CORE ON-BOARD DIAGNOSTIC SKILLS REQUIRED BY MOTOR VEHICLE MECHANICS FOR TROUBLESHOOTING ENGINE PERFORMANCE AND TRANSMISSION SYSTEM OF MODERN AUTOMOTIVE IN NIGER STATE

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Abstract

The era of depending solely on trial by error method and the experience of motor vehicle mechanics when troubleshooting various systems and subsystems of modern automotive is gradually coming to an end. This study was therefore carried out to identify the core on-board diagnostic (OBD) skills required by motor vehicle mechanics for troubleshooting engine performance and transmission system of modern automotive in Niger State. A survey research design was employed for the study. The population for the study comprised 833 motor vehicle mechanic master craftsmen and 29 automobile technology lecturers. A structured questionnaire which was designed by the researcher was used for collecting data from the respondents. The instrument was validated by three experts. Cronbach alpha reliability method was employed to determine the internal consistency of the questionnaire items and reliability coefficient of 0.84 was obtained. Two research questions guided the study while the two null hypotheses formulated were tested at 0.05 level of significance. Mean and standard deviation were used to answer the research questions while z-test statistics was used to test the null hypotheses at 0.05 levels of significance. It was found out that all the forty skills suggested are required by motor vehicle mechanics for troubleshooting engine performance and transmission system of modern for modern automotive. It was therefore recommended that all the skills identified in this study be included in the training given to motor vehicle

mechanics apprentices in Niger State. The state government should come to the aid of the motor vehicle mechanics by providing funds to enable them undertake the training as well as procure OBD scan tool.

Keywords: Diagnostic, Required, Mechanics, Troubleshooting Engine Performance.

Introduction

Motor vehicle mechanics are the experts saddled with the responsibility of inspecting, troubleshooting, repairing and maintaining of cars, buses, trucks, motorcycles and other vehicles in order to make such automotive roadworthy. According to Hiller & Coombes (2014) and Penn (2011), Motor Vehicle Mechanics are skilled personnel, trained in auto mechanics, specialized in motor vehicle troubleshooting, maintenance, repairs and sometimes modification of motor vehicles which also encompasses auto body repair and spraying or painting, auto electrical work, auto body mechanic work, auto body building (panel beating) and auto parts merchandise. In the opinion of Baba, Jacob and Issifu (2018) and Motavalli, (2010), since modern automotive running on the roads are now being manufactured and controlled by modern technology, proper troubleshooting and maintenance of faults associated with these vehicles can only be best carried out by a skilful motor vehicle mechanics who will be competent enough to fully undertake the troubleshooting of various aspects of modern vehicles.

Troubleshooting generally refer to a form of problem solving technique or skill most often applied to repair failed components or systems. It is a systematic and logical search for the root cause of a problem so that it can be rectified such that the components and systems can be restored back to it functional state. Good troubleshooting of modern automotive in the word of Kevin (2014), involves the ability of mechanics to adopt diagnostic skills in retrieving Diagnostic Trouble Codes (DTCs) as well as the use of a scan tool that communicates with the vehicle's on-board computer to access the OBD-II system in order to review history and affirm if it is a pending, current, or permanent fault, diagnose according to the steps in the repair manual. This means that for mechanics to do these, he/she must possess the required skills in the use of OBD scan tool.

Skill is a unique ability which an individual has (an inborn trait, or learnt through apprenticeship) which he/she uses to perform a task. Skills according to Idris, Saba and Mustapha (2014) and Adetokunbo (2009) denotes an ability possessed by an individual which enables him to perform a given task to a high degree of precision and accuracy, which is developed in the course of training and experience demonstrated. Sound skill is always demonstrated by an individual's ability to expertly use manual dexterity in a particular vocation. Udogu (2015) stated that troubleshooting skills required for maintaining and servicing modern automotive includes, performing magnetic sensor testing to identify defective sensor and component, to checking for spark using plug wire or adapter, checking the crank sensor using diagnostic tool among others. However, it is disheartening to know that most motor vehicle mechanics master craftsmen who teach the apprentice lack the required skills to work not only with special tools and diagnostic equipment, but also with sophisticated electronics and on-board diagnostic scan tool which is the major interface for troubleshooting modern motor vehicle.

On-board diagnostics (OBD) is an automotive term referring to a vehicle's self-diagnostic instructions programmed into the vehicle's on-board computer(s) installed in the vehicle. The on-board computer is also referred to as Engine Control Unit (ECU). The programmes are specifically designed to detect failures in the sensors, actuators, switches and wiring of the various vehicle emissions-related systems. OBD systems turns up and malfunction indication light (MIL) if the computer detects a failure in any of these components or systems (Nandhini, & Vidhya, 2014; Smith, 2006). Early versions of OBD would simply illuminate a malfunction indicator light if a problem was detected but would not provide any information as to the nature of the problem. Modern OBD implementation use a standardized digital communication port to provide real-time data in addition to a standardized series of diagnostic trouble codes (DTCs), which allow one to rapidly identify and remedy malfunctions within the vehicle. However, aspects of modern automotive systems and subsystems that requires adoption of OBD skills for troubleshooting include; engine, braking system, cooling system, transmission system and steering system. Even though modern vehicles are equipped with complex systems that will make them safer and easier to operate, engine remains the heart of automobile.

The automobile engine converts chemical energy in various forms of fuel to thermal energy through combustion. The thermal energy is then converted to mechanical energy which propels the vehicle. The conventional engine consists primarily of the crankshaft, connecting rod, piston and rings, valves, cam shaft(s) among others. Modern day vehicles have very complex systems that are built to make them safer and easier to operate, as well as providing more enjoyable driving experience. In the opinion of Erjavec (2010), the incorporation of sensors and actuators is geared towards enabling vehicle manufacturers produce enough vehicles that are eco-friendlier vehicles and will not have much tailpipe emission that can disrupt the ecological system. These new technologies ranges from optimum power and fuel economy by the engine which is the power unit without exceeding federal regulations, such as emissions levels and Corporate Average Fuel Economy (CAFE) set by the Environmental Protection Agency (EPA). Mechanisms which make this possible include the variable valve timing intelligence (VVTi), knock sensor, Mass Airflow (MAF) sensor, variable camshaft timing among others. However, it should be noted that the power unit becomes ineffective without a functional transmission system.

Transmission system is a key element in the power train that provides a link between the power unit and the vehicle wheels. Mayur (2012) stated that effectiveness in the torque provided by the power is only achieved if gears of various sizes are able to give the engine a mechanical advantage over the driving wheels while keeping the engine within that range. Inclusion of torque converter, dual clutch transmission (DCT), electrically variable transmission (EVT) alongside sensors like output shaft speed (OSS) sensor, turbine shaft speed sensor (TSS) and other technologies into the transmission system of modern motor vehicles enables the system perform its function effectively. With these innovations, troubleshooting and maintenance of modern automotive is best carried out using the on board diagnostic (OBD) scan tool since most of these systems now are primarily electrically operated. This new approach is not just an upgrade of the primitive trials by error or solely manual technique, it is the one of the major ways a motor vehicle mechanic can remain relevant in 21st century automobile world.

It is a common knowledge that a large proportion of motor vehicle mechanics both experienced and trainees operating in their workshops find it extremely

difficult to troubleshoot, repair and maintain modern automotive simply because of lack of on-board diagnostic skills to do so. This study is therefore designed to identify on-board diagnostic skills required by motor vehicle mechanics for troubleshooting modern automotive in Niger State.

Motor vehicle mechanics by default are supposed to be the safe haven where vehicle owners should run to whenever their motor vehicles malfunction. Baba *et al* (2018) stated that motor vehicle mechanics are instrumental in socio-economic development of any society because they render troubleshooting and maintenance services to car owners in order to make their cars roadworthy at all times. Hence, they are supposed to understand the working principles of every system and subsystems of both conventional and modern automotive and be able to relate with each component, troubleshoot the component following established diagnostic procedures and run effective maintenance to restore the faulty components to its full functional state with ease. It is also expected that this skill base should as a matter of necessity not be limited to the primitive manual or mechanical diagnostic procedures, bearing in mind that troubleshooting is now a combination of mechanical and electrical diagnostic procedure, motor vehicle mechanics are supposed to be abreast with on-board diagnostic knowledge which will help them carry out effective maintenance on modern automotive with ease.

However, it has been observed that a key problem area within the current skills base that is often raised by vehicle maintenance companies is the absence of effective practical skills by its labour force in vehicle diagnostics which seems to have become major concern in the automotive industry. The leading skill missing being sound on-board diagnostic skills which involves electronic troubleshooting or fault finding techniques, along with the appropriate actions to be taken in order to rectify identified problem. Ribbens (2003), noted that the use of scan tools like On-Board Diagnostic, One, Two and Three (OBDI, OBDII, and OBDIII) are commonly available only manufacturer's approved service centres today. This may be due to the fact that most motor vehicle mechanics are not financial buoyant enough to afford the machine in addition to the fact that they lack the prerequisite skills required for its usage. This has led to more damage of automotive because despite the use of diagnostic scan tools by some of these motor vehicle mechanics, there seems to be a large element of misdiagnosis or failure to adequately pinpoint the real source of

particular vehicle problems. This ends up leaving the vehicle worse than it was brought for maintenance in most cases because more damages are caused when trial by error is used. It is against this backdrop that this study intends to identify the core on-board diagnostic (OBD) skills required by motor vehicle mechanics for troubleshooting engine performance and transmission system of modern automotive in Niger State.

Method

Descriptive survey research design is adopted for this study. According to Kennedy and Kepha (2015), descriptive research specifically deploys a cross-sectional survey to gather information from different groups of people who share common characteristics such as socio-economic status, educational background among others but differ in variable area of interest. This design is suitable for this study because the study is aimed at seeking the opinion of motor vehicle mechanics master craftsmen and lecturers about OBD skills required for troubleshooting modern automotive in Niger State. The study was carried out in the three zones of Niger State. The total population was 8367 which comprises of 8338 of Motor Vehicle Mechanic Master Craftsmen and 29 Automobile Technology Lecturers from higher institutions offering automobile technology in Niger State. Simple proportionate random sampling was used to draw out 833 motor vehicle mechanics master craftsmen shown in Table 1 below while there was no sampling done for the lecturers since their population is relatively manageable.

Table 1: Sample Distribution of the Population of Motor Vehicle Mechanics Master Craftsmen

S/N	Zones	Motor vehicle mechanics master craftsmen
1.	Zone A	265
2.	Zone B	352
3.	Zone C	216
	Total	**833**

The instrument that was used for data collection was a structured questionnaire titled: Motor Vehicle Mechanics' On Board Diagnostic Skill Questionnaire

(MVMOBDSQ). The questionnaire contains 40 on board diagnostic skills, developed after a review of literatures within the reach of the researcher and expert opinion from notable automobile maintenance workshops. The questionnaire was designed with response options: Highly Required (4), Required (3), Moderately Required (2) Not Required (1). The instrument was divided into two sections (Sections 1 and 2). Section 1: consists of personal information of the motor vehicle mechanics master craftsmen and automobile technology lecturers. Section 2 comprises of two (2) subsections (A and B): Section A: focuses on board diagnostic skills required for troubleshooting engine performance of modern automotive and it contains 20 items, while Section B deals with on-board diagnostic skills for troubleshooting transmission system containing 20 items. The instrument was validated by three experts. The internal consistency was determined using Cronbach Alpha and a coefficient of 0.84 was obtained. A total of 862 questionnaires were distributed and a total of 807 was returned representing 94%.

The data collected for the study was analysed using Mean and Standard Deviation to answer the research questions, while z-test statistics was used to test the hypotheses at 0.05 level of significance using Statistics Package for Social Sciences (SPSS 23). The decision for each research question was based on the resulting mean scores interpreted relative to the concept of the real lower and upper limit of numbers shown in Table 2 Similarly, decision on hypotheses formulated for the study was based on comparing the significant value with ($p<0.05$) level of significance. That is, where the significant value is less than ($p<0.05$), the null hypothesis will be rejected, while when it equals or is greater than ($p\geq0.05$) level of significance, it will be upheld.

Table 2: Decision Rule

S/N	Response Mode	Rate	Reg/Limit	Decision
1.	Highly Required	4	3.50 – 4.49	Highly Required
2.	Required	3	2.50 – 3.49	Required
3.	Moderately Required	2	1.50 – 2.49	Moderately Required
4.	Not Required	1	0.50 – 1.40	Not Required

Results

Research Question 1

What are the on-board diagnostics skills required by motor vehicle mechanics for troubleshooting the engine performance of modern automotive?

Table 3: Mean and Standard Deviation of Responses of Respondents on the on-board diagnostics skills required by motor vehicle mechanics for troubleshooting the engine performance of modern automotive $N1 = 778, N2 = 29$

S/No	ITEM	$\bar{x}_{av}$	SD_{av}	Remark
1.	Ability to use the diagnostic scan tool Monitor the variable camshaft timing (VCT) circuit to the PCM for high and low voltage	3.24	0.77	Required
2.	Ability to monitor camshaft timing using diagnostic scan tool	3.23	0.77	Required
3.	Ability to check the variable camshaft timing (VCT) position for a misalignment using the scan tool	3.23	0.69	Required
4.	Using the scan tool to check if the oxygen sensor signal response for a fuel shift corresponds to the correct engine bank	3.14	0.80	Required
5.	Monitor vehicle operation rationality check with the aid of a scan tool	3.09	0.72	Required
6.	Ability to check the Mass Airflow (MAF) sensor signal using a scan tool	3.13	0.71	Required
7.	Use the scan tool to monitor the powertrain control module (PCM) for low air flow (or voltage)	3.19	0.61	Required
8.	Ability to check the MAF sensor tube for air leaks using the scan tool.	3.22	0.70	Required
9.	Checking the functionality of Manifold Absolute Pressure (MAP) using scan tool	3.09	0.69	Required
10.	Monitoring the live date of Engine Coolant Temperature (ECT) on a scan tool	3.11	0.76	Required
11.	Use the scan tool to monitor the throttle position (TP) sensor circuit for a non-closed throttle position at idle.	3.20	0.69	Required

12.	Checking the cylinder heat temperature (CHT) for voltage variations	3.21	0.70	Required
13.	Testing the Intake Air Temperature (IAT) sensor for detected temperature variation.	3.08	0.77	Required
14.	Ability to check the Turbocharger/Supercharger Inlet Pressure Sensor for voltage fluctuation.	3.12	0.66	Required
15.	Using the scan tool to read heated oxygen sensor (HO2S) heaters for open and short circuits.	3.18	0.69	Required
16.	Ability to run diagnosis on the adaptive fuel strategy and fuel delivery hardware to detect and rectify air/fuel ratio imbalances	3.17	0.75	Required
17.	Using the scan tool to ascertain if the Fuel Temperature Sensor reading falls within calibrated limit.	3.20	0.62	Required
18.	Checking the Engine Oil Temperature (EOT) Sensor reading for voltage fluctuation	3.20	0.71	Required
19.	Ability to test the comprehensive component monitor (CCM) for faults	3.04	0.60	Required
20.	Ability to check the powertrain control module (PCM) excessive engine RPM in neutral or operated in the wrong transmission.	3.24	0.67	Required

$\bar{x}_{av} = Mean\ Average, \qquad SD_{av} = Standard\ Deviation\ Average$

The result above shows that the mean of all the 20 items falls within the range of 3.04 and 3.24 while the standard deviation lies within a positive value of 0.60 and 0.80, indicating that all the 20 items are considered as OBD skills that are required by motor vehicle mechanics for effective troubleshooting of the engine performance of modern automotive.

Research Question 2

What are the on-board diagnostics skills required by motor vehicle mechanics for troubleshooting the transmission system of modern automotive?

Table 4: Mean and Standard Deviation of Responses of Respondents on the on-board diagnostics skills required by motor vehicle mechanics for troubleshooting the transmission system of modern automotive $N1 = 778, N2 = 29$

S/No	ITEM	$\bar{x}_{av}$	SD_{av}	Remark
1.	Ability to diagnose voltage fluctuation in the Clutch Switch Input Circuit	3.21	0.71	Required
2.	Using the scan tool to test for voltage fluctuation in the Transmission Range Sensor	3.12	0.59	Required
3.	Ability to check the Actuator Supply Voltage circuit for any interruption in transmission solenoid	3.25	0.61	Required
4.	Ability to detect open or short circuit and possible voltage fluctuations in the Output Shaft Speed (OSS) Sensor	3.35	0.63	Required
5.	Using the scan tool to identify possible cause of clutch pedal position switch trouble	3.15	0.83	Required
6.	Using the scan tool to test the Park/Neutral Position (PNP) switch for functionality	3.19	0.75	Required
7.	Ability to test for functionality and appropriateness of 4x4L when the switch is cycled on and off	3.35	0.67	Required
8.	Checking output shaft speed (OSS) sensor for irregular or interrupted rotation of the transmission output shaft	3.09	0.72	Required
9.	Using the scan tool to diagnose intermittent malfunction signal in the Turbine Shaft Speed (TSS) Sensor	3.25	0.57	Required
10.	Testing Transmission Fluid Pressure to determine if it meet the minimum calibrated value	3.13	0.63	Required

11.	Ability to monitor signals from Park / Neutral Switch Input Circuit to ensure it is within minimum calibrated value	3.25	0.71	Required
12.	Using the scan tool to Test the circuit signal of the TCM communication circuit to ensure it is within calibrated value	3.12	0.76	Required
13.	Ability to diagnose the cause of Torque Converter Clutch Circuit Malfunction	3.32	0.66	Required
14.	Ability to monitor live data reading of Clutch Pedal Switch Circuit to ensure it is within the calibrated value	3.19	0.63	Required
15.	Using the scan tool to Diagnose possible cause of gear Shift Malfunction	3.23	0.60	Required
16.	Ability to diagnose Transmission Control System Malfunction and clear the freeze data from the ECU	3.07	0.65	Required
17.	Using the scan tool to diagnose Incorrect Gear Ratio	3.17	0.66	Required
18.	Ability to calibrate newly mounted gear box and other power train components	3.04	0.66	Required
19.	Using the scan tool to monitor the Engine Speed Input Circuit to ensure the signal is within calibrated value	3.16	0.76	Required
20.	Ability to retrieve and clear transmission system freeze data in the ECU	3.28	0.58	Required

$\bar{x}_{av} = Mean\ Average, \qquad SD_{av} = Standard\ Deviation\ Average$

The result shows that the mean of all the 20 items falls within the range of 3.04 and 3.35 while the standard deviation lies within a positive value of 0.57 and 0.83, indicating that all the 20 items are considered as OBD skills that are required by motor vehicle mechanics for effective troubleshooting of the transmission system of modern automotive.

Hypothesis 1

There will be no significant difference in the mean response of motor vehicle mechanics master craftsmen and automobile lecturers on on-board diagnostics skills required by motor vehicle mechanics for troubleshooting the engine performance of modern automotive.

Table 5: The z-test analysis of Responses of Respondents on the on-board diagnostics skills required by motor vehicle mechanics for troubleshooting the engine performance of modern automotive $N1 = 778, N2 = 29$

Hartley test for equal variance						95.0% Confidence Intervals for Difference	
	Mean Diff.	Std. Error Diff.	t	df	Sig. (2-tailed)	Lower Limit	Upper Limit
Equal variances assumed	-.030	.131	-.230	805.000	.819	-.286	.226
Equal variances not assumed	-.030	.136	-.221	29.949	.827	-.296	.236

The result presented in the table above shows that the probability value calculated is greater than 0.05. Therefore, the null hypothesis is upheld.

Hypothesis 2

There will be no significant difference in the mean response of motor vehicle mechanics master craftsmen and automobile lecturers on on-board diagnostics skills required by motor vehicle mechanics for troubleshooting the transmission system of modern automotive.

Table 6: The z-test analysis of Responses of Respondents on the on-board diagnostics skills required by motor vehicle mechanics for troubleshooting the transmission system of modern automotive $N1 = 778, N2 = 29$

Hartley test for equal variance						95.0% Confidence Intervals for Difference	
	Mean Diff.	Std. Error Diff.	t	df	Sig. (2-tailed)	Lower Limit	Upper Limit
Equal variances assumed	-.110	.128	-.857	805.000	.392	-.362	.142

Equal variances not assumed	-.110	.123	-.893	30.329	.379	-.351		.131

The result presented in the table above shows that the probability value calculated is greater than 0.05. Therefore, the null hypothesis is upheld.

Discussion of Results

The results emanating from the of respondents' responses to research question one and hypothesis one as presented in Table 3 and Table 6 respectively revealed that the 20 skills itemised are required for effective troubleshooting of engine performance of modern automotive because the mean and probability value calculated are above the set values of 2.5 and p>0.05 respectively. Some of these skills among others include; ability to use the diagnostic scan tool to check the variable camshaft timing (VCT) circuit to the PCM for high and low voltage, ability to monitor camshaft timing using diagnostic scan tool, ability to check the variable camshaft timing (VCT) position for a misalignment using the scan tool, using the scan tool to check if the oxygen sensor signal response for a fuel shift corresponds to the correct engine bank, monitor vehicle operation rationality check with the aid of a scan tool, ability to check the Mass Airflow (MAF) sensor signal using a scan tool, using the scan tool to monitor the powertrain control module (PCM) for low air flow (or voltage), using the scan tool to read heated oxygen sensor (HO_2S) heaters for open and short circuits, Monitoring the live data of Engine Coolant Temperature (ECT) on a scan tool, using the scan tool to ascertain if the Fuel Temperature Sensor reading falls within calibrated limit, ability to check the comprehensive component monitor (CCM) for faults, checking the functionality of Manifold Absolute Pressure (MAP) using scan tool.

The synergy between the opinion of both motor vehicle mechanics master craftsmen and automobile lecturers is an indication that both parties agree to the fact that modern automotive are now computerised and have to be electronically troubleshot using OBD and other technologies for better efficiency. This finding is in conformity with the findings of Udogu (2015), who opined that motor vehicle mechanic work graduates of various technical colleges require OBD skills in the maintenance of engine, ignition, fuel, transmission and braking system of vehicles brought to their respective workshops because of the

technologies that drives such automobile systems. This view also supported by Yavala (2010), who stated that graduates of motor vehicle mechanics practice from technical colleges need improvement in work skills for engine maintenance, steering and braking system and auto electricity in order to be employed in the automotive maintenance industry since most systems and sub systems of modern automotive are primarily controlled by computerised systems, else loss their source of income.

Results from research question two revealed that all the items suggested were agreed by both group of respondents as skills required for effective troubleshooting of transmission system of modern automotive. The convergent view of motor vehicle mechanics master craftsmen is further reinforced by the result presented in Table 6 which shows that there was no significant difference in the response of both groups of respondents. Some of the skills agreed by both parties among others include; ability to diagnose voltage fluctuation in the Clutch Switch Input Circuit, using the scan tool to test for voltage fluctuation in the Transmission Range Sensor (TRS), ability to check the Actuator Supply Voltage circuit for any interruption in transmission solenoid, ability to detect open or short circuit and possible voltage fluctuations in the Output Shaft Speed (OSS) Sensor, using the scan tool to identify possible cause of clutch pedal position switch trouble, using the scan tool to test the Park/Neutral Position (PNP) switch for functionality, checking output shaft speed (OSS) sensor for irregular or interrupted rotation of the transmission output shaft, using the scan tool to diagnose intermittent malfunction signal in the Turbine Shaft Speed (TSS) Sensor.

This finding above is in agreement with Jittiwut (2010) and Robert (2004), which was established that the operation of vehicle electronic and software control systems operates on a number of different levels. Therefore, troubleshooting procedure should be carried out in this order starting from individual entity down to network level by taking readings from the individual sensor and comparing readings with the calibrated value in order to accurately troubleshoot the fault.

Conclusion

Motor vehicle mechanics in Niger state need on board diagnostic skills to enable them effectively troubleshoot the modern automotive trouping into the state

from the Federal Capital Territory (FCT) and other neighbouring states. This will enable them to be able to discharge their duties effectively and efficiently as well as remain relevant in the 21st century. It is against this backdrop that this study was designed to identify the core on-board diagnostic (OBD) skills required by motor vehicle mechanics for troubleshooting engine performance and transmission system of modern automotive in Niger State.

Recommendations

1. All the skills identified in this study be included in the training given to motor vehicle mechanics apprentices in Niger State.
2. The state government should come to the aid of the motor vehicle mechanics by providing funds to enable them undertake the training as well as procure OBD scan tool.

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