AJSSM
African Journal of Social Science and Management

African Journal of Social Science and Management
ISSN: 3141-5369
Journal homepage: www.ajssm.com

Research article

Technical skills of diagnostic monitors for optimising petrol engine maintenance instruction in technical colleges in Southeastern Nigeria

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Abstract
The study was on the utilization of diagnostic monitors for optimizing Petrol Engine Maintenance (PEM) instruction in Nigerian Technical Colleges. The study was structured around two central research questions and a corresponding hypothesis. This descriptive survey study utilized Borich's needs assessment model to evaluate competency gaps among automotive educators in Southeastern Nigeria. A 15-item questionnaire was administered to a sample of seven technicians and 58 Motor Vehicle Mechanics' Work (MVMW) teachers. The instrument achieved a Cronbach's Alpha reliability coefficient of 0.93 following face validation by three experts. Descriptive statistics, specifically mean scores and the Improvement Need Index (INI), answered the research questions, while Analysis of Variance (ANOVA) tested the hypothesis. The assessment indicated a critical deficiency in on-board diagnostic (OBD) system competencies among the teachers. Based on this result, the study advocates for institutionalized in-service training to upskill MVMW teachers in modern electronic diagnostics.

Keywords: Borich's needs assessment, diagnostic monitors, Motor Vehicle Mechanics' Work (MVMW), On-Board Diagnostics (OBD), Petrol Engine Maintenance (PEM), Southeastern Nigeria, technical colleges.

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How to cite this article: Igwe, N. (2026). Technical skills of diagnostic monitors for optimising petrol engine maintenance instruction in technical colleges in Southeastern Nigeria. *African Journal of Social Sciences and Management, 1*(2): 60-67.

INTRODUCTION

The integration of automotive computing prompted an industry-wide mandate for diagnostic standardization. Consequently, the Society of Automotive Engineers (SAE) introduced the On-Board Diagnostic (OBD) standard in the 1980s, primarily aimed at mitigating exhaust emissions and accelerating fault detection and rectification. In its current iteration, the OBD-II system generates raw data compiled as Diagnostic Trouble Codes (DTCs). Because these codes require decoding to become actionable repair intelligence, specialized software applications are utilized to translate the raw telemetry. While experienced technicians can decipher these codes natively, interactive software interfaces significantly optimize the diagnostic workflow. To facilitate this, various developers have engineered proprietary OBD-II software tailored for dedicated diagnostic scanners, personal computers, and mobile platforms. Many of those packages are very well designed, with excellent user interfaces, data interpretation, graphic depictions of data, and ways to show how different data points are interrelated and affect each other (Conrad, 2012). Software interprets the codes.

According to Smith (2006) OBD Pending Codes are also referred to as "continuous monitor" and "maturing codes". Intermittent faults initially trigger the storage of a pending code within the vehicle's On-Board Diagnostic (OBD) memory. Should the malfunction fail to recur within 40 subsequent engine warm-up cycles, the system automatically purges the transient code. Conversely, if the fault persists across a predetermined threshold, the pending code matures into a definitive Diagnostic Trouble Code (DTC), illuminating the Malfunction Indicator Lamp (MIL)—historically designated as the "Check Engine" or "Service Engine Soon" light. These five-digit alphanumeric DTCs are established to assist technicians in isolating the root cause of system failures. To ensure cross-brand compatibility, standardized "Generic DTCs" are implemented across all compliant vehicles, enabling a universal scan tool to interface with diverse makes and models. Typically prefixed with "P0" or "P2" to denote powertrain anomalies (e.g., P0120 or P2310), these standardized codes were fundamentally engineered to mitigate excessive vehicular emissions by flagging component failures early. On-Board Diagnostic System (OBDS) operates in an automobile.

Automobile technology involves the application of scientific knowledge in the design, selection of materials, construction, operation, maintenance and improvement of the automobile (Forster, 1992). Automobile craft represents a core vocational programme established within the technical college curriculum. Olufemi and Anthony (2010) stated that in Nigeria, technical colleges produce craftsmen for various sectors of the economy including craftsmen in automobile and are regarded as the principal vocational institutions for such purposes. Technical colleges provide a diverse array of mechanical engineering trades, prominent among which is Motor Vehicle Mechanics' Work (MVMW). In Nigeria, the MVMW curriculum is strategically engineered to train competent, high-skilled automotive craftsmen capable of driving the nation's technological advancement and industrial growth. According to National Board for Technical Education (NBTE, 2009), auto-mechanics craftsmen are expected to test, diagnose, service and completely repair any fault on the motor vehicle to the manufacturer's specification. To standardize instructional quality, all technical colleges accredited by the National Board for Technical Education (NBTE) adopt a uniform national curriculum. The Motor Vehicle Mechanics' Work (MVMW) program is structured to integrate a comprehensive secondary general education with specialized occupational training. Ultimately, the primary mandate of the MVMW trade is to equip recipients with the practical competencies demanded by the contemporary automotive industry. A critical module within this trade is Petrol Engine Maintenance (PEM), which aims to produce proficient craftsmen capable of understanding fundamental operating principles and executing general maintenance and reconditioning tasks. Key instructional objectives require trainees to master the basic operational mechanics of petrol engines to restore them to peak

performance, alongside grasping the functional principles of vehicular fuel systems. Attaining these objectives necessitates an innovative, diagnostic-driven instructional mechanism capable of early fault identification and remediation.

Consequently, MVMW educators must continuously align themselves with technological advancements to maintain instructional relevance and efficacy. This demands continuous professional up skilling and continuous capacity building to remedy identified pedagogical or technical deficiencies. While Nigerian technical college instructors are structurally expected to exhibit high proficiency in teaching PEM, empirical evidence suggests a significant competency gap. A prominent technological milestone in modern automotive engineering is the integration of On-Board Diagnostic Systems (OBDS). Crucially, the ongoing technological evolution of OBDS operates independently of the instructors' static teaching experience. Given that these MVMW educators are civil servants employed under the Ministry of Education, institutional intervention through structured training is essential to bridge this technological divide. As a civil servant he/she has 35 years of service to put in his/her knowledge, skill and energy in teaching, provided he/she has not attained the age of 60 before the 35 years (Daily Trust, 2009). The study surveyed a teaching faculty of varying experience levels—ranging from 0 to 35 years of service—alongside five on-board diagnostic technicians.

While official course specifications require teachers to instruct students on sensors, actuators, computerized ignition, and electronic diagnostics, these topics are currently delivered in isolation. To improve instructional efficacy, teachers must shift toward a holistic approach that highlights how these parts interact. Ultimately, the modern On-Board Diagnostic System (OBDS) is the functional intersection of these interrelated electronic components and advanced emission control innovations. Most teachers do not teach OBDS effectively, because they lack the competence to do so (Odigiri, 2004). Consequently, a pivotal question arises: what pedagogical and technical interventions must Motor Vehicle Mechanics' Work (MVMW) teachers adopt within Petrol Engine Maintenance (PEM) instruction to ensure graduates possess the competencies required to service modern, OBD-compliant vehicles? To address this challenge, it is imperative to identify the specific competency gaps of MVMW instructors regarding the application of diagnostic monitors. Bridging this instructional divide is crucial for aligning technical college training with contemporary automotive manufacturing standards.

This study, therefore, aims to investigate the competency improvement needs of Motor Vehicle Mechanics' Work (MVMW) educators regarding the integration of on-board diagnostic software for teaching Petrol Engine Maintenance in Nigerian technical colleges. To achieve this overarching purpose, the study specifically addresses the following objectives:

i. to isolate the core competencies required by MVMW teachers for the operational use of diagnostic monitors in petrol engine maintenance pedagogy.
ii. to determine the precise baseline competency gaps and improvement needs of the teachers in applying these diagnostic monitors within the workshop and classroom.

To provide statistical direction, the following null hypothesis was formulated and tested at the 0.05 probability level of significance:

Ho: No significant difference exists in the mean responses of technical college teachers, based on their years of teaching experience, regarding the diagnostic monitoring competencies required for effective instructional delivery in Petrol Engine Maintenance.

RESEARCH METHOD AND MATERIALS

This study adopted a descriptive survey research design integrated with the Borich Needs Assessment Model. Grounded in the framework established by Borich (1980), this model mandates the calculation of a Mean Weighted Discrepancy Score (MWDS) for each individual competency, item, or instructional activity evaluated. Within this analytical framework, a competency discrepancy is quantified by systematically comparing the participants' current observable behaviors, technical skills, and baseline competencies against the benchmark goals and performance standards of the educational programme "a discrepancy analysis that identifies the two polar positions of what is and what should be". Furthermore, this analytical framework facilitates a comparative evaluation that contrasts a target group's perceived level of current competence against their desired level of proficiency required to execute a specific task.

Method of data analysis

The statistical tools used for data analysis and hypothesis testing are descriptive and inferential statistics which include Weighted Mean scores and Improvement Needed Index (INI) framework. The hypothesis testing was evaluated using Analysis of Variance (ANOVA) at alpha = 0.05 level of significance. Decision rule is that items with a mean score of 3.50 are considered as needed, while items with a mean score < 3.50 are considered as not needed. The 3.50 cutoff is mathematically justified as the lower real limit of the 4.00 scale interval (representing "averagely needed"). The Improvement Needed Index (INI) Formula was used to calculate the index; the mean of the "needed" category and the mean of the "performance" category were computed. The discrepancy value was derived. The resulting values were interpreted using three criteria:

i. Positive Difference: this indicates that improvement is required because the level of need exceeds current performance.
ii. Negative Difference: this implies that no improvement is required because the teachers' current performance mean is higher than the required competence level.
iii. Zero Difference: this shows that a neutral state requiring no intervention. This occurs when importance and performance scores are balanced across all dimensions: Very Highly Needed = Very High Performance; Highly Needed = High Performance; Averagely Needed = Average Performance; Slightly Needed = Low Performance and Not Needed = Very Low Performance (Olaitan & Ndomi, 2000).

Target population

The target population for this study comprised instructors of Motor Vehicle Mechanics' Work (MVMW) from the 40 technical colleges accredited by the National Board for Technical Education (NBTE) across the Southeastern States of Nigeria. The sample size is 65 respondents, consisting of seven specialized On-Board Diagnostic System (OBDS) technicians and all 58 instructors of Motor Vehicle Mechanics' Work (MVMW). Methodologically, the cohort of technicians provided data to address objective one, whereas the entire faculty of technical instructors' responses were used to evaluate objective two.

Geographical scope of the study and instrumentation

The study was carried out in the five Southeastern states of Nigeria: Abia, Anambra, Ebonyi, Enugu, and Imo. This region features numerous commercial vehicle maintenance workshops, as well as an active automotive assembly and service plant in Enugu State, providing an ideal environment

and an adequate pool of respondents for this technical assessment. The list of accredited technical colleges within the study area was verified through the respective State Ministries of Education.

A 15-item structured questionnaire was utilized to assess teachers' competency improvement needs regarding OBDS diagnostic software. The instrument employs a dual-column, five-point Likert scale to evaluate items across two parallel categories: "Needed" (Very Highly Needed = 5 down to Not Needed = 1) and "Performance" (Very High Performance = 5 down to Very Low Performance = 1). Face validation was performed by three experts, and the instrument's internal consistency was established using the Cronbach's alpha method, which yielded a highly acceptable reliability coefficient of 0.93.

RESULT PRESENTATION AND DISCUSSION

The results of the analyzed data are presented in Tables 1 and 2 in accordance with the specific research objectives and hypothesis of the study.

Objectives one and two

Table 1. Mean ratings and discrepancy scores of technical teachers on diagnostic monitors competencies

No	Item statement	$\bar{x}N$	$\bar{x}P$	$\bar{x}N - xP$	Remark
1	Interpret diagnostic trouble codes	5	1.1	3.90	RIN*
2	Differentiate among the codes	5	1.1	3.92	RIN
3	Identify maintenance reminder lamps	4.9	4.9	0.06	RIN
4	Identify malfunction indicator lamp	5	5	-0.02	RINN**
5	Interpret malfunction indicator lamp	4.9	5	-0.02	RINN
6	Turn off malfunction indication lamp manually	4.9	1.4	3.56	RIN
7	Differentiate between malfunction indicator lamp and maintenance reminder lamps	4.9	4.8	0.04	RIN
8	Identify freeze frame data of engine conditions	5	1.1	3.90	RIN
9	Identify catalytic converter	5	5	-0.02	RINN
10	Identify engine control unit	4.9	3.5	1.44	RIN
11	Interpret diagnostic tests on engine control unit monitor	4.9	1.1	3.86	RIN
12	Monitor the operations of vehicle's emission-related components in engine control unit monitor	3	3	0.00	NR
13	Differentiate between trip drive cycle and On-board diagnostic drive cycle	5	1.1	3.90	RIN
14	Interpret preset reference value in on-board computer	5	1.1	3.88	RIN
15	Interpret parameter identification number codes	5	1.1	3.92	RIN

*Required and Improvement Needed, **Required but Improvement is not Needed, ***Not Required

Table 1 indicates that 11 competency items are required and present clear instructional improvement needs for the teachers. While an additional three items are necessary for classroom instruction, the teachers' performance levels preclude the need for further up skilling on them. For item 12, respondents uniformly reported average ratings across both dimensions. Therefore, the essential OBDS diagnostic software competencies required for effective instruction in Petrol Engine Maintenance, along with the identified improvement needs, comprise the following:

i. Interpreting diagnostic trouble codes
ii. Differentiating among the codes

iii. Identification of maintenance reminder lamps
iv. Turning off malfunction indication lamp manually
v. Differentiating between malfunction indicator lamp and maintenance reminder lamps
vi. Identification of freeze frame data of engine conditions
vii. Identification of engine control unit
viii. Interpreting diagnostic tests on engine control unit monitor
ix. Differentiating between trip drive cycle and On-board diagnostic drive cycle
x. Interpreting preset reference value in on-board computer
xi. Interpreting parameter identification number codes

Hypothesis

Ho: No significant difference exists in the mean responses of technical college teachers, based on their years of teaching experience, regarding the diagnostic monitoring competencies required for effective instructional delivery in Petrol Engine Maintenance.

Table 2. Analysis of Variance (ANOVA) Summary for Teachers' Ratings Based on Teaching Experience

Source of Variation	Sum of Squares	Degrees of Freedom (df)	Mean Square	Calculated F-Value (F-cal)	Critical F-Value (F-tab)
Between Groups	1.7603	6	0.2934	3.41	2.32
Within Groups	20.425	43	0.475		
Total	22.1853	49			

ANOVA result in Table 2 reveals a statistically significant difference in the instructors' mean responses based on teaching experience, as the calculated value of 3.41 is greater than the critical table value of 2.32. Accordingly, the null hypothesis is rejected, indicating that years of teaching experience significantly influence teachers' perceptions of diagnostic monitors' competencies.

Discussion of findings

Technological innovations have transformed the automotive industry, rendering traditional mechanical repair skills insufficient and introducing a critical need for advanced diagnostic competencies. Modern vehicles imported or assembled in Nigeria feature complex and computerized systems that demand updated skill sets from auto-mechanics craftsmen seeking industry employment. Despite this industrial transformation, contemporary automotive advancements are not yet reflected in the instructional curriculum of Nigerian technical colleges. This curricular lag creates an institutional bottleneck, leaving technical college graduates ill-equipped to navigate modern workshop environments without substantial post-graduation upskilling. Invariably, there is a mismatch between the Motor Vehicle Mechanics' Work curriculum and the skills required for employment in the automobile industry (Olufemi & Anthony, 2010). Ultimately, the outdated MVMW curriculum has ruptured the link between trade theory, workshop practice, and contemporary automotive technology. This disconnects produces technical graduates who lack the requisite competencies for modern automotive employment, ultimately worsening Nigeria's unemployment crisis. Recognizing this institutional deficit, contemporary automotive industries no longer rely on the qualifications provided by technical colleges, forcing employers to look elsewhere or invest heavily in post-graduation remedial training.

Odigiri (2004), and Olufemi and Anthony (2010) studied the level of practical and theoretical knowledge of teachers of Motor Vehicle Mechanics' Work in the recent innovations of automobile. The studies shown that the teachers lack relevant competencies; which would enable them impart the innovations to the students effectively. Table 1 confirms the above assertion as it shows the data indicate that 11 essential items present distinct instructional improvement needs for the teachers. Meanwhile, an additional three items are required for teaching and learning, though the instructors already possess sufficient proficiency, eliminating any immediate need for further training on those specific tasks and learning though the teachers did not need improvement on them largely because they are more competent than what is required. Item number 12 has all the respondents responding at average this maybe because the item is ambiguous to the respondents therefore improvement is rated as not needed on the item by them. These outcomes emphasize the critical need to train technical instructors in On-Board Diagnostic (OBD) system software competencies. Given that the Engine Control Unit (ECU) acts as the operational brain of the modern automotive powertrain, mastery of diagnostic software interfaces is essential for accurate fault isolation and maintenance. Providing teachers with structured training in these digital diagnostic workflows is imperative if technical institutions are to bridge the current gap between conventional instructional theory and modern automotive service realities. It receives information from the input devices and instructs the actuators on what to perform according to the programmed preset information for the engine. The diagnostic software becomes the interface between the engine and the driver who reads what happens to the engine from the dashboard of the vehicle. Nice (2001) opined that diagnostic software bring the control of the vehicle nearer to the driver. This, the author explained, is possible through the emission control information programmed in the engine control unit. Should there be any problem in the engine; the information gets to the driver through the Diagnostic Trouble Code to the Malfunction Indicator Lamp situated at the dashboard.

These outcomes emphasise the critical need to train technical instructors in On-Board Diagnostic (OBD) system software competencies. Given that the Engine Control Unit (ECU) acts as the operational brain of the modern automotive powertrain, mastery of diagnostic software interfaces is essential for accurate fault isolation and maintenance. Providing teachers with structured training in these digital diagnostic workflows is imperative if technical institutions are to bridge the current gap between conventional instructional theory and modern automotive service realities.

CONCLUSION

Upskilling technical instructors in OBD applications fundamentally elevates the delivery of Petrol Engine Maintenance curricula, turning out economically self-reliant automotive graduates. The finding that years of teaching experience do not significantly alter instructors' mean competency ratings indicates that the demand for modern diagnostic training is a uniform challenge shared across the entire teaching cadre. Ultimately, it is concluded that Nigerian technical college teachers require immediate, structural capacity development in OBD platforms to remain instruction-ready. Left unaddressed, this pedagogical deficit will continue to leave graduates ill-prepared for modern vehicle servicing. To bridge this gap, it is recommended that:

i. School administrators systematically implement professional in-service workshops and provide study leave with pay to upgrade instructors' technical competencies.
ii. Technical institutions actively source and deploy OBD-compliant vehicles for practical training, utilizing internal budgets alongside strategic external donations from PTAs and corporate automotive donors.

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