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Effect of On-Board Diagnostic System on Fault Detection in Automobile on Trainees' Achievement and Retention in Idaw River Layout Area, Enugu South L.G.A

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ABSTRACT

Technology has made significant impact in the Automobile industry. The digital era made tremendous in-road into the Automobile industry. Most automobiles manufactured according to the specifications of the Society of Automobile Engineers (SAE), from the year 2000 referred to as millennium vehicles possess some unique features. Such features include, components hitherto merely mechanical are now electro-mechanical, mechatronics and digital sensors with electrical/electronic linkages. The digital device has the ability for the vehicle system to record operating conditions. They are fitted with standardized codes that engender diagnostic capabilities of the device. The codes and operating conditions of the vehicle could be read from an appropriate scan tool. This technological development enhances fault detection in millennium vehicles. This study therefore sought to determine the compliance status of local motor mechanics who employ traditional diagnosing method to those who use the On-Board Diagnostic System (OBDS). The study was a quasi-experimental research design. A research question and a hypothesis guided the study. The instrument for data collection was a 20-item achievement test (OBDSAT). An intact class of seven students offering Automobile Technology from Department of Technology and Vocational Education, ESUT, was used as experimental group while a cluster of motor mechanics with bias in Japanese Toyota cars brand at Emeka Ebila area of Idaw River layout, Enugu were used as control group. The instrument used was validated by three experts. The reliability coefficient using Kuder Richardson (K-R 20) coefficient formula yielded 0.78 while internal stability using Pearson Product Moment coefficient formula yielded 0.68. The research question and hypothesis analysis showed that the traditional/conventional fault detection methods could not achieve as high as those exposed to the (OBDS). It is therefore recommended by the researcher that government should set up an agency of government to re-engineer the analog motor mechanics to embrace the OBDS. This process would enhance their competencies and the economy of the state. Alternatively, since the motor mechanics are already organized in clusters, their leaders could be trained on the OBDS skills so that they in turn would train their members. The ability of this large array of motor mechanics to be OBDS compliant would save the operators of millennium vehicles the agony of exposing their cars to trial-and-error cartels. Finally, a five-year moratorium should be allowed for the local mechanics to adopt the OBDS skills and acquire the equipment. At the expiration of the five years, the government agency would issue OBDS compliant certificate whose inscription should be boldly erected at the entrance of the motor mechanic workshops of all those certified compliant

Keywords: *Fault Detection; Digital Sensors; On-Board Diagnostic System (OBDS); Automobile Industry*

1. Introduction

Fault detection in an automobile requires a major skill. The traditional fault detection techniques involve the use of a number of human faculties. They include, the sense of sight, the sense of hearing, feeling, touching and smelling. All these faculties come into play in the course of the automobile technician or technologists' attempt to detect the performance of a car. This system is relatively subjective as it is incumbent on the level of competence of the automobile technician/technologist. There is the tendency that this system may not be replicable should the need arise. It is rather a function of the level of proficiency of a particular technician/technologist (Bent, 2002).

However, technology has improved for many years. The automobile industry equally improved tremendously for many years. The society of Automobile Engineers (SAE) has been doing a great work of standardization internationally. This standardization has not only been in respect of the maze of the vehicle makes and models but also in the direction of harmonizing a repair/maintenance system. These efforts gave rise to the introduction of the various scan tools now available in the industry. They include- Elite auto Scanners (ACTRON), On-Board Diagnostic I (OBDI); On-Board Diagnostic II (OBD II), multi-purpose Diagnostics as well as all data machines.

The scan tool was developed by experts in the automotive service industry to help diagnose vehicles and assist in troubleshooting procedures. The Scan tool monitors vehicles events and retrieves codes from the vehicle's control modules to help pinpoint problem areas.

On-Board Diagnostics I (OBD I)
The original On-Board Diagnostics I (OBDI) lacked consistency in communication and interface while allowing different interpretations among vehicle manufacturers. Ford and Chrysler used different types of engine control computers and data link connectors (DLCs) and GM varied the trouble codes and communication protocols from year to year.

On-Board Diagnostics II (OBD II)
On-Board Diagnostics version II (OBD II) is a system that the Society of Automotive Engineers (SAE) developed to standardize automotive electronic diagnostics. Beginning in 1996, most vehicles sold in the United States were fully OBDII compliant.

Technicians can now use the same tool to test any OBD II compliant vehicle without special adapters. SAE established guidelines that provide

1. A universal connector, called the DLC, with dedicated pin assignments.
2. A standard location for the DLC, visible under the dash on the driver's side.
3. A standard list of diagnostic trouble codes (DTCs) used by all manufacturers.
4. A standard list of parameter identification (PID) data used by all manufacturers.
5. Ability for vehicle systems to record operating conditions when a fault occurs.
6. Expanded diagnostic capabilities that record a code whenever a condition occurs that affects vehicle emissions.
7. Ability to clear stored codes from the vehicle's memory with a scan tool. J 2012 and ISO 15031-6 are standards for all DTCs, established by the SAE, International Organization for Standardization (ISO), and other governing bodies.
8. Codes and definitions assigned by these specifications are known as generic OBD II codes.
9. The display has a large viewing area displaying messages, instructions and diagnostic information.

Read Codes
The read code's function allows the scan tool to read the DTCs from the vehicle's control modules. DTCs are used to help determine the cause of a problem or problems with a vehicle. These codes cause the control module to illuminate the Malfunction Indicator Lamp (MIL) when emission-related or drivability fault occurs. MIL is also known as service engine soon or check engine Lamp.

Analog Fault Detection System or Techniques

The Engine:
The symptoms of the engine requiring overhaul are made manifest by these

a. Loss of power.

b. Heavy oil consumption.

c. Increased mechanical noise.

Consequently, to discover if an engine is losing power, the obvious analog approach for detecting such is by driving the car up a hill where the performance of an efficient engine is made manifest. The complexity in this system arises from the fact that one symptom could present from different components within the same region of the automobile. For instance, valve failure to seat properly could cause loss of compression, excessive noise and loss of power. In such a case, the remedy is to dismantle the engine and effect repairs, not mere overhaul as in the symptom of the engine making increased mechanical noise. Both scenarios are noise from within the same region but the faults are not only different but of different magnitudes.

For the cooling system, the symptoms of an overheated engine include – pinking or knocking, boiling, loss of power, and the eventual seizure. Some of the causes of overheating include, shortage of water, choked circulation system, slipping fan belt and retarded ignition. All these causes are not physically observable before putting the vehicle running except for the shortage of water. This makes the analog fault detection system moribund. There are some other fault detection techniques such as confirming the spots where possible leakages are taking place in a radiator. It is advised that the radiator be dismantled. The inlet and outlet pipes are sealed, then place the radiator in a bath of water. Attach an air pump to the overflow pipe using a pressure of about 21.29N/m^2, when any leaks will be evidenced by a stream of bubbles. This sounds credible but more cumbersome than its credibility.

In the carburetion system there are probable causes of explosions in the silencer, occurring when a vehicle is travelling downhill with the throttle closed. The probable causes include – a defective exhaust valve, slow running jet too small and air leaks in the silencer or pipe leading to it. However, these are not exhaustive for the probable causes or explosion in the silencer. For instance, poor quality fuel composition as well as poor combustion ratio could also cause explosions in the silencer. Bent (1981), posited that if a condenser presents symptoms of faulty performance, it could be verified by determining how frequently a faulty condenser causes misfiring at high speeds. The quickest method according to Bent is to substitute a new one and re-test. This recommendation sounds as a trial-and-error process. Unfortunately, the symptom of presenting misfiring at high speed is not peculiar to faulty condensers. In effect this poses a very complicated challenge but for the millennium On-Board Diagnostic Devices that help to factor the faults into their specificity.

The automobile brake system is a very delicate system, so difficult to have its faults readily detected by analog means. However, vehicles fitted with functional indicator lamps could be of immense help in addressing faulty brake system. For instance, several informative checks on the system as a whole, however, can be made without using any extra instruments. Simple tests can be made with the vehicle stationary and the engine switched off. The brake pedal should feel right-not spongy or rubbery. Pedal travel should be between 10 and 50mm. If the brakes are pumped rapidly the pedal should remain hard and not slowly move to the floor when the brake is applied.

The hand brake equally needs to be checked for lever travel, but ensure the vehicle is on a level surface. The movement of the lever should preferably not exceed about 100mm. If the brake is fitted with a serve mechanism it can also be checked. This is done by switching on the engine with the pedal lightly depressed and noting the increase in "hardness" of the feel. The brake could be further checked by applying the brake as hard as the driver conveniently can for a few seconds, the idea being that if a pipe or hose is defective it will fail on the spot and not later in some dangerous traffic situations. Indeed, it is recommended that these simple checks should be done every day as a matter of routine or habit.

It is worthy of note that an organization examined the brakes of about 800 cars in detail. More than 80% had one defect or the other and many had more than one. In about three-quarters of the vehicles the brake assemblies were faulty, the most common of them being that the brakes were out of adjustment, next the pads or linings were faulty-generally worn and next disc or drum defective. About 15% had seized or defective wear adjusters. Piping or hoses were defective on about 30% of the cars examined. Some parts of the hand brake mechanisms were faulty on about $^{1}/_{3}$ of the cars and nearly 1 in 5 had a seized or faulty linkage. Half the vehicles had been in accidents (which was why they had been examined) and about 3% of the accidents had been due to faulty brakes the brakes either not being able to stop the car or causing it to swerve (Newcomb and Spurr, 1983).

It is therefore recommended that for vehicles still operating on an analog diagnostic system that there should be routine check of brake fluid level. Any sudden loss of fluid indicates a leak somewhere and should be investigated immediately. If the vehicle has drum brakes on the front wheels and the brakes are not fitted with automatic wear adjusters, they should be adjusted every 1600km though less often if the car is not driven hard. It is also imperative that the disc brakes should be checked for wear, the pistons should also move freely in their bores and there should be no sign of fluid leakage. In addition, the air filter of the servo, if the car is fitted, should be checked for cleanliness. After 32,000km the hydraulic system should be drained and flushed with proprietary liquid, then refilled with the correct fluid and bled appropriately. Whereas after 64,000km the system needs a complete overhaul and the master cylinder, wheel cylinders, shoes, housing, etc. should be replaced. Discs and drums must be examined very carefully and replaced if worn, scored, or corroded (Newcomb and Spurr 1983). It is advisable that the brake pedal of a vehicle should never be slammed fully on, particularly at high speeds when adhesion can be reduced. The pedal should be applied gradually from a low to the highest pedal effort without the wheel locking. The initial build-up in pressure needs only occupy a fraction of a second but it helps avoid a skid and loss of control. It also enables the tyres to be held near the locking point to give maximum deceleration This is especially important at high speeds. Reduction of the pedal effort at the very end of a stop prevents a disagreeable jerk as the car comes to rest. The distance covered while braking is called the braking distance. The stopping distance is the distance the vehicle will take to stop, from the moment the driver realizes the need to commence braking. This is a function of the thinking distance as well as the braking distance. The thinking distance is the distance covered during the reaction time of the driver which is on average about $^{2}/_{3}$ of a second. Consequently, the higher the vehicle speed the greater the thinking distance. At a speed of 48km/h the vehicle will travel 9m.

All these uncertainties are troubleshooting of faults using the Analog (conventional) method of sense of sight, hearing, feeling, touching, and smelling by trial and error gave rise to researches into modern auto fault detection devices. The researches have so far given rise to OBD I – OBDII –Multi-purpose diagnostic machines – All Data machines. These machines provide accurate, exact, empirical, and reproducible results. At the press of one or two buttons now on any of these machines properly fitted onto a compliant vehicle would display the fault of the vehicle and even print them out on paper. Before this, the troubleshooting/fault detection procedures existed using the elimination process.

2. Research Methodology

The study adopted a quasi-experimental research design anchored on the applied research method. Given that applied research is concerned with testing the applicability cum efficacy of a theory, policy, idea or principle in practical situations. It is not concerned with introducing new things but rather in applying existing ones to determine their efficacy or otherwise (Idoko, 2011). In this study, therefore, the efficacy of the conventional technique of fault detection in automobiles through the sense of sight, touch, smell, hearing, and the feeling was tested alongside the On-Board Diagnostic system. The application further gave a leap for determining the performance of the subjects (the students and mechanics) by practical evaluation.

Evaluation research was equally involved in the study. Evaluative research is concerned with generating data or information that forms the basis of passing value judgments on educational materials, programs, methods, and policies in relation to predetermined set standards. Such judgments lead to decisions to modify, improve, replace or drop educational programmes, processes, tools, materials, etc. (Idoko, 2011). She stressed that evaluative research could therefore be regarded as decision-taking tool since it addresses problems concerned with how well, relevant, appropriate, adequate etc. or otherwise are educational programmes, ideas, practices, policies and other issues. Uzoagulu (2011) and Frey (2018) classified evaluation studies under experimental research, which Uzoagulu (2011) noted to involve controlled observation of change and development. Essentially, evaluation research is designed not to make the decision but to produce alternative options for decision making (Onuchukwu, 2007).

The researcher used an intact class of year three students of Mechanical Technology option, Department of Technology and Vocational Education (TVE), Faculty of Education, Enugu State University of Science and Technology (ESUT). These students offer Automobile theory and practice. The students constituted the experimental group taught with the On-Board Diagnostics system (OBDS). They were taught the theory and practice of fault detection in an automobile with the On-Board Diagnostics system (OBDS). This system is digital and its readings are replicable (Usoro and Ikpe, 2011). This implies that the use of any two OBD II Scanning tools, the result of the fault status of the same car remains the same.

However, improved fault detection procedures by scientific and empirical systems became averse to the traditional method. While the conventional system was based on trial and error, that of on-board diagnostic is scientific, empirical, and replicable. On the other hand, it is said, engage any two-automobile mechanics on the status of a car employing the traditional method, the result is bound to differ one from the other. To confirm the veracity of this assertion, the control group was made up of a cluster of automobile mechanics (Japanese Toyota brand bias) within Idaw River layout off Emeka Ebila axis. They were taught with the traditional method.

Research Procedure

The subjects in the experimental group were taught with OBDS fault detection techniques. In addition, they were driven in the car for the practical. The control group in turn was driven in the same vehicle through the same terrain by the same driver. In the course of the experimental drive, they drove through a smooth as well as rough and bad roads. They ascended and descended a steep gradient and negotiated both left and right bends. After the driving, the car was parked and allowed to steam in an idling position for some time. A set of 20-item standardized questions were asked the students on the fault status of the car bordering on the three compartmentalization of the vehicle, viz, power strain, chasis, and body. These questions constituted the OBDS Achievement Test (OBDSAT). During the first contact, the OBDSAT was administered to both experimental and control groups and their responses to the questions were kept away. The correct answers were not disclosed to them. After teaching the experimental group using the OBDS for six weeks; the OBDSAT items were reshuffled and administered to both experimental and control groups. Their scores were recorded as posttest scores. The questions were recovered from them and the scores were not disclosed to them. Two weeks after the posttest, the OBDSAT were further reshuffled and printed on a different colour of paper and administered to the experimental and control groups. Their scores were recorded as retention scores.

The instrument for data collection was the On-Board Diagnostics system instructional model Achievement Test (OBDSAT). The instrument was used for the collection of pretest, posttest, and retention scores. The instrument was a 20-item achievement test. It was subjected to face validation by three experts.

The validated instrument was trial tested and the data collected was computed for reliability using the Kuder Richardson (K-R 20) reliability coefficient for internal consistency. It yielded 0.78. The validated instrument was also tested for item stability by test-retest method and the correlation coefficient was computed using the Pearson Product Moment correlation coefficient, which yielded 0.68. Both values for internal consistency and item stability were high enough for the study.

The area of the study comprised Emeka Ebila street, Egbo Nnaji street and Nnaji Nwedeh street all in Idaw River layout of Enugu South Local Government Area of Enugu state.

3. Results

One research question and one hypothesis guided the study.

Research Question

How does the mean achievement and retention scores of students-trainees taught Fault Detection in Automobile using On-Board Diagnostic System (OBDS) compare with those taught same with traditional fault detection method?

The Null Hypothesis (H_{01})

There is no significant difference in the mean achievement and retention of those taught Fault Detection in Automobile using On-Board Diagnostic System (OBDS) and those taught same with the traditional method.

The results are as follows:

Table 3.1 Research Question One

Group	*N*	*Pre-test*		*Post-test*		*Retention*	
		Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Experimental	7	3.12	0.483	5.14	0.465	5.20	0.478
Control	22	3.10	0.510	3.11	0.522	2.98	0.531

From the above table, the pretest mean-scores for both experimental and control groups of 3.12 and 3.10 respectively are almost the same. This indicates that before the experiment, both groups were almost at par.

However, after the treatment, the experimental group recorded a higher mean achievement score of 5.14 for post-test while the control group's mean achievement score was 3.11. Similarly, the mean retention score for the experimental group was 5.20 as against 2.98 for the control group. The higher mean retention score indicates that the experimental group retained more than the control group. This indicates that learning took place in the experimental group.

The standard deviation for the experimental group stood at 0.483, 0.465 and 0.478 for the pretest, posttest and retention scores respectively. All the standard deviations are below unity which indicates no extreme case of scores. In other words, the entire class achieved the scores, not a few super individuals or extremely poor candidates. For the control group, the standard deviations were 0.510, 0.522 and 0.531 for pretest, posttest and retention scores respectively. The three are also below unity which indicates homogeneity. This implies there were neither extreme super scores nor extreme poor scores. The group achieved the scores.

Null Hypothesis (H_{01})

There is no significant difference in the mean achievement and retention scores of those taught fault detections in Automobile using On-Board Diagnostic System (OBDS) and those taught same with the traditional method.

Table 3.2 ANCOVA Analysis of the Subjects Achievement of Pretest Scores

Source of Variance	*DF Squares*	*Sum of Squares*	*Fcal*	*Fcrit*	*Significance*
Between groups	1	0.203	0.203		
Within groups	28	19.995	0.714	0.28	
Total	29	20.198			

From the ANCOVA analysis of the subject's achievement of pretest scores, the Fcrit. Of 4.20 is greater than the Fcal of 0.28. Therefore, we do not reject the null hypothesis. This means that significant differences do not exist in the mean achievement scores of the subject taught automobile fault detection with (OBDS) and those taught with the traditional method, before the treatment of the experimental group.

Table 3.3 ANCOVA Analysis of the Subjects Achievement Scores for Post-test

Source of Variance	*DF Squares*	*Sum of Squares*	*Fcal*	*Fcrit*	*Significance*
Between groups	1	21.393	21.393		
Within groups	28	1.362	0.049	0.28	
Total	29	22.755			

The Fcrit. Value of 4.20 is less than Fcal of 436.59. Therefore, we reject the null hypothesis. This implies that significant differences exist in the mean achievement scores of the subjects taught Automobile fault detection using (OBDS) and those taught the same with traditional method. The achievement was recorded after the treatment of the experimental group with (OBDS).

Table 3.4 ANCOVA Analysis of the Subjects Retention Scores

Source of Variance	*DF Squares*	*Sum of Squares*	*Fcal*	*Fcrit*	*Significance*
Between groups	1	14.106	14.106		
Within groups	28	7.287			
Total	29	21.393			

The Fcrit value of 4.20 is less than Fcal of 54.25. Therefore, we reject the null hypothesis. This implies that significant differences exist in the mean retention scores of the subjects taught Automobile fault detection with (OBDS) and those taught with the traditional method. In effect, two weeks after the posttest the experimental group retained more of their scores in respect of the OBDSAT

Summary of Findings

Before the experiment, the pre-test mean achievement scores showed that both the experimental group and control group were almost at par in respect of achievement in the OBDSAT scores. This was supported by the null hypothesis which showed that significant differences do not exist in the mean achievement scores of the subjects taught fault detection in Automobile with (OBDS) and those taught same with the traditional method.

After the treatment of the experimental group with OBDS, the mean achievement and retention scores of the experimental group were higher than those of the control group. These results were supported by the null hypothesis which indicated that significant differences existed between the subjects taught Automobile fault detection with OBDS and those taught the same with the traditional method.

Discussion of Findings

The findings of the experiment clearly showed that many of the motor mechanics (in this instance Toyota-Japanese brand) are not conversant with On-Board Diagnostics System (OBDS). Obvious lack of the relevant skills to manipulate the equipment played out in the experiment. The unfortunate development implies that these crupts of mechanics lacked the needed equipment to handle the maintenance and repairs of the millennium vehicles this experiment was carried on. The competency needed to maintain and repair the millennium vehicles because of the enhanced technology involved in the manufacture are high. The millennium vehicles experimented with are fitted with so many digital sensors. The status of the functioning of such sensors is only accurately detected using the OBDS. Therefore, operators of millennium vehicles should beware of submitting their vehicles for trial and error which would rather mar the performance of the vehicle than make it.

4. Conclusion

The National Policy on Education states that Technical and Vocational Education and Training (TVET) is facing many challenges. Two of the challenges are inadequate equipment and training materials. Research has been on in developed technology in the automobile industry to manufacture on-board diagnostic equipment. The relative successes of the research developed the onboard diagnostic tool I(OBD I), later improved on it to have OBD II. Currently, the continuing research has developed multi-purpose on-board diagnostic equipment. This current diagnostic equipment has the capacity to scan different makes and models of the millennium vehicles.

Before this era of modern diagnostic equipment, fault detection and troubleshooting activities were done by trial and error. The troubleshooting and fault detection activities employed the sense of sight, hearing, smell, feeling, and touch. The quasi-experiment conducted by the researcher proved that the efficacy of the traditional method of fault detection and troubleshooting was highly defective. It becomes imperative that institutions offering Automobile mechanics technology should embrace modern technological equipment and training materials for the training of the students and artisans so that they will align with modern technology in the industry.

The Nigerian Institution of Automobile Engineers under the auspices of the Nigerian Society of Engineers should rise to challenges of the occasion to ensure proper regulation of the industry.

5. Recommendations

Following the findings, the researcher recommends as follows:

1. A review of the teaching method used by teachers in teaching Auto technology.
2. That the relevant authorities should embrace the modern technological tools in teaching practical automobile technology.
3. That the use of on-board diagnostic tools should take the place of the traditional fault detection technique in automobile fault detection and troubleshooting using the sense of sight, hearing, smell, touch and feel.
4. Nigerian Institution of Automobile Engineers should be entrusted with the regulation of the motor mechanics practice at all levels.
5. Nigerian Institution of Automobile Engineers should be empowered to embark on an aggressive capacity-building campaign of the mechanics who are not OBDS compliant.
6. A moratorium of five years should be allowed the mechanics to acquire the skill and the equipment. At the end of which those who have complied should be certified/licensed to handle millennium vehicles. Those who fail to meet up should be banned from further operations in the overall public interest.
7. In addition, the certification/license to operate should be renewable after the periodic refresher course (annually).
8. Alternatively, training the trainer's arrangement could be entered into with the various leaderships of the mechanic cluster groups and the relevant government agency for the capacity building and training.
9. Those who flout the refresher course requirement should be banned from running motor mechanic workshops.
10. The ignorant/unsuspecting millennium vehicle owners should be spared the agony of trial-and-error muss in the hands of uncertified/unlicensed motor mechanics by having the certification/license boldly inscribed at the entrance of the mechanic workshop. In the absence of that anyone who patronizes such does at his/her peril.

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