounding social context. Consequently, leveraging the ZPD facilitates practical skill training across diverse domains.

6. What Will Affect the EV Technicians Training?

The need to develop an educational system for technicians who desire to learn to maintain electric vehicles was not a modern concept. On the contrary, it was in 2010 with the spread of hybrid vehicles at that time. Therefore, Gover, Thompson and Hoff (2010) reports that the HEV technicians' Training is crucial to customize the educational programs to address the unique requirements and skill sets of automotive technicians within the industry. In addition, this targeted approach ensures that the Training effectively enhances their capabilities and expertise in the field. For example, from Slovakia, Huba and Ferencey (2015) addresses the need for EV education to prepare highly qualified EV instructors.

The training quality in the Electric Vehicle (EV) technician field will be profoundly impacted by the cost associated with Training. Therefore, a comprehensive understanding of the cost implications is crucial for ensuring optimal training outcomes in this domain. For example, Fechtner, Ismail, Braun and Schmuelling (2017) found that Training for electric vehicles can be expensive because electric vehicles are more complex than traditional vehicles and require specialized Training. In addition, Fechtner, Ismail, Braun and Schmuelling (2017) found that the quality of Training for electric vehicles can vary because there is no standard curriculum for electric vehicles, and the quality of Training can depend on the training provider. For any current time, Fayziyev, Ikromov, Abduraximov and Dehqonov (2022) presents the picture of the current reality that the technological processes for the maintenance and repair of electric vehicles are still in their early stages of development. In addition, several challenges must be addressed to improve these processes' organization.

7. The Previous Training Methods for EV Technicians around the World and the US

Manufacturing companies for electric vehicles provide electric vehicle training technicians for the employees to satisfy their customers with their services and follow the market demand. DAF Trucks is well-positioned to support its customers as they adopt electric vehicles. The company has a strong network of technicians who are trained in the specific needs of electric vehicles (Point, 2021). Additionally, DAF Trucks is investing in new tooling and charging infrastructure to support the growing demand for electric vehicles.

Training begins with diagnosing faults, the first step in vehicle maintenance.

Diagnosing faults requires training since electric vehicles' components differ from those of internal combustion vehicles. Zhang and Guo (2022) found a design for a training platform for pure electric vehicle fault diagnosis, Developing of a fault diagnosis system for pure electric vehicles. This difference is due to the difference in the main components between electric vehicles and vehicles that operate on internal combustion. Also, Tang, Tang, Kusumadi and Chuan (2013) report that a remote telemetry and diagnostic system can be developed for electric vehicles and supply equipment, providing valuable benefits for E.V. users and technicians. This system enables remote monitoring and troubleshooting of electric vehicles and associated charging infrastructure, enhancing efficiency and convenience in maintenance and support.

Since hybrid electric vehicles (HEV), researchers are trying to develop an educational system like small-scale hybrid electric vehicles (HEV). For example, Fajri, Lotfi, Ferdowsi and Landers (2016) found that the educational small-scale HEV setup effectively teaches students and engineers about hybrid electric vehicles. In addition, the setup is easy to use and provides a hands-on learning experience. Moreover, Brusaglino, Gava, Leon and Porcel (2013) found that the pilot training program developed in this research effectively develops the competencies required to maintain electric and hybrid vehicles.

Digital Game-Based Learning is one of the methods that have been used to train electric vehicle technicians. Proulx, Romero and Arnab (2016) reports that the most effective learning mechanics and game mechanics for fostering motivation are those that are aligned with the four basic psychological needs of autonomy, competence, relatedness, and meaningfulness. The use of learning mechanics and game mechanics can be tailored to the individual needs of learners. Another method for electric vehicle education is the 3D Motion Controller. Kim and Lee (2020) found that in their study, the students who used the content reported enjoying learning about electric vehicles using the 3D motion controller.

Augmented Reality is one of the tools used to train technicians before. Rymer, Damiano, McCombs and Torre (2018) found that A.R. technologies can be used to improve the training of automotive technicians so the technicians can locate parts more quickly and accurately than when using the non-augmented computer-based manual. Also, digital twin technology and V.R. can be used to develop electric vehicle maintenance education ability. Lee and Jung (2020) state that digital twin technology and VR can create realistic and immersive maintenance training environments. As a result, VR-based maintenance training programs can effectively teach E.V. technicians how to perform basic maintenance tasks.

Finally, the Problem- and Project-Based Learning (PPBL) method enhances engineering students' learning in electric vehicles. Gonzalez-Rubio, Khoumsi, Dubois and Trovao (2016) reports that from PPBL, they develop a deeper understanding of engineering principles, apply their knowledge to solve real-world problems, develop critical thinking and problem-solving skills, work effectively in teams, and communicate with others.

8. Conclusion

The electric vehicle (EV) industry presents significant opportunities for high-paying employment and job creation, particularly in comparison to the traditional automotive sector. The transition to electric vehicles is fueled by technological advancements, the availability of charging infrastructure, and supportive government policies. Governments play a crucial role in facilitating this transition by formulating regulations, funding, and incentives. To meet the demands of the growing market, comprehensive training programs for EV technicians are essential. The training should encompass a deep understanding of EV systems, hands-on experience, and strong customer service skills. Adult learning principles are vital for effective training outcomes. The Zone of Proximal Development (ZPD) can be leveraged to tailor training to individuals' needs, improving satisfaction and performance. Various training methods, including digital game-based learning, augmented reality, and problem-based learning, have been employed to enhance the training experience for EV technicians. By addressing the market demands and government policies and employing practical training approaches, the EV industry can continue flourishing, contributing to sustainable mobility and economic growth.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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