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Developing a Resilient
Workforce for a
Technologically Disrupted
Automotive Service Industry

Niranjan Singh

Prem Chandra Samujh

Anura Bakmeedeniya

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Contact:

epress@unitec.ac.nz
www.unitec.ac.nz/epress/
Manukau Institute of Technology and Unitec
Private Bag 92025, Victoria Street West
Auckland 1142
New Zealand



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Niranjan Singh, Prem Chandra Samujh
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Abstract

The purpose of this workforce capability study is to quantify the magnitude of the challenge for tertiary education teachers. The automotive service sector is continuously evolving, so it is essential to stay updated on vehicle innovations and technological changes. As new technology is introduced in vehicles, the repair workflow changes and a technician cannot simply repair the fault, as sensors and software will need to be recalibrated for function. Hence, it is critical in the tertiary sector for teachers to remain current with automotive technological advancements. Available literature from global policy makers, vehicle manufacturers and national agencies were reviewed to determine the anticipated trends and disruptions to meet sustainability targets. Literature indicates that legacy technology combined with software will require a major reskilling across the service sector, requiring competencies and improving the development of human soft skills. Disruptions are hard to predict, and this study aims to identify how non-traditional skills will form the required workforce capability in the automotive service sector. Key industry leaders, service technicians and tertiary education teachers were interviewed, and findings from this study suggest industry stakeholders need to work collaboratively across the automotive service sector to develop service technicians' knowledge and skillsets. The triangulation of literature and data suggests the reduction of the knowledge gap of graduates for the automotive service industry requires all industry stakeholders to make informed decisions to take their workforce forward and avoid redundancies. Recommendations are made for visionary, innovative and planned decision-making for the future of the industry. Collaboration with standard-setting authorities, industry

partners and educational institutes, and a national vocational education and training framework will ensure the future workforce for the industry has the right capability and set of skills.

KEYWORDS

Automotive service industry, continuous education, training, electric vehicles, skills shortage, workforce development

Introduction

Developing and maintaining teacher proficiency in a rapidly changing automotive industry focuses on equipping these teachers with knowledge and skills to effectively provide current learning information to their students. Preparing students for the automotive service industry requires teachers to adapt to these rapid technological advances with an emphasis on practice-based learning facilitation. Practice-based learning develops students with deep cognitive learning and industry-standard experience.

The shift in the automotive industry towards environmentally friendly autonomous and electrified vehicles, supported by sophisticated cutting-edge technology, is continuously challenging teacher proficiency. The car of the future is full of advancement possibilities, undergoing a sociotechnical revolution and transforming into a computer on wheels, and the automotive service industry needs major reforms to proactively align to meet the digitisation of vehicles. Vehicles are being fitted with technologies that can be overwhelming, such as head-up displays, Bluetooth connectivity, infotainment systems, reconfigurable display consoles, seating comfort with heat and posture settings, and ambient light controls. Making sure that industry service technicians can meet the demands of technologies, training programmes and qualifications need to include sophisticated vehicle systems as part of the curriculum.

The New Zealand Qualifications Authority (NZQA) state their purpose as making Aotearoa New Zealand qualifications recognised and respected globally, and the credentials meeting the needs of learners in the changing world. Learner-development programmes for technicians represent the process of improving knowledge and skills to be effective when performing a task. The World Bank Group (2025) reports that skills development is at the centre of changes happening in the labour market amid global megatrends such as action against climate change, and digitisation, and these will redefine the paradigms of education and workforce development globally.

To succeed as a technician in the current and future automotive service sector, technicians need to know what technology is being introduced and continuously update themselves. Machado (2024) suggests that the pace of new technology has created many opportunities and raised challenges that require systems that nurture a culture of resilient tools and processes. The rapid pace of technological advancements and evolving labour markets can make technical and specialised skills quickly redundant. On the contrary,

transversal skills, such as critical thinking, problem solving and adaptability, will become more transferrable and resilient to changes in the job market (World Bank Group, 2025). Driving this shift requires industry leaders to expand their traditional roles to a wider range of proactive staff development.

The transport sector is critical to economic activities and growth in all countries. According to KPMG (2023), the global automotive sector is making a quantum leap in decarbonisation; however, the transport sector still contributes 40% of global emissions as the sector aspires to introduce innovative technologies as a catalyst for decarbonisation. Heineke et al. (2024) report that 2023 was a big year of changes for the transport sector as regulations, investments patterns, consumer preferences and technology such as autonomous driving, connectivity and electrification continued to evolve. Kelker et al. (2024) further suggest that cars are evolving as electric vehicles (EVs) become more sophisticated and autonomous driving capabilities including blind-spot sensors and self-driving become a preference. Autonomous driving capability uses vehicle-to-infrastructure communication to control and monitor vehicles. Sensors located on the vehicle can identify hazards in the vehicle's travel path, and slow or stop the vehicle as required.

The net-zero transition is reshaping the automotive service sector by opening new opportunities, and at the same time imperilling those that are not adapting to change. These innovations are the systemic introduction of technologies for adoption in their products and acceptance by customers (International Energy Agency, 2023b). Heineke et al. (2024) further report that vehicle electrification has continued growth with new technologies, while autonomous vehicles have ventured deeper into serious investigation of the potential use of generative artificial intelligence (AI).

Digital connectivity and driver assistance systems such as automatic braking are becoming important considerations for vehicle purchasers. The introduction of these technologies aspires to drive measurable progress on sustainability towards the United Nations Sustainable Development Goals, so the planet can flourish and societies have a positive chance for a better life.

There are three key drivers for the introduction of disruptive technologies in vehicles: the first is global and national policies to reduce emissions; the second is the introduction of technologies to reduce emissions, including the introduction of EVs; and the third is social responsibility to society with a focus on Sustainable Development Goals.

The aim of this research is to:

- A. Review global and national policies that influence the road transport sector in Aotearoa.
- B. Investigate the technical innovations introduced in vehicles to meet emission reduction policies.
- C. Identify social and technical skillsets required by technicians in the vehicle service sector.

Literature review

This literature review is undertaken to ascertain what has previously been studied and the resulting knowledge that is freely available. The literature review is divided under subheadings for clarity. Work in the automotive service sector is constantly being reshaped by the introduction of new technologies by automotive manufacturers. The introduction of new technologies makes it harder for the service sector to predict which skills will be important, and which skills will be superseded. To understand the nature of technological changes imposed by the need to improve the quality of life for all, this review analyses four automotive manufacturers' rationales and manufacturing transformation. The United Nation's Sustainable Development Goals for greener vehicles mandates manufacturers to include emission-mitigating technologies, and, as Hašková and Zatkalik (2018) argue, the inclusion of new technologies in the construction of motor vehicles introduces the need for continuous improvement of the service sector to deal with their service, maintenance and repair.

GLOBAL AND NATIONAL CLIMATE POLICIES

Climate change and sustainability are issues of great importance to societies around the world. Climate change is an urgent priority for most people and environmental sustainability is a consideration in their vehicle buying decisions. According to the International Energy Agency (2023c) report, *World Energy Outlook 2023*, in 2022 the global transport sector was responsible for 21% of total energy-related CO₂ emissions, with road vehicles emitting 16% of the total. Road vehicles are a major contributor to greenhouse gas emissions and passenger cars produced about half of global road emissions in 2022.

Climate change is now impossible to ignore, and vehicle buyers are responding by opting for eco-friendly vehicles. As greenhouse gases soar, global policies and undertakings have demanded the manufacturing sector of the vehicle industry create a smaller environmental footprint and at the same time reduce the amount of plastic used in components. McElhaney and Spencer (2024) suggest that consumers are increasingly interested in moving to sustainable transportation, and vehicle buyers' demand for efficient, low-carbon-emitting vehicles has raised a myriad of considerations for reducing vehicle weight and developing high-performing vehicles and components. Reducing the weight of vehicles is critical to improving fuel efficiency. Combatting greenhouse gas directly relates to the transport sector, and in Aotearoa responsible automotive corporate organisations have developed their own sustainable frameworks to align with the United Nations Sustainable Development Goals (UNSDGs).

Global policies

Aotearoa is a signatory to the United Nations Framework Convention on Climate Change and has made commitments to reducing greenhouse gases under the Kyoto Protocol. In the Paris Agreement, which took effect in 2016, Aotearoa committed to reduce greenhouse gas emissions to 50% below the country's 2005 level by 2030. The UNSDG 17 states that countries need to

take urgent action to combat climate change. The 2030 Agenda for Sustainable Development calls for the widest possible international co-operation aimed at accelerating the reduction of global greenhouse gas emissions and addressing adaptation to limit the adverse impacts of climate change (International Energy Agency, 2023a).

National policies

In Aotearoa the transport sector accounts for the highest share of emissions and is almost entirely dependent on fossil fuels. The road transport sector represents 17% of greenhouse gas emissions in Aotearoa, a figure that would be significantly reduced by increasing the number of hybrid and electric vehicles. According to the International Energy Agency (2023a), Aotearoa has the opportunity to use its clean electricity strengths to decarbonise its transport sector. The emission reduction plan sets out how this country will meet its first phase of the period from 2022 to 2025. The budget for the period limits the emissions to 290 metric tonnes of carbon dioxide. The Clean Car Standard regulates vehicle importers to reduce the CO₂ emission to specific targets. It aims to reduce carbon emissions by encouraging a greater supply of low- and no-emission vehicles. These policies compel manufacturers to introduce new technologies that enable the vehicles to meet Aotearoa's vehicle import standards.

Technological innovations

Driven by the UNSDGs, future technological advancement and environmental impact mitigation go hand in hand, and vehicle manufacturers are moving into that space. Tongur and Engwall (2014) present the argument that the present vehicle technological paradigm suffers several inherent ecological disadvantages for its greenhouse gas emissions and reliance on fossil fuels. A more radical way forward is to change the energy source to electric or hybrid engines.

Driven by the ramp-up of electrification and technical improvements brought to conventional vehicles, the CO₂ emissions of new vehicles are improving year-on-year. Ford Motor Company (2024) declared that the automotive industry is experiencing change at a remarkable rate and magnitude, and they are taking the lead to help make a better world for all. Heineke et al. (2024) agree with their report that the previous years have provided evidence that the global transport sector is undergoing major disruptions as the industry is becoming more electric, and micro mobility is gaining share in consumer shifts. McElhaney and Spencer (2024) argue that the first shift that we all probably know to be true is that there will be more EVs. EVs will come with more technology and the management of data from those vehicles will challenge the service technicians' skillsets.

The addition of autonomous driving functions using AI and connected services such as personal assistants improve overall user comfort and experience. All these technological advances are directly linked to vehicle safety and emission reduction to meet targets set by global bodies.

A General Motors (2023) sustainability report states that their primary approach to reducing their reported global emissions footprint is through the gradual replacement of traditional internal combustion engine vehicles with

EVs. Stellantis (2024), according to their *Corporate Social Responsibility Report 2023*, have set a target of 50% reduction in their carbon footprint by 2030. All four major manufacturers whose reports are reviewed in this paper – Ford, Toyota, General Motors and Stellantis – are using the advantage of EVs, which lies in their significantly lower emissions intensity compared to equivalent internal combustion engine models.

Toyota New Zealand (2023) report that the company is supporting Aotearoa to establish a hydrogen economy beyond light transport and expanding their business operations through technological innovations. Toyota has introduced new hydrogen technologies in the form of hydrogen internal combustion engine and fuel cell vehicles to support the construction and conservation sectors in this country. As an initiative, they introduced hydrogen technology into Aotearoa to support their carbon-neutral ambition: a highly innovative hydrogen-powered fuel cell Mirai car in an exclusive car-sharing scheme with commercial partners in Aotearoa. Their hydrogen efforts focus on hydrogen opportunities in both mobile and static technology solutions as part of their ambition to diversify and continue to build a carbon-neutral business.

Stellantis (2024), in their *Corporate Social Responsibility Report 2023*, state that they have added an additional asset, which is a hydrogen fuel cell zero emission solution that combines the advantages of hydrogen fuel cells and electric battery technology in a fuel cell electric vehicle (FCEV). This technology offers 400 kilometres of range, with a refuelling time of less than four minutes. Their solution is particularly suited to the needs of light commercial vehicle (LCV) customers requiring long range, fast refuelling and zero emissions without compromising payload capacity. Tongur and Engwall (2014) argue that customers will ask for electrified powertrains, and new competencies for servicing electrified vehicles will take a long time to create and normalise.

General Motors (2023) state that they are taking positive environmental actions, and have adopted ambitious climate goals of achieving carbon neutrality in products and operations by 2040 by continuing to create a broad portfolio of EVs. They report that their investments in electric and autonomous technology are helping to realise that vision. The report further elaborates that to make the biggest impact on climate change, they need to focus on investing in programmes that reduce greenhouse gas emissions. They are committed to the objectives of the Paris Agreement and the Business Ambition Pledge to eliminate tailpipe exhaust from new vehicles by 2035. They continue to work toward meeting our near-term science-based targets for emissions reductions to support this commitment (General Motors, 2023).

Ford Motor Company (2024), in their sustainability report, state that to achieve their carbon neutrality goal, they have focused on the CO₂ emissions of their vehicles and have invested heavily in EVs. They further state that their sustainability efforts drive their business for a new era of electric and connected vehicles. On the other hand, the *Corporate Social Responsibility Report 2023* from Stellantis (2024) undertakes to cut CO₂ emissions in their vehicles as a strategic decarbonisation plan and achieve carbon net zero by 2038. To limit CO₂ emissions from vehicles, Stellantis report that they are continuing to develop efficient products by implementing technical solutions whose cost effectiveness is beneficial for its customers. Technology is driving

a paradigm shift, and the major manufacturers are uniquely positioned to integrate new digital solutions that build on their strong foundation of vehicle development and support networks.

Software adoption

Trending automotive design from vehicle manufacturers includes systems that provide a range of functions to improve vehicle safety, comfort and performance, and designers have used electronic control units to control these functions. The mechanical components of the vehicles have remained largely the same over the last few decades; however, the introduction of software into the vehicles sees the dynamics change radically and the software is becoming more valuable in its operation. A new generation of technologies is enhancing vehicle operation by using generative sensor information to make fine adjustments to vehicle performance, leading to sustainability.

To accelerate technological development, AI has the potential to transform the use of embedded software in vehicle systems. Software-driven vehicles are revolutionising transport, making vehicles smarter, more efficient and driver friendly. In the last 15 years there has been a quantum leap from everything being hard-wired in a vehicle where nothing changes to vehicles that are dynamically controlled through software. Software is now used to control critical vehicle functions such as acceleration, steering and braking, and these vehicles are much more complex than any other transportation mode, as there are considerations of vehicle dynamics and safety. Ford Motor Company, in their 2024 report, state that they are designing and manufacturing vehicles that offer innovative driver assist technologies towards a future that is free from vehicle crashes. The system allows owners to drive hands-free while it steers, accelerate and brakes, and keeps the vehicle centred in the lane. A driver-facing camera that monitors eye gaze and head position to ensure the driver is actively monitoring the road will only get better going forward, because there will be more technologies that help keep passengers safe. Several vehicle components are now classed as internet of things (IoT). These are digitally controlled components that are embedded with sensors to communicate with the computers, either onboard or cloud based. Ford Motor Company (2024) report that their vehicles are now equipped with advanced over-the-air (OTA) software updates that have critical capability to quickly and easily enhance vehicle performance.

Software is now at the centre of technology going forward. Schneider et al. (2024) forecast that technology could accelerate and present new challenges and could spur realignment of products. Stellantis (2024), in their *Corporate Social Responsibility Report 2023*, commit to new features in their vehicles through software and on-demand features, and will work to provide drivers with the ability to tailor their vehicles to individual needs and desires through over-the-air updates, further strengthening the bond between the vehicle and driver. Generative AI will cause disruptions in the software sector and adoption in vehicles will have an impact on the skill requirements of automotive service technicians. Even in these early days of adoption, vehicles already have onboard vision cameras, LiDAR and radar in combination with applied AI for driver assistance and automatic safety responses. For vehicle users, AI provides an experience of allowing improved productivity and

reliability. To work with these innovative technical shifts, service industry players need to think ahead continually and upgrade their technicians' knowledge and skillsets. As technology becomes embedded and requires innovative solutions, the skillset requirement of the technicians becomes less routine and straightforward. This puts a premium on technology-literate graduates and those training providers with a reputation for career-readiness programmes of study.

Recycling

Reducing the volume of unrecyclable parts in vehicles reduces end-of-life disposal issues. Kelker et al. (2024) found in their research that sustainability was a key issue vehicle buyers considered during purchase. As a responsible corporate citizen, Toyota New Zealand (2023) reports, recycling vehicle components is a big challenge and they are at the start of their journey to be able to repair, rebuild, repurpose and responsibly recycle all aspects of what they sell, with a commitment that they enrich natural resources and use energy from renewable resources.

General Motors' (2023) sustainability report states that the organisation is working towards reducing the carbon footprint of the materials in new vehicles through material selection and sourcing decisions. The company further supports a circular economy principle, where they are also working to incorporate more recycled and renewable content to reduce carbon footprint and dependence on non-renewable resources.

Social responsibility

According to the World Bank Group (2025), investing in human capital is the priority for the current evolving opportunity and the focus is on advanced cognitive skills, socio-behavioural skills and predictive adaptability, which is supported by lifelong learning. A skilled workforce requires cognitive skills that include complex problem-solving, socio-behavioural skills, teamwork and predictive ability. The automotive service sector workplace is a critical environment for worker social interaction. It is critical that workers in the sector have a healthy environment with clean air and clean water.

Brassey et al. (2024) suggest that in building a thriving workplace, industry leaders must reimagine the work, the workplace and the worker. To build a thriving workforce, companies need to focus on effective teams, a healthy work environment and employee wellbeing. A healthy work environment includes everything from destressing play facilities to the promotion of positive mental health. Toyota New Zealand (2023) report that staff engagement is important in their organisation, and management communicates with staff regularly to share information and gather feedback through monthly staff meetings and an annual question-and-answer session with the executive team. They conduct annual staff surveys to understand where they are doing well and where they can do better.

The Hays 2025 Skills Report (Hays, 2025) suggests that the pace of change means that learning both technical and soft skills will have to become a continuous pursuit for society, employees and organisations alike. Employee wellbeing is integrally connected to continuous professional development, and in the transport service sector ongoing education in new technologies is

critical for retaining employment. Brassey et al. (2024) report that generative AI has begun to reshape jobs, and for workers to thrive and function positively they need to have a holistic way of being in which they have a purposeful equilibrium between physical, mental, social and spiritual health. These attributes allow workers to demonstrate higher levels of cognitive and social skills in a collaborative work environment.

While previous focus might have been limited to recycling and waste control, many business organisations are working with experts who can help them take a holistic assessment of energy and carbon reduction for their business operation. A key factor in the automotive service centres is monitoring CO₂, which helps identify the air quality in workshops. Pumping in fresh air creates a healthier environment for the technicians. Toyota New Zealand (2023) report that their organisation has undertaken to promote an inclusive workforce that reflects our communities. As part of their 2050 Vision, the organisation plans to be inclusive and make all current and future employees feel welcome and supported. They recognise that there is room for improvement in terms of diversity and inclusion practices (Toyota New Zealand, 2023).

Service sector

The Hays 2025 Skills Report (Hays, 2025) has identified that Aotearoa and Australia have been facing skills shortages for the best part of this decade, and they are getting more acute. They further report that the changing employment arrangements and skills needed within an occupation, and inadequate staff training rates, are just some of the reasons for skills shortage. Automotive service sector employees require a range of skills, some being durable skills, also known as soft skills, such as adaptability, teamwork and social empathy, while other skills, such as use of tools and test equipment, can be perishable as technology evolves.

The World Bank Group (2025), in their report on the changing nature of jobs, reaffirm that human capital, being the employees, also fosters social capital and consists of their knowledge, skills and health, which realise their potential as productive members of society. In the current digital storm, industry leaders encounter numerous challenges in their efforts to achieve successful industry transformation. The efficiency of the service sector in coping with changing job skills depends on how quickly the tertiary sector provides the new skills. Garibaldi et al. (2023) argue that demand for talent in the automotive technology industry has been competitive and high-technology talent remains a scarce commodity; hence, there are critical talent capability gaps that require new skill sets. If these gaps are not managed, companies can struggle to keep up with changing technical demands and social trends. Kelker et al. (2024) recommend that if companies wish to stay ahead, they need to prioritise technician talent by building internal capabilities and implementing targeted technician-specific hiring plans.

Toyota New Zealand (2023) report that their management is committed to a succession plan that ensures to grow diversity in their business operation. Some companies may fill knowledge gaps by retraining current employees, while others might look externally for the correct capability. The adaptability of service technicians to innovative technologies requires an individual's

ability to adapt to new work processes, environments and workplace cultures. Toyota New Zealand (2023) state that one of the three key objectives for their service department is to ensure that they have a skilled, diverse and healthy workforce. Employees with strong durable skills can easily attain mastery of specific technical knowledge, leading to their skills development (Heineke et al., 2024). This creates a culture of learning by upskilling the workforce and retaining high-potential technical talent. A skills-development community within a company is a way for managers to develop their technicians' skills as technology evolves. Zahidi et al. (2018) confirm that as the types of knowledge and skills needed in the industry change rapidly, individual employees will have to engage with lifelong learning if they are to remain employable and to achieve a fulfilling and rewarding career.

General Motors' (2023) sustainability report states that to attract and inspire the most qualified and diverse talent, they focus on fostering great employee experiences. They cultivate an inclusive culture in which everybody can learn, grow and thrive. The inclusive strategy includes feedback from across the business to improve staff engagement. The culture of learning sets a virtuous cycle of growing skills within the technician pool, leading to improved adaptability while thinking unconventionally and focusing on durable skills.

Brassey et al. (2024) suggest that as tasks become automated, the remaining work becomes more complex, dynamic and creative. Automation is anticipated to increase demand for highly educated service technicians, creating a greater need for technological, socio-emotional and cognitive skills. Hence, effective team dynamics become critical as work requires higher levels of innovation and collaboration. Garibaldi et al. (2023) suggest that mentorship, coaching and feedback are tools that senior team members can use with incumbents to lead the charge in the transition to build an agile high-technology skill-building culture. For companies, reskilling and upskilling strategies will be critical if they are to find the talent they need and to contribute to socially responsible approaches to the future of work (Zahidi et al., 2018).

Aotearoa industry training and education

The New Zealand Qualifications Authority (NZQA) has a critical role in regulating and assuring the quality of training and education for the automotive service industry. NZQA regulates through a framework of qualifications by setting standards and rules for quality assurance. Aotearoa's automotive training and educational pathways include apprenticeships and qualifications at different levels.

An apprenticeship is an industry-based structured programme of learning, in which individuals learn the automotive trade through a combination of on-the-job training and classroom education. Van der Klink and Streumer (2002) argue that on-the-job training is not an entirely effective method for training and has limitations, including lack of learning structure, the absence of experienced professionals for coaching and the risk of perpetuating bad practices. On-the-job training, while beneficial for exposing trainees to industry practice, also has several drawbacks, including untrained trainers, inconsistent training quality, risk of expensive errors and limited scope of knowledge

development. The tasks are limited to the type and frequency of jobs coming into the workshop. The other issue that adds complexity to on-the-job training is the number of prospective students wanting to join the industry and the number of places available in the industry.

Hašková and Zatkalík (2018) argue that the current trend in the automotive industry is electro-mobility, and to ensure relevantly qualified people for this trend, programmes of study must be made available to the sector. They further elaborate that new technologies have been elicited by environmental considerations, and they are aimed at increasing the introduction of environmentally clean vehicles. Vocational training and education have been facing challenges to introduce relevant courses and upgrade the current programmes of study.

Work-based learning

Work-based learning is a New Zealand Government initiative, as an educational approach that integrates learning experiences within a real work environment, providing practical skills and knowledge relevant to the automotive industry. Work-based learning requires the formal collaboration of the trainee, the employer and the education provider. This approach is designed to bridge the gap between theory and practice. However, in practice, the initiative still has similar disadvantages to on-the-job training, especially with smaller businesses that cannot financially support trainees.

To add to the complexity, the automotive sector is transitioning through a technological revolution with a paradigm shift, and key challenges for this model in the automotive sector are:

- A. The number of trainees interested in pursuing a career and the number of placements the industry can provide.
- B. The capability of the workplace supervisor to teach and assess a trainee.
- C. The productivity of the trainee against workshop income targets.
- D. The ability of the business to provide the range of experience to the trainee as required for the qualification.
- E. The relationship between technological shift, service innovation and business survival.

Work-based learning is suitable for industries that have stable processes and are not influenced by external factors; however, the automotive industry is experiencing a phenomenal technological shift, and the industry is currently unable to fully implement work-based learning.

Summary of literature review

The global automotive service industry is at a crossroads as electrification and autonomous technology continue to drive innovation, resulting in sophisticated technology. The review of literature has identified potential gaps that adversely impact the service of vehicles with new technologies to mitigate emissions and improve safety. When reviewing reports from major manufacturers, it is apparent that future technologies currently in the pipeline for introduction will exacerbate the demand for technicians with relevant skills. The challenge

is for the average service technician to stay up to date in an industry that is constantly changing in a technological revolution. To overcome these challenges, the literature suggests a need to shift our traditional thinking to enable a supply of new workers into the industry with higher levels of education. Several of the reports suggest that improving the work environment will result in a congenial work ethic.

This literature review establishes that:

- A. United Nations Sustainable Development Goals are the driving force for the automotive manufacturing industry to move towards environmentally sustainable products and services.
- B. To meet the Sustainable Development Goals, vehicle manufacturers are increasing the inclusion of new technologies in their products to increase vehicle safety and reduce emissions.
- C. The service industry is undergoing disruptive changes to its practices and service technicians are under pressure to upskill their knowledge of these emerging technologies.
- D. The New Zealand Government views work-based learning to be most effective when it involves work-integrated learning for the automotive sector.
- E. There is a moral obligation for business organisations to have an inclusive workforce with employee wellbeing at the centre of their business models.

METHODOLOGY

A qualitative methodology was used to explore the complex experiences, opinions and industry challenges arising from the ever-accelerating introduction of new technologies in motor vehicles. The sieved, qualitative data allowed us to synthesise data from multiple perspectives. Data was analysed using qualitative methodological principles to identify themes, patterns, trends and common threads, which were then analysed to identify common segments and words, and coded accordingly to provide better insight.

Method of data collection

Data for this research was drawn from manufacturing industry and employment bureau reports, and interview and questionnaire responses gathered by two students in Level 7 Automotive Engineering study. Interviewees selected were service technicians employed in dealerships, as they are the first to encounter new vehicle technologies.

Semi-structured interviews followed research protocols, with questions covering participants' industry background, understanding of industry trends, views on diversity and developing trends in industry. All participants in the data collection are anonymised for privacy purposes. Interview questions were as follows:

- A. What are the changes to the motor vehicle sector?
- B. Tell me about current and emerging technologies in motor vehicles.
- C. How do you know when new technologies are introduced in the automotive industry?

- D. How do you learn new technologies introduced in vehicles?
- E. What professional development opportunities are provided by your organisation?

Selection of participants

Participants selected for data collection were divided into three groups:

- A. Automotive service industry leaders who were able to make decisions on service technician recruitment and training.
- B. Service technicians who were directly involved in the service and repair of vehicles.
- C. Teachers involved with industry training.

Three groups of in-depth industry interviews were held between March and September 2024.

Three service industry leaders were selected from dealerships and the aftermarket industry. The interview discussions were broad, but emphasised the point that current workforce skill shortages across the automotive service industry are causing vehicle repair delays and unplanned cost escalation for customers.

Three interviews were conducted with technicians who were active in industry. Interviewees were selected from dealerships and the aftermarket service industry. The foci of the conversations were emerging technologies and the challenges of working with advanced systems in vehicles.

A further three in-depth interviews were conducted with the teachers in tertiary training institutes. The interview discussions focused on drivers of change for the road transport sector, sourcing information on emerging technological trends and trainee development.

FINDINGS

The data highlighted specific competencies that are not adequately represented in the existing technician development training and programmes of study.

Analysis of data

Narrative data from the participants was analysed using a phenomenographic approach, the qualitative analysis focusing on variation and categorisation of how the participants described their experience and understanding of the industry.

Service industry response

The consensus from service industry leaders was that manufacturers are introducing, and vehicle buyers are demanding, vehicles with software-driven green technology, with the intent to mitigate the carbon footprint of the road transport sector. All the participants reported that vehicles still had most of their legacy components, but the control mechanisms had shifted to the use of electronics.

Service Industry Participant 1 said, “*New breakthroughs such as electric*

vehicle technology, autonomous vehicles, advanced driver assist systems, advanced materials and hydrogen fuel cell technology are already a challenge for the service sector."

Service Industry Participants 2 and 3 stated that the future of vehicles coming into the country are full of advancement possibilities, and incorporating them will lead to improved vehicle safety and efficiency; however, these new technologies will expose the service technicians to increased system complexity.

Service Industry Participant 2 said, *"To attract and keep technicians with talent there needs to be a clear career pathway that leads to meaningful goals."*

A common response from all service industry leadership was that greener technologies are good for the environment by reducing greenhouse gasses.

In meeting the skills demand for working with new technology, the common theme from all the service industry participants was that the industry currently faces a battle to upskill the workforce as there are limited training programmes available.

Service Industry Participant 3 reported that they responded to *"technological challenges in vehicles by either retraining current technicians or recruiting experienced technicians, [or outsourcing] the work to specialised workshops."*

Service Industry Participant 1 said, *"While it may sound relatively easy to retrain the existing workforce or recruit graduates with the needed skills, getting the right employees is next to impossible."*

All service industry participants agreed that green technology is important for constantly improving the emissions from cars, and there needs to be more emphasis on greener technologies in the curriculum taught by training institutes.

All the service industry participants concurred that they preferred to employ technicians who have a range of skillsets, from experience on working with legacy technology to being able to work on contemporary vehicles that have programmable electronic control systems.

Service Industry Participants 1 and 2 suggested that the solution to skill shortages would come from targeting school leavers with high cognitive abilities to boost the technological skills of technicians in coming decades.

A recurring theme in the data analysed was the importance of effective training to prepare industry entrants who can work with contemporary vehicles.

Service technician response

Automotive Service Technician Participants 1 and 3 said they are exposed to customer expectations as well as complex vehicle repairs, physical demands of various repair tasks and keeping their knowledge updated on the ever-changing vehicle technology.

Participant 2 said their role *"includes investigative inspections of vehicle systems for diagnosis, decipher codes from their diagnostics tool, rely on informed and previous practice of similar diagnosis and carry out repairs as to manufacturer's specification within the prescribed time."*

When asked what types of technological changes they were experiencing

in their workplace, Service Technician Participants 2 and 3 stated that there was an increase in hybrid and electric vehicles with increased technological complexities.

Service Technician Participant 1 specifically said, *"The continuing surge on the number of vehicles turning into greener technology has put the service industry under various pressures and challenges."*

Service Technician Participants 1 and 3, from dealerships, expressed that they were given *"limited opportunities to"* adjust with market demand as new technologies were introduced. They said that business viability always took precedence over training needs, which resulted in gaps in knowledge about the technology they were expected to deal with.

Service Technician Participant 2 also highlighted that tertiary education providers had virtually no courses for them to upgrade their knowledge.

All the service technician participants said they had a mismatch of skillsets and critical knowledge gaps when working on new vehicle models and lacked the training to diagnose high-technology vehicles.

Industry training response

Automotive tertiary teachers are aware of the move towards reduction of the carbon footprint and the increased emphasis on green technology in vehicles.

Response from the teachers in industry training indicates that the programme content for trainees has a strong focus on fossil-fuel vehicles, with limited content on hybrid and electric vehicles. All three interviewees said that the curriculum has not kept pace with the advancement in vehicle technology and there is a lack of realia in the training workshops.

Reflecting on their own practice, Industry Training Participant 1 said, *"For us to be current in our technical knowledge of current vehicle developments, continuing to review and learn from automotive literature is critical."*

Industry Training Participants 1 and 3 further elaborated that industry placement for professional development would at least bridge the current knowledge-gap of technology; however, they still will not be prepared for the emerging technologies.

Industry Training Participant 2 suggested that *"the content in learning programmes needs to move towards more electrical content, reflecting the change in industry."*

Industry Training Participant 2 further elaborated that *"changes that need to be incorporated in learning programmes are hydrogen fuel technology, electric and hybrid vehicle technology, advanced driver-assistance systems and connected vehicles."*

All three teacher participants concurred that computer programming was the new dimension added to vehicle complexity, and they needed to upgrade themselves in the field of automotive computer applications.

Data segments

To further analyse the data, and towards a deeper understanding of the research question, the data was categorised into segments to identify themes and relationships:

Theme	Number of occurrences
Software-driven vehicles	8
Vehicle electrification / green technology	11
Skillsets	7

Software-driven vehicles: The automotive industry is undergoing a major shift from hardware-centric designs to being software-driven vehicles. Software is becoming the common catalyst of vehicle driver experience and vehicle system functionality.

Vehicle electrification: Vehicle green technology includes a range of advancements aimed at improving performance and comfort and reducing emissions, leading to a sustainable transport system.

Skillset: Industry leaders and service technicians acknowledged that even though there were broad transferrable skillsets, there was still a need for specialised skillsets for working with new vehicles.

Industry training teachers recognised the challenges of self-development to ensure programmes of study included high-technology content to develop graduates who were agile to transition as new technology evolved.

Consolidated findings

Industry leaders have acknowledged the quantum shift in innovative technology included in vehicles due to emission-reduction demands, safety technologies and driver-assistance technologies. The service industry indicated the struggle with fast-paced technological advancements that have put pressure on their service departments in coping with the changes. These changes have led to the need for upgrading current skill levels in the service industry workforce.

There is an overwhelming agreement by all service technicians about major changes in the technology of vehicles they work with now. The service technicians and their employers have embraced the opportunities to understand the importance of greener technology in vehicles. Service technicians need to stay relevant and ahead of the competition by adjusting their approaches to how they gain new knowledge and present their skillsets.

The overwhelming response by service technicians has obviously given a mandate to include green and safety technology content in a more immersed tertiary-study content. Tertiary teachers who provide training and education to the automotive service industry have acknowledged personal and training programme knowledge gaps on current vehicle technology, including electronic controls and safety-response systems.

DISCUSSION

This research paper enquires into the dynamics of global policies on climate change, technological response by vehicle manufacturers, and challenges faced by service technicians and tertiary teachers in the automotive field. Literature suggests that global concerns about climate change have evolved with the United Nations establishing the Sustainable Development Goals and

vehicle manufacturers have adopted the goals as guiding principles in their products. The result is that the electrification of vehicles has gained substantial momentum in recent years and will remain one of the most significant trends in the automotive industry. Increasing numbers of automakers are investing in developing EVs to meet the growing demand for environmentally friendly mobility solutions.

Despite the cost to consumers, there has been a steady increase in the sales of EVs and hybrid vehicles in Aotearoa in recent years. Sales rose from 33% in 2022 to 40% in 2023, indicating a strong trend towards hybrid and electric vehicles, which tend to include more complex technology in the endeavour to mitigate environmental impact. As these new technologies continue to be introduced in vehicles, there is a constant requirement for training (and upskilling existing technicians) in the service industry. The qualitative modelling suggests that the Aotearoa automotive service sector is likely to see gaps in their capability to service vehicles with new technologies. Automotive service management must understand the complex digital transformation, cybersecurity, the impact of climate change protocols, limited talent, an imbalance in workforce diversity, as well as employee ambitions. The larger workshops can afford to train the current technicians, while the medium and small workshops will need to either outsource work or recruit experienced technicians.

Industry skills reports have identified that Aotearoa has been facing skill shortages for the best part of this decade. The situation is getting more acute, with changing employment arrangements and skills needs within the industry, and inadequate staff training rates being just some of the challenges. Feedback from service technicians confirms that there is a gap between the service technicians' knowledge required to meet technological diagnostic demands of disrupted technologies in new vehicles. However, one of the barriers to upskilling the existing service workforce is that there is a lack of awareness of the payoff for continuous education in the transport sector. The capability gap would need to be filled by a combination of increasing technician training, attracting skilled workers from other sectors and introducing incentives to encourage more people into the road-vehicle-related education sector.

The challenge is working out how to equip graduates and existing technicians with knowledge and skills that will endure the technological disruptions imposed by sustainable products. There is strong evidence of support on upskilling for technicians at all levels. The use of product-support lines by manufacturers was seen as leading support compared to in-house training and specialised technical trainers hired by companies. This study indicates that there needs to be a shift in thinking towards transforming the transport ecosystem, and this should be regarded as an opportunity for the industry training institutes to develop programmes that are suitable for automotive technicians to upskill themselves, as high-technology clean-vehicle technician jobs are going to be in demand in coming years.

There is an urgency now to align the current trends in the industry with the content being taught in the industry training institutes, and the tertiary education sector needs to meet this gap to deliver curriculum, pedagogy and experiences that best prepare students for success in the automotive

service industry. Including new technology in the service technician education teaching curriculum is challenging, given the differences in vehicle technologies, diagnostic systems, software platforms, tools and repair procedures across manufacturers, models and generations of vehicles. Industry training providers need to have an in-depth understanding of the knowledge requirements of the future workforce and create educational programmes to enable the graduates to be employable. Educational programme management needs to take charge and develop bold strategies to improve employment and educational outcomes for those pursuing a career in the automotive service industry. Programmes of study need to move beyond the traditional limits of legacy technology and incorporate relevant social and entrepreneurial aspects that will take graduates to management and customer-service roles.

The Tertiary Education Commission has reviewed their policy, and the current opportunity for trainees in the industry is to gain practical experience while learning in a workplace setting. This theoretically provides the essential skills and guidance from both the employer and the training provider. Evidence from the literature and review of qualifications concludes that the current qualification offerings would not meet the requirements of service technicians to repair electric, hybrid and software-driven vehicles.

In summary, the non-dealership workshops tend to be reactive to the introduction of new technologies in vehicles, and the dealerships tend to be responsive to the changing technology and are supported by the manufacturing industry; however, the industry training sector has very limited understanding of the developing technological changes. None of the three dimensions of the service industry are proactive in dealing with the new technologies.

RECOMMENDATIONS

The automotive service sector needs to become proactive and establish training programmes to prepare their service technicians for modernised operations and invest in the education of their low- and middle-skilled workforce, as well as implement programmes to attract and retain a diversity of workers with respect to gender, race and socio-economic background, because this diversity improves a team's innovation and performance. The industry is now moving into the high-technology mode and needs to promote the sector inclusively to a broad range of secondary and tertiary students.

Service technicians need to continuously upskill and attend training programmes to retrain in new and emerging technologies so they can provide the necessary skills required to work on high-technology green vehicles. Technician education needs to develop a strategy for incorporating decarbonisation materials and technologies into the road transport sector. To stay competitive, technicians who want to make an impact need to continuously develop new skills to thrive in the current perpetual state of uncertainty.

Industry must establish the current and emerging knowledge and skill requirements of the automotive service industry, and collaborate with the New Zealand Tertiary Education Commission and tertiary education providers

to mandate the content of educational programmes. Industry training organisations need to have learning programmes that underpin the capabilities necessary to embrace technological developments. Programmes need to include flexibility to transform, reshape and drive change by incorporating new technologies, and create knowledge-sharing arrangements between vehicle manufacturers, vehicle dealerships, vehicle service industry and teachers.

This research has provided some insights into drivers of technical paradigm shifts in vehicles, fleet technology shifts, education and training needs for service technicians, and tertiary teachers' knowledge and skills; however, many aspects still need to be investigated and questions answered.

CONCLUSION

In the automotive service industry, the gap between what the training institute system delivers and what outcomes the industry demands have widened significantly over the past decade. This will have a dramatic consequence for the future of service technician employment as the complexity of vehicle technology overtakes the knowledge and capability of current service technicians. Employing the right people with the right skills and capabilities is essential to meeting these demands. The time is coming when the automotive service sector will call for a quantum reskilling across the workforce, requiring new technical competencies and the strengthening of uniquely human soft skills. Industry leaders within the smaller service industry continue to fail to adequately account for change and innovation, causing their employees to miss the opportunities or threats of disruptive technology until it's too late.

The work-based learning model suits industries that have stable technology, but the model does not fit with the technological revolution of the automotive service industry. Educational institutes and smaller service industry operators will need to be proactive and forge alliances with larger operators to develop a shared knowledge-bank of technological and social innovation for the industry.

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AUTHOR

Niranjan Singh is an experienced transport industry practitioner and educator, currently serving as a Lecturer at the Manukau Institute of Technology and Unitec. He has extensive teaching experience across Aotearoa New Zealand, Fiji, China, Papua New Guinea and Malaysia. Niranjan holds a Bachelor of Applied Technology in Automotive Engineering and a Master of Educational Leadership and Management. Actively engaged in research examining educational practice, industry challenges and technical analysis, his work focuses on enhancing student learning experiences and outcomes. nsingh@unitec.ac.nz

Prem Samujh is an emerging applied researcher focused on technology-enhanced learning, industry-aligned training and evidence-based workplace improvement within vocational and technical education.

Anura Bakmeedeniya is a practice-based researcher who uses reflective inquiry and workplace-centred investigation to generate practical, evidence-informed improvements in vocational and applied technology education.