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Skills gap in the automotive industry: a technical and evolutionary analysis of professional training and contemporary technological demands

Gap de competências na indústria automotiva: uma análise técnica e evolutiva entre a formação profissional e as demandas tecnológicas contemporâneas

Brecha de competencias en la industria automotriz: un análisis técnico y evolutivo entre la formación profesional y las demandas tecnológicas contemporáneas

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Abstract:
The contemporary automotive industry is undergoing an accelerated process of technological transformation, characterized by the growing integration of embedded electronic systems, vehicle communication networks, control software, and electrification solutions. In this context, there is a significant mismatch between traditional technical education and the competencies required for professional work in highly digitalized environments, a phenomenon known as the "skills gap." This article aims to analyze this gap in the automotive industry from a technical and evolutionary perspective, emphasizing electronic diagnostics in Chevrolet dealerships. The methodology is based on qualitative analysis, technical review, and practical observation in an automotive diagnostic environment. The study discusses historical aspects of vehicle technology development, the complexity of current systems, the limitations of professional education, and the operational impacts arising from this mismatch. It also proposes guidelines for curriculum restructuring and continuous competency development, considering future trends such as connected vehicles and artificial intelligence. It concludes that adapting technical education is essential to ensure efficiency, diagnostic accuracy, and sustainability in the automotive sector.

Keywords:
Automotive industry; Electronic diagnostics; Technical education; Embedded systems; Professional competencies.

Resumo:
A indústria automotiva contemporânea atravessa um processo de transformação tecnológica acelerada, caracterizado pela crescente integração de sistemas eletrônicos embarcados, redes de comunicação veicular, softwares de controle e soluções de eletrificação. Nesse cenário, observa-se um descompasso significativo entre a formação técnica tradicional e as competências exigidas para atuação profissional em ambientes altamente digitalizados, fenômeno denominado "gap de competências". O presente artigo tem como objetivo analisar, sob uma perspectiva técnica e evolutiva, essa lacuna no contexto da indústria automotiva, com ênfase na prática de diagnóstico eletrônico em concessionárias da marca Chevrolet. A metodologia adotada baseia-se em análise qualitativa, revisão técnica e observação prática em ambiente de diagnóstico automotivo. São discutidos aspectos históricos da evolução tecnológica dos veículos, a complexidade dos sistemas atuais, as limitações da formação profissional e os impactos operacionais decorrentes dessa defasagem. O estudo também propõe diretrizes para reestruturação curricular e desenvolvimento contínuo de competências, considerando tendências futuras como veículos conectados e inteligência artificial. Conclui-se que a adaptação da formação técnica é essencial para garantir eficiência, precisão diagnóstica e sustentabilidade no setor automotivo.

Palavras-chave:
Indústria automotiva; Diagnóstico eletrônico; Formação técnica; Sistemas embarcados; Competências profissionais.

Resumen:
La industria automotriz contemporánea atraviesa un proceso de transformación tecnológica acelerada, caracterizado por la creciente integración de sistemas electrónicos embarcados, redes de comunicación vehicular, software de control y soluciones de electrificación. En este escenario, se observa un desajuste significativo entre la formación técnica tradicional y las competencias requeridas para el desempeño profesional en entornos altamente digitalizados, fenómeno denominado “brecha de competencias”. El presente artículo tiene como objetivo analizar, desde una perspectiva técnica y evolutiva, esta brecha en el contexto de la industria automotriz, con énfasis en la práctica del diagnóstico electrónico en concesionarios de la marca Chevrolet. La metodología adoptada se basa en el análisis cualitativo, la revisión técnica y la observación práctica en un entorno de diagnóstico automotriz. Se discuten aspectos históricos de la evolución tecnológica de los vehículos, la complejidad de los sistemas actuales, las limitaciones de la formación profesional y los impactos operativos derivados de este desfase. El estudio también propone directrices para la reestructuración curricular y el desarrollo continuo de competencias, considerando tendencias futuras como los vehículos conectados y la inteligencia artificial. Se concluye que la adaptación de la formación técnica es esencial para garantizar la eficiencia, la precisión diagnóstica y la sostenibilidad en el sector automotriz.

Palabras clave:
Industria automotriz; Diagnóstico electrónico; Formación técnica; Sistemas embarcados; Competencias profesionales.

1. Introduction

Over the past decades, the automotive industry has undergone a structural transformation driven by the convergence of mechanical engineering, electronics, and information technology. The modern vehicle is no longer a predominantly mechanical system; it has become a complex cyber-physical platform composed of multiple interconnected electronic modules managed by software.

In this context, professional work in automotive maintenance and diagnostics has come to require a significantly broader and more multidisciplinary set of competencies. However, in many cases, traditional technical education has not kept pace with this technological development, resulting in a mismatch between acquired knowledge and market requirements.

This article aims to analyze this skills gap from a technical and evolutionary perspective, based on practical experience with automotive diagnostics in Chevrolet dealerships and focusing on embedded electronic systems, control modules, and digital diagnostic tools.

The relevance of the topic is directly associated with the need to ensure accurate diagnoses, operational efficiency, and vehicle safety in a scenario of increasing technological complexity.

2. Theoretical framework

2.1 Historical development of automotive technology

The technological development of vehicles can be divided into three major phases: mechanical, electromechanical, and electronic/digital. In the mechanical phase, predominant until the mid-twentieth century, automotive systems consisted essentially of physical components whose operation was based on mechanical and hydraulic principles.

Beginning in the 1980s, the transition to electromechanical systems started with the introduction of electronically controlled sensors and actuators. Electronic fuel injection was one of the first systems to incorporate control modules, marking the beginning of automotive digitalization.

In the 1990s, the standardization of the OBD (On-Board Diagnostics) system enabled continuous fault monitoring and the reading of diagnostic codes. This advance represented a milestone in the development of maintenance processes.

With technological progress, manufacturers such as General Motors began developing more complex electronic architectures based on multiplexed communication networks, such as CAN (Controller Area Network), enabling integration among various control modules.

2.2 Electronic architecture and embedded systems

Modern vehicles consist of a network of electronic control units (ECUs) responsible for managing critical functions such as engine and transmission control, safety systems, comfort, and infotainment.

These modules communicate through digital protocols, forming a distributed architecture. Communication over the CAN network, for example, enables real-time data exchange among different systems, increasing efficiency and reducing the need for physical wiring.

Furthermore, the introduction of advanced driver-assistance systems (ADAS) has added a new layer of complexity involving high-precision sensors, such as radars, cameras, and ultrasonic sensors, which require specific calibration and diagnostics.

2.3 Diagnostic tools and automotive software

Automotive diagnostics has developed significantly through the use of digital tools. Chevrolet dealerships use platforms such as GDS2 (Global Diagnostic System 2) and Techline Connect, which provide full access to vehicle systems.

These tools enable the reading of diagnostic trouble codes (DTCs), real-time parameter analysis, active testing, and electronic module reprogramming. However, their effective use requires in-depth technical knowledge and logical interpretation skills.

3. Methodology

This study adopts a qualitative approach based on technical review and practical analysis of the automotive diagnostic process. The methodology includes direct observation in a dealership environment, analysis of technical procedures, and critical reflection on professional education.

Practical experience as a diagnostic technician at a Chevrolet dealership enables a contextualized analysis of the sector's actual demands, contributing to the identification of existing competency gaps.

4. Analysis and discussion

4.1 Characterization of the skills gap

The skills gap in the automotive industry refers to the difference between the abilities required for the effective performance of technical activities and those actually developed during professional education.

This mismatch is particularly evident in areas related to embedded electronics, communication networks, and software-based diagnostics. Many professionals enter the market with limited knowledge of these aspects, which compromises their ability to perform their work.

4.2 Operational impacts

The lack of technical competencies directly affects the quality of services provided. Inaccurate diagnoses can lead to unnecessary component replacement, longer repair times, and customer dissatisfaction.

In addition, the complexity of current systems requires precision in performing procedures such as software updates and sensor calibration. Errors in these processes may compromise vehicle operation and create safety risks.

4.3 Limitations of traditional technical education

Traditional technical education is still, in many cases, based on pedagogical models centered on mechanical systems, with little emphasis on digital technologies. The absence of up-to-date content and the lack of adequate infrastructure hinder the development of essential competencies.

Another relevant factor is the limited integration between educational institutions and industry, which prevents curricula from being continuously updated and adapted to actual market demands.

4.4 Proposals for curriculum restructuring

To reduce the skills gap in the automotive industry, it is essential to promote curriculum restructuring that includes up-to-date content aligned with the sector's emerging technological trends. In this context, incorporating subjects focused on advanced embedded electronics is indispensable, enabling professionals to understand the operation of electronic control modules and their interaction with sensors and actuators. Likewise, studying vehicle communication networks such as CAN, LIN, and automotive Ethernet becomes essential for analyzing the electronic architecture of modern vehicles.

Additionally, mastery of software-assisted diagnostic tools should be incorporated into technical education, enabling professionals to read and interpret real-time data and to perform functional tests and module reprogramming. At the same time, the development of competencies in basic programming and computational logic becomes indispensable,

considering that current automotive systems are heavily based on algorithms and digital control strategies.

Another relevant aspect concerns the inclusion of content related to advanced driver-assistance systems (ADAS), which demand specific knowledge for sensor calibration, diagnostics, and validation. Furthermore, the growing presence of hybrid and electric vehicles in the market requires the education of professionals capable of working with high-voltage systems, battery management, and power electronics.

Finally, it is essential to promote the integration of theory and practice through the use of simulators, real diagnostic tools, and access to technologically up-to-date vehicles. This approach consolidates technical knowledge and develops operational skills, contributing to the education of professionals who are better prepared for the requirements of the contemporary automotive industry.

4.5 Continuous professional development

Rapid technological development requires professionals to adopt an attitude of continuous learning. Participation in training, certification, and capacity-building programs offered by manufacturers such as General Motors is fundamental to maintaining technical currency.

Competency development should be understood as a continuous process extending throughout a professional career.

4.6 Future trends

The future of the automotive industry is strongly associated with connectivity, electrification, and artificial intelligence. Connected vehicles will be able to transmit data in real time, enabling remote diagnostics and predictive maintenance.

The use of data-analysis algorithms will make it possible to identify fault patterns and anticipate problems, requiring technicians to have analytical skills and the ability to interpret complex information.

5. Integration between industry and technical education institutions

Integration between the automotive industry and technical education institutions is one of the fundamental pillars for reducing the skills gap observed in the sector. Historically, professional education has taken place relatively separately from actual market demands, resulting in outdated curricula with little adherence to emerging technologies. In the current context, characterized by rapid technological innovation, this disconnection becomes even more critical.

Practical experience in Chevrolet dealerships shows that many newly trained professionals have significant difficulty interpreting electronic diagrams, using diagnostic tools, and understanding the operating logic of control modules. This deficiency results not only from the complexity of the systems but also from the absence of education aligned with the technological standards adopted by the industry.

In this regard, creating strategic partnerships among manufacturers, dealerships, and educational institutions is indispensable. General Motors, for example, has technical training programs that could be integrated into the academic environment, allowing students to access up-to-date content, real tools, and diagnostic methods used in the market. This rapprochement contributes to educating better-prepared professionals and reduces adaptation time in the workplace.

In addition, implementing dual-learning programs, in which students alternate between theoretical education and practical experience in an industrial environment, may represent an effective solution. This model enables the simultaneous development of technical and behavioral competencies, promoting more comprehensive education aligned with the requirements of the contemporary automotive sector.

6. The influence of vehicle electrification on the professional profile

The transition to electrified vehicles, including hybrid and fully electric models, represents one of the most significant recent changes in the automotive industry. This transformation not only alters vehicle architecture but also redefines the set of competencies required for technical work. High-voltage systems, lithium-ion batteries, inverters, and electric motors become part of the automotive professional's scope of work.

From a technical perspective, diagnostics in electrified vehicles requires specific knowledge of power electronics, thermal management, and safety in high-voltage systems. Unlike conventional vehicles, in which the focus is on the internal combustion engine, electric

vehicles require analysis of parameters related to energy efficiency, battery state of charge (SoC), and the integrity of energy-storage systems.

In practice, technicians working in Chevrolet dealerships face challenges related to the absence of specific education for dealing with these systems. Improper handling of high-voltage components may pose risks to the professional's and the vehicle's safety, highlighting the need for specialized training and technical certification.

Thus, vehicle electrification further widens the existing skills gap, requiring urgent curriculum updates and the inclusion of content focused on electric mobility. Educating professionals capable of working in this new scenario is essential to ensure the safety, efficiency, and sustainability of automotive maintenance.

7. The digitalization of automotive diagnostics and the role of data

The digitalization of automotive diagnostics represents one of the industry's main technological trends, transforming how faults are identified and resolved. The use of advanced tools enables the collection and analysis of large volumes of data in real time, making more accurate and evidence-based diagnoses possible.

At Chevrolet dealerships, platforms such as GDS2 and Techline Connect provide access to detailed information on the operation of vehicle systems. However, the effectiveness of these tools depends directly on the technician's ability to interpret the displayed data, correlate information, and make well-founded decisions.

The growing use of telemetry and vehicle connectivity allows data to be transmitted remotely to analysis centers, enabling predictive diagnostics. In this model, data-analysis algorithms identify behavioral patterns and anticipate faults before they occur, reducing vehicle downtime and maintenance costs.

However, this technological transformation requires a new professional profile with skills in data analysis, computational logic, and interpretation of digital reports. Automotive technicians no longer act merely as executors of procedures but as systems analysts capable of understanding complex information and making strategic data-based decisions. This change reinforces the need for constant updating and the development of digital competencies in the automotive sector.

8. Conclusion

The analysis developed throughout this article shows that the skills gap in the automotive industry is not an isolated phenomenon but a structural one, resulting from the rapid technological development of vehicles and the obsolescence of traditional technical education models. The transition from predominantly mechanical systems to complex electronic architectures, combined with the growing digitalization of diagnostic processes, requires professionals with multidisciplinary competencies that are not yet fully developed in conventional educational environments.

Expanding the discussion to include topics such as integration between industry and educational institutions reinforces the need to build a collaborative professional education ecosystem. Bringing manufacturers such as General Motors closer to technical education centers can significantly reduce professionals' adaptation time to the market, promoting education more closely aligned with actual technological demands. Models such as dual education and integrated training programs emerge as effective alternatives for mitigating this gap.

Furthermore, vehicle electrification and the digitalization of diagnostic processes are transformation vectors that further increase the technical complexity of the field. The introduction of high-voltage systems, advanced batteries, and real-time data analysis redefines the automotive professional's profile, who becomes an integrated-systems specialist. In this context, competencies related to the safe operation of electrical systems, data interpretation, and logical reasoning become essential to ensure efficiency, reliability, and safety in maintenance processes.

Finally, it is concluded that overcoming the skills gap depends on a structural change in technical education based on curriculum updating, encouragement of continuous learning, and appreciation of technical-scientific knowledge. The ability to adapt to new technologies will be decisive for the sustainability of the automotive industry, ensuring not only the quality of services provided but also safe vehicle operation and customer satisfaction in an increasingly competitive and technology-oriented market.

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