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DEVELOPMENT AND VALIDATION OF AUTO MECHATRONICS INSTRUCTIONAL TASK SHEETS FOR AUTO MECHANIC INFORMAL APPRENTICESHIP TRAINING

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ABSTRACT

The study developed and validated an automechatronics instructional task sheet for automechanic informal apprenticeship training in Lagos State. It adopted a research and development (R&D) design. The study area was Lagos State, Nigeria, with a population comprising 427 master mechanics from the formal automotive service sector, 100 automechanics from the informal sector, and 42 educators in automotive and mechatronics engineering from technical colleges and tertiary institutions in Lagos State. A purposive sampling technique was employed to select 16 automechanics from the informal sector for trial testing of the instructional task sheet.The study utilized the Automechatronics Instructional Task Sheet Items Rating Instrument (AITSIRI) and the Automechatronics Instructional Task Sheet Evaluation Checklist (AITSEC) for data collection. Data analysis involved mean and standard deviation to analyze raters ratings and agreement, and paired sample t-tests to determine significant differences in automechatronics skills of automechanics before and after usng the instructional task sheet and test if there is a significant diffrence in the mean ratings of master mechanics and educators regarding task items considered relevant for inclusion in the instructional task sheet. Findings revealed no significant difference between master mechanics and educators rating regarding the task items' considered relevant for inclusion in the instructional task sheet. However, there was a significant improvement in automechatronics skills among mechanics before and after using the developed instructional task sheet, demonstrating its effectiveness in skill enhancement. The study recommends implementing the instructional task sheet in mechanic villages or clusters to equip apprentices with the skills needed to handle modern vehicles.

Keywords: Automechanic Informal apprenticeship training, automechatronics Instructional task sheets, development and validation

1.0 INTRODUCTION

Automechatronics is an multideciplinary field that brings together automotive technology, mechanical engineering, and mechatronics to design, develop, maintain, and repair advanced automotive systems. Automechatronics stresses on combining mechanical systems with electronics, computer controls, and sensors to create smart, efficient, and safe vehicles. The word "automechatronics" comes from the combination of "automotive" and "mechatronics," which itself is a fusion of mechanics, electronics, and computing (Bolton, 2021).

Automechatronics has gained importance due to the increasing intricacy of modern vehicles, particularly with the rise of electric vehicles (EVs), autonomous driving technologies, and advanced driver-assistance systems (ADAS).

One of the key applications of automechatronics is vehicle diagnostic and repairs. Modern vehicles are equipped with On-Board Diagnostic (OBD) systems that monitor various components of the vehicle systems and inform users about the malfunctions via Diagnostic Trouble Codes (DTCs). This helps automechatronics professional and mechanics to use OBD scanners to interprete these codes and identify faults in the systems like engine, transmision, ignition, fuel and perform necessary repairs. The Electronic Control Unit (ECU) manages important system like fuel injection, ignition timing, braking and airbag deployment which requires diagnostics that involves checking for software glitches, sensors malfunctions and actuators issues using ECU programmer and diagnostic softwares. Additionaly, Modern vehicles rely on sensors (example, oxygen sensors, and ABS sensors) and actuators (examples, fuel injectors, throttle actuators) for ideal functioning. Automechatronics allows the precise testing and calibration of these components to ensure proper functionality.

The application of automechatronics in vehicle diagnostics and repair offers numerous benefits. It allows for pinpointing issues precisely using advanced tools and systems, which helps to reduce diagnostic errors. Additionally, it speeds up repair processes, thereby reducing vehicle downtime. Another significant advantage is that it ensures vehicles meet standards and emission regulations, thereby enhancing compliance and safety

An Instructional Task Sheet is a structured guide created to aid learning and skill acquisition, usaually applicable in technical and vocational education. It outlines specific tasks, objectives, procedures, and assessment criteria to help learner's master practical skills in a methodical and organized manner. Task sheets are especially effective in informal apprenticeship training and hands-on learning environments, such as in automechatronics or other technical fields (Okoro and Udo, 2018).

The key components of an instructional task sheet include the title, learning objectives, tools and materials, pre-requisite knowledge, step-by-step instructions, and safety guidelines (Joyce, Weil, & Calhoun, 2015). The title clearly defines the task or activity that needs to be performed by learners, while the learning objectives describe what learners should achieve by the end of the task. The list of tools and materials specifies the items required for task performance, ensuring learners are adequately prepared. The step-by-step instructions provide detailed procedures for completing the task in a sequential order, ensuring clarity and consistency. Additionally, safety guidelines are included to ensure the safety of learners during task performance by highlighting necessary precautions.

Reigeluth (2013) explains that an instructional task sheet offers learners a clear and structured guide, reducing confusion and ensuring consistency in the instructions provided to all learners. It emphasizes the development of specific, measurable skills and enables learners to work at their own pace, revisiting steps as necessary

Automechanic informal apprenticeship training in Nigeria is a predominant mode of skill acquisition in the automotive informal sector, where would-be auto-mechanics and technicians learn on the job under the guidance of experienced master craft person. This traditional system of apprenticeship traning plays an important role in furnishing individuals with hands-on skills, particularly in low-income and rural areas, where formal training opportunities are limited.

In Nigeria, informal apprenticeships in the automotive informal sector are characterized by an unstructured curriculum and lack of standardized training modules (Palmer and Afenyandu, 2013). Instead, training is based on observation, practice, and the mentorship provided by the master craftsperson. Apprentices learn skills such as engine diagnostics, vehicle repairs, electrical system troubleshooting, and bodywork through practical engagement over several years.

The informal apprenticeship system plays a vital role in youth employment and workforce development; however, it faces significant challenges, including outdated techniques, limited access to modern tools, and insufficient theoretical knowledge. Modern vehicles are increasingly equipped with advanced electronic control systems, onboard diagnostics (OBD), and sophisticated safety features that require specialized tools and expertise. Informal mechanics often lack the necessary diagnostic tools and technical knowledge to handle these complex systems effectively. Since informal mechanics primarily acquire skills through traditional apprenticeship systems that emphasize conventional mechanical repairs, their ability to adapt to advancements in automotive technology is limited. Developing structured guides, such as automechatronic instructional task sheets, for training informal automotive mechanics in automechatronics can address these gaps and equip them with the skills required to keep pace with modern automotive technology advancements.

1.1 Purpose of the Study

The main purpose of this study was to develop and validate auto mechatronics instructional task sheet for auto mechanic informal apprenticeship training in Lagos State. Specifically, the study sought to determine:

1. The task items for the auto mechatronics instructional task sheets for auto mechanic informal apprenticeship training.
2. If the developed auto mechatronic instructional task sheet significantly improves the acquisition of diagnostic and repair skills among auto mechanics/apprentices.

1.2 Research Questions

The following research questions guided the study.

1. What are the task items of the auto mechatronics instructional task sheet?
2. Does the developed auto mechatronic instructional task sheet significantly improve the acquisition of diagnostic and repair skills among auto mechanics/apprentices?

1.3 Hypotheses

The following null hypotheses were tested at .05 level of significance:

1. There is no significant difference in the mean ratings of educators and master mechanics on the task items considered relevant for inclusion in the auto mechatronics instructional task sheet.
2. There is no significant difference in the auto mechatronic skills of auto mechanics before and after using the auto mechatronic instructional task sheet (AITS).

2.0 METHOD

Research and development (R & D) research design was adopted for the study. Research and development is a process that involves the preparation of new educational materials, the introduction of procedures/programmes and systematic trying out in which feedback is gotten and the feedback can be used for enriching the educational experience of students. According to Nworgu (2015), research and development is a process whereby educational products such as textbooks, equipment or curricular are developed and trial-tested in the field to ensure their effectiveness. The study was conducted in Lagos; a major state in Nigeria, located in the southwestern part of the country along the coast of the Gulf of Guinea with Latitude and longitude coordinates of 6.465422 and 3.406448. The population for this study consisted of a total of 469 participants. This included 42 educators specializing in technical education in the fields of automobile and mechatronics, drawn from technical colleges and tertiary institutions in Lagos. Additionally, the study involved 100 auto mechanics from the informal sector, such as roadside workshops, all located in Lagos State, Nigeria. The researcher utilized the entire population of 469 participants, which comprised 42 educators in technical education specializing in automobile and mechatronics from technical colleges and tertiary institutions, 427 master mechanics from the formal automotive industry, and 100 auto mechanics from the informal sector (roadside workshops) in Lagos State. Sampling was not employed in the selection of the educators and the master mechanics from the formal automotive sector. The study adopted a census approach and a cluster sampling technique to select the 16 informal auto mechanics from the mechanic clusters in Lagos state.

2.1 Method of Data Collection

The Automechatronics Instructional Task Sheet Rating Instrument (AITSIRI) was used to collect data from experts (educators and master mechanics) to evaluate the suitability of the items proposed for inclusion in the instructional task sheet. A total of 496 copies of AITSIRI were administered to these experts by the researcher and research assistants for rating the instructional task sheet items. After completion by the experts, the instruments were retrieved, with 491 copies successfully collected, corresponding to a 98% return rate.

The Automechatronic Instructional Task Sheet Evaluation Checklist (AITSEC) was used by the researcher to collect data from the trial group during the evaluation stage of the instructional task sheet development. AITSEC was a checklist used by the researcher and two trained research assistants to evaluate the performance of the auto mechanics used for the trial testing. The researcher used the checklist to score the subjects on skills and task performance (accuracy and time taken). Copies of the instrument were presented to the auto mechanics so that they could perform the tasks listed on it following the instructions mean while the researcher and the research assistants observed, scored, and recorded the time it took for the completion of the tasks. The AITSEC was administered before and after the training of the auto mechanics using the developed AITS.

2.2 Method of Data Analysis

The mean was used to address research questions 1, while the standard deviation was used to analyze the level of agreement or consensus among the experts (educators and master mechanics) who evaluated the items/components of the instructional task sheet. Items with mean ratings of 4.0–5.0 and 3.5–3.9 were considered to reflect very high and high agreement, respectively, while items rated 3.0–3.4 were considered neutral. Conversely, items with mean ratings of 2.0–2.9 and 1.0–1.9 were categorized as indicating low and very low agreement, respectively. The research hypotheses were tested at a 0.05 level of significance using paired sample t-tests. The probability values (P-values) obtained for the groups after data analysis was less than the 0.05 alpha value. This indicates that there were no significant differences in the mean ratings of both educators and master mechanics on the task items of the auto mechatronic sinstructional task sheet. However, there was a significant difference in the performance of auto mechanics in auto mechatronic skills before and after using the instructional task sheet. Consequently, all the hypotheses were rejected.

2.3 Data Presentation

Research Question 1

What are the task items necessary for inclusion in the auto mechatronics instructional task sheet?

Table 1: Mean Ratings of Experts (Educators and Master Mechanics) and Standard Deviations on task items for Inclusion in the Auto-mechatronic Instructional Task Sheet. N = 563

S/N	Use Automobile Diagnostic and Repair tools such as:	X	SD	Remarks
1	Identify parts of the multi-meter-display screen, dial/selector switch, ports for probes, probes (red for positive and black for negatives	4.01	0.10	R
2	Set up the multi-meter- Insert the black probe into the COM (common) port; insert the red probe into the VΩmA port for most measurements	4.86	0.57	VR
3	Measure electrical quantities -voltage, current, resistance using the multi-meter	4.04	0.20	R
4	Measure continuity using the multi-meter	4.58	0.47	VR
5	Measure battery voltage using the multi-meter and interprete the results	4.23	0.42	R
6	Locate OB II scanner port under the vehicle	4.76	0.57	VR
7	Connect OBDII scanner to OBD II port using blue tooth adaptor, cable and pair blue tooth adaptor with smartphone or tablet	4.14	0.35	R

8	Turn on the OBD II scanner and navigate the menu	4.25	0.44	R
9	Select diagnostic option on the menu, read and interprete DTC	4.12	0.33	R
10	Identify different types of wrenches and select the right type of torques wrench suitable for the job/task	4.30	0.46	R
11	Set the desired torque and position the torque wrench by placing the socket on the torque wrench and fitting the socket onto the bolt or nut.	4.29	0.46	R
12	Follow tips for proper use of torque wrenches	4.24	0.43	R
13	Follow safe tips on how to use fuel pressure guage	4.31	0.46	R
14	Locate fuel pressure test port by referring to the service manual	4.26	0.44	R
15	Relive fuel pressure system	4.25	0.44	R
16	Connect fuel pressure guage and check leaks	4.19	0.39	R
17	Read and record fuel pressure guage and compare the fuel pressure reading to the specifications provided in the service manual.	4.12	0.33	R
	Use Vehicle Service Information			R
18	Identify the correct service manual by ensuring the manual corresponds to the vehicle’s make, model, and year	4.30	0.46	R
19	Familiarize with the section of the service manual such as content, index and introduce to quickly locate specific topic or component	4.20	0.43	R
20	Follow troubleshoot guide or diagnostic flow chart to diagnose issues	4.27	0.47	R
21	Identify and access technical service bulletin and follow instruction on TSBs to diagnose and repair vehicles	4.29	0.48	R
	Follow Procedures for Diagnosis and Repair of Sensors			R
22	Identify symptoms of different types of sensors such as poor fuel economy, rough idle, or Check Engine Light (CEL) codes related to oxygen sensor malfunction.	4.15	0.36	R
23	Visually inspect sensors checking for damages, loose connections, corrosion, alignments	4.35	0.48	R
24	Test the voltage output of the different types of sensors using a multi-meter	4.37	0.49	R
25	Test the resistance of different types of sensors using a multi-meter	4.15	0.36	R
26	Replace a faulty sensors following service manual guide and clear DTC related to malfunction sensors	4.25	0.44	R
27	Check engine temperature range	4.02	0.14	R
28	Scan for DTC related to sensors using OBD II scanner	4.86	0.59	

29	Test the CKP sensor output signal	4.02	0.14	R
30	Replace or repair crankshaft position sensor if tests show its faulty	4.76	0.58	VR
31	Test camshaft position output signal such as voltage and resistance	4.26	0.44	VR
32	Test knock sensor voltage output signal and resistance using multi-meter	4.68	0.48	VR
33	Replace faulty knock sensor and clear DTCs associated with faulty knock sensor	4.13	0.34	R
34	Test intake air temperature sensor output (voltage) using the multi-meter and comparing values with service manual specifications	4.25	0.44	R
35	Replace faulty intake air temperature sensor	4.18	0.39	R
36	Test oil pressure sensor output following manufacturer’s instructions	4.24	0.43	R
37	Check oil level and perform oil pressure test	4.21	0.41	R
38	Replace faulty oil pressure sensor	4.18	0.39	R
39	Test for fuel pressure sensor output	4.28	0.45	R
40	Check for fuel pressure fuel pressure gauge	4.25	0.44	R
41	Replace fuel pressure sensor if testing shows signs of damage	4.27	0.45	R
42	Inspect the EGR valve and its wiring for damage, corrosion, or loose	4.30	0.46	R
43	Test Exhaust gas recirculation (EGR) position sensor output	4.09	0.29	R
44	Check EGR valve-verify the operation of the EGR valve, ensuring it opens and closes properly	4.09	0.29	R
45	Replcae EGR position sensor if test shows signs of damage	4.13	0.34	R
46	Use a diagnostic scan tool to retrieve fault codes stored in the ECU by a faulty MAP sensor	4.12	0.33	R
47	Check MAP sensor voltage signal(output)	4.25	0.44	R
48	Inspect vacuum lines	4.14	0.35	R
49	Use diagnostic test tool to test the functionality of a MAP sensor	4.15	0.36	R
50	Replace a faulty MAP sensor following service manual instructions	4.27	0.45	R
51	Check for TPS-related error codes using an OBD-II scanner	4.16	0.58	R
52	Check for ECT-related error codes using an OBD-II scanner.	4.21	0.41	R
53	Test ECT sensor resistance with a multimeter	4.12	0.33	R
54	Measure coolant temperature with infrared thermometer or scan tool	4.20	0.40	R
55	Replace ECT sensor if resistance is outside of specifications or if sensor is faulty	4.23	0.42	R

56	Test wheel speed sensor voltage output	4.16	0.37	R
57	Replace faulty wheel speed sensor following service manual instructions	4.08	0.27	R
58	Test brake pad wear sensor continuity	4.11	0.31	R
59	Replace worn brake pad and set reset brake pad wear indicator light if applicable	4.14	0.35	R
60	Check brake fluid level sensor resistance using multimeter	4.21	0.41	R
61	Check fluid reservoir level and inspect fluid leaks	4.23	0.42	R
62	Replace brake fluid level sensor if faulty	4.39	0.49	R
63	Perform electrical and functional test of the BPPS using a multimeter and OBD tool	4.15	0.36	R
64	Remove and replace old sensor if faulty	4.35	0.48	R
65	Recalibrate the BPPS	4.37	0.49	R
66	Locate and access the transmission fluid sensor following the service manual instructions	4.15	0.36	R
67	Measure sensor resistance of transmission fluid sensor and interpret results	4.25	0.44	R
68	Replace the faulty transmission fluid sensor if testing shows damage	4.02	0.14	R
69	Locate the transmission fluid pressure sensor-follow the instruction on the service manual to locate the sensor	4.86	0.59	VR
70	Measure the resistance of the transmission fluid pressure sensor cold	4.02	0.14	R
71	Heat the sensor (if necessary) and measures sensor resistance (hot)	4.76	0.58	VR
72	Test the resistance of the transmission range sensor	4.26	0.44	R
73	Replace or repair the TRS if testing shows sign of damage	4.68	0.48	VR
74	Use a multi-meter to test the steering angle sensor's resistance or voltage output to confirm if it is faulty.	4.13	0.34	R
75	Replace the steering angle sensor if fault is found	4.25	0.44	R
76	Test the toque sensor output	4.18	0.39	R
77	Replace the torque sensor if faulty	4.24	0.43	R
78	Test yaw rate sensor output and replace if faulty	4.21	0.41	R
79	Use the OBD-II scanner or diagnostic tool to identify any trouble codes related to the yaw rate sensor.	4.18	0.39	R
80	Use an OBD-II scanner to check for fault codes related to the G sensor	4.28	0.45	R

81	Use a multi-meter to measure the voltage or resistance output of the G sensor	4.25	0.44	R
82	Replace a faulty G-sensor following service manual procedures	4.27	0.45	R
83	Use a TPMS scan tool to read error codes and identify the faulty sensor.	4.30	0.46	R
84	Use the TPMS scan tool to program the new sensor to the vehicle's system.	4.09	0.29	R
85	Check for physical damage to the ignition switch and associated wiring	4.09	0.29	R
86	Measure voltage at various key positions to ensure proper electrical continuity and signals of ignition switch position sensor	4.13	0.34	R
87	Replace the ignition switch position sensor if faulty	4.12	0.33	R
88	Check for physical damage to the battery temperature sensor, wiring, and connectors.	4.25	0.44	R
89	Measure the resistance of the sensor at various temperatures to ensure the battery temperature sensor is within the specified range.	4.14	0.35	R
90	Compare the readings with the specifications in the service manual	4.15	0.36	R
91	Repair or replace the battery temperature sensor if faulty	4.27	0.45	R
92	Test the battery voltage sensor and replace if faulty or damage	4.16	0.58	R
93	Test the battery current sensor by verifying if the sensor's readings match the actual battery current.	4.21	0.41	R
94	Replace battery current sensor if faulty	4.12	0.33	R
	Follow Procedures for Diagnosis and Repair Actuators			
95	Check for symptoms of a faulty actuators-listen to noises, wears, obvious damages, leaks	4.22	0.42	R
96	Inspect fuse, check switch and wiring of actuators	4.26	0.44	R
97	Test power window actuator	4.16	0.37	R
98	Replace power window actuators if test shows its faulty	4.14	0.35	R
99	Perform brake fluid inspection	4.17	0.38	R
100	Perform mechanical testing	4.18	0.39	R
101	Repair the master cylinder	4.23	0.42	R
102	Repair calipers or wheel cylinders	4.13	0.34	R
103	Bleed the brake system	4.15	0.36	R
104	Use an OBD-II scanner to check for any error codes related to the transmission system	4.17	0.38	R

105	Check transmission fluid	4.20	0.40	R
106	Check for any obvious signs of leaks in the power steering fluid lines, hoses, and around the actuator.	4.26	0.44	R
107	Use a diagnostic scan tool to check for any error codes related to the power steering system, especially in vehicles with electric power steering	4.27	0.45	R
108	Relace power steering fluid, bleed system if applicable	4.27	0.45	R
109	Inspect the suspension components, including the actuators, for any visible damage, leaks, or corrosion.	4.26	0.44	R
110	Check the electrical connectors and wiring for signs of wear, corrosion, or disconnection.	4.16	0.37	R
111	Perform ride height measurement in suspension systems	4.13	0.34	R
112	Replace suspension actuators	4.19	0.39	R
113	Check for any visible signs of damage, wear, or leaks in the turbocharger actuator and associated vacuum lines or wiring.	4.17	0.38	R
114	Inspect the turbocharger for signs of oil leaks, which could indicate a failing seal.	4.24	0.43	R
115	Perform a boost pressure test	4.14	0.35	R
116	Check actuator function test, check actuator movement	4.48	0.50	R
117	Use handheld vacuum pump to adjust the actuator rod length and ensure it opens and closes the waste gate at the correct pressure-pneumatic actuators	4.46	0.50	R
118	Check for visible signs of leaks or damage around the thermostat housing.	4.50	0.50	VR
119	Inspect coolant levels and look for any signs of coolant contamination, such as oil or debris in the coolant.	4.54	0.50	VR
120	Do a thermostat function test	4.47	0.50	VR
121	Perform coolant flow check	4.41	0.49	VR
122	Drain coolant, replace thermostat	4.57	0.50	VR
123	Bleed the cooling system	4.51	0.50	VR
124	Fix issues such as inconsistent cabin temperatures, lack of air movement from certain vents, or unusual noises from the HVAC system.	4.51	0.50	VR
125	Inspect the HVAC actuators and surrounding components for visible damage, loose connections, or obstructions.	4.50	0.50	VR
126	Check for diagnostic trouble codes (DTCs)	4.45	0.50	R
127	Perform manual testing of the HVAC system	4.49	0.50	R

128	Remove faulty actuators and replace with a new one (if necessary)	4.48	0.50	R
129	Check for symptoms of a faulty fuel injector such as engine misfire. poor fuel economy	4.49	0.50	R
130	Perform fuel pressure test, injector pulse test, injector balance test	4.46	0.50	R
131	Perform ultrasonic cleaning and flow testing	4.52	0.50	VR
132	Perform noid light testing of injector and interpret result	4.53	0.50	VR
133	Replace injector if test shows its faulty	4.57	0.50	VR
134	Check for symptoms of a faulty starter motor actuator	4.48	0.50	R
135	Perform voltage test on starter motor	4.45	0.50	R
136	Perform bench test on a starter motor	4.47	0.50	R
137	Test the starter motor solenoid	4.49	0.50	R
138	Perform voltage and resistance test of the shift solenoid sensor	4.50	0.50	VR
139	Replace solenoid shift sensor	4.36	0.48	R
140	Identify Symptoms of a Faulty Pressure Control Solenoid	4.85	0.58	VR
141	Perform resistance and voltage test	4.37	0.49	R
142	Perform hydraulic pressure test	4.79	0.57	VR
143	Perform functionality test of the pressure control solenoid	4.62	0.49	VR
144	Check Diagnostic Trouble Codes (DTCs) to verify the fault of the torque converter clutch solenoid	4.75	0.56	VR
145	Perform resistance and voltage test of the TCC solenoid	4.60	0.49	VR
146	Perform functional test of the TCC solenoid	4.26	0.44	R
147	Replace TCC solenoid if test shows its faulty	4.58	0.50	VR
	Follow Procedures for Diagnosis and Repair of Electronic Control Units and Modules	4.22	0.42	VR
148	Identify symptoms of a faulty ECU such as Check Engine Light (CEL), poor acceleration, stalling, misfires, hesitation, starting problem, hard starting	4.26	0.44	R
149	Inspect the ECU for any obvious physical damage, such as burnt components or corrosion	4.16	0.37	R
150	Check power and ground supply to the ECU	4.14	0.35	R
152	Check ECU input and out signals	4.17	0.38	R
153	Perform functional test on the ECU	4.18	0.39	R
154	Replace faulty ECU	4.23	0.42	R

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155	Perform software updates on the ECU	4.13	0.34	R
156	Visually Inspect the TCM and related wiring for any visible damage, corrosion, or loose connections	4.15	0.36	R
157	Use diagnostic scanner to read and interpret DTCs associated with TCM	4.17	0.38	R
158	Check sensors and solenoids	4.20	0.40	R
159	Check power and ground supply to the TCM	4.26	0.44	R
160	Check for TCM communication	4.27	0.45	R
161	Remove, replace and re-programme TCM	4.27	0.45	R
162	Check Warning Light-If the ABS warning light on the dashboard is illuminated, it indicates a problem with the ABS system.	4.26	0.44	R
163	Inspect the ABS module and related wiring for visible damage, corrosion, or loose connections.	4.16	0.37	R
164	Use an OBD-II scanner to read the stored fault codes.	4.13	0.34	R
165	Check the ABS Module Fuse and Relay	4.19	0.39	R
166	Test ABS pump and motor	4.17	0.38	R
167	Repair or replace ABS module	4.24	0.43	R
168	Check the ESC Warning Light	4.14	0.35	R
169	Check Wheel Speed Sensors	4.48	0.50	R
170	Inspect Brake System Components	4.46	0.50	R
171	Test ESC system	4.50	0.50	R
172	Replace blown fuses or faulty relays	4.54	0.50	R
173	Replace and recalibrate ESC module	4.47	0.50	R
174	Visual Inspection of SBW for any visible damage to the wiring, connectors, or the SBW module itself.	4.41	0.49	R
175	Perform system check on the SBW	4.57	0.50	VR
176	Perform functional test on the SBW system	4.51	0.50	VR
177	Perform software updates	4.51	0.50	VR
178	Replace SBW components	4.50	0.50	VR
	Use Automobile Diagnostic and Repair Tools			
179	Use multi-meter in diagnosis of a vehicle faults and testing of components	4.64	0.48	VR
180	Use OBD II scanner in diagnosis and repair of vehicles	4.56	0.67	VR

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181	Use torque wrench in the tightening bolts and to specifications	4.56	0.54	VR
182	Use pressure Guage to measure fuel pressure to manufacturers specified range	4.20	0.62	R
	Grand Mean	4.30	0.43	R

Key: X = Mean, VR = Very relevant, R = Relevant, SWR = Somewhat Relevant, LR = Lowly relevant, NR = Not Relevant

The results presented in Table 1 offer a detailed analysis of task items necessary for inclusion in the Auto Mechatronics instructional task sheet based on responses from experts who rated the items. The mean scores and standard deviations provide insights into the perceived importance of various tasks in auto mechatronics skills. The majority of task items recorded high mean values, indicating their significance. The results indicate a strong consensus on the necessity of including these tasks in the instructional task sheet.

2.4 Testing Hypothesis

Hypothesis One

There is no significant difference in the mean ratings of educators and master mechanics on the task items relevant for inclusion in the auto mechatronics instructional task sheet in Lagos State.

Table 2: t-Test Comparison of Educators' and Master Mechanics' Mean Ratings on Task Items for Inclusion in the Auto-Mechatronic Instructional Task Sheet.

Source of variation	N	X	SD	df	t-cal	*P*-value	Remark
Educator	**42**	**3.12**	**.75**				
				567	**.40**	**.68**	**Not-Sig**
Master Mechanics	**527**	**3.16**	**.68**				

The results in Table 10 shows that the mean score for educators (M=3.12, SD=.75) was not significantly less than that of those with master mechanics (M=3.16, SD=.68); t (567) =.40, p=.68. The null hypothesis of no significant difference between the two groups on the task items considered relevant for inclusion in the auto mechatronics instructional task sheet was therefore not rejected.

Hypothesis Two

There is no significant difference in auto mechatronic skills of auto mechanics before and after using the auto mechatronic instructional task sheet (AITS).

Table 3: t-Test Analysis of Auto-mechanics' Auto-mechatronic Skills Before and After Using the Auto-Mechatronic Instructional Task Sheet = 16.

Variables	Test		SD	t	F-value	Sig	Remarks
Test the voltage of a battery using a multi-meter	Pretest	7.63	2.63	-6.85	15.498	0.000	Sig
	Posttest	12.50	1.10				
Use information in service manual in replacement of oxygen sensor	Pretest	9.88	3.44	-5.33	2.483	0.126	NS
	Posttest	15.50	2.45				
Follow procedures for diagnosis and repair of sensor	Pretest	9.31	2.89	-9.53	8.506	0.000	Sig
	Posttest	16.63	1.02				
Follow procedure for diagnosis and repair of actuator	Pretest	9.13	2.42	-11.42	7.641	0.001	Sig
	Posttest	16.63	1.02				
Follow procedures for diagnosis of ECU/modules	Pretest	8.25	0.68	-23.58	4.358	0.001	Sig
	Posttest	16.44	1.21				
		12.19	1.89	-11.34	7.697	0.003	Sig

Key: Sig = Significant.

The results presented in Table 3 are based on a hypothesis testing the effect of the Auto Mechatronic Instructional Task Sheet on the skills performance of auto mechanics. The paired-samples t-test was conducted to examine whether there was a statistically significant difference in skills performance before and after the use of the instructional task sheet. The hypothesis posits that there is no significant difference in auto mechatronic skills performance of auto mechanics before and after using the developed auto mechatronic instructional tasks sheet.

The overall improvement in task performance across all tasks, with a grand mean increase from 12.19 (SD = 1.89) in the pretest to 16.44 (SD = 1.02) in the posttest, further supports the hypothesis. The t-value of -11.34 and a p-value of 0.003 confirm that the instructional task sheet had a significant positive impact on task performance overall. The results of the paired-samples t-test generally support the hypothesis that the Auto Mechatronic Instructional Task Sheet significantly improved the task performance of auto mechanics, with most tasks showing statistically significant improvements from pretest to posttest.

3.0 DISCUSSION OF FINDINGS

3.1 Task Items Necessary for Inclusion in the Auto Mechatronics Instructional Task Sheet

The findings from research question two, which focused on the necessary task items for inclusion in the auto mechatronics instructional task sheet, reveal significant insights into the practical tasks required for diagnosing and repairing modern automobile systems. Table 1 outlines a comprehensive set of tasks, primarily centered on the use of diagnostic and repair tools, testing sensors, electronic control units/modules and actuators, as well as the application of vehicle service information in the service of vehicles. The findings of this study highlight the increasing importance of aligning tasks of informal auto mechanics with automotive repair industry, particularly as vehicles become more complex with the integration of electric, autonomous, and sensor-based systems. This is consistent with the work of Smith and Brown (2021), which emphasized that auto mechanics require ICT and electronic training to manage modern vehicles. This emphasizes the importance of updating auto mechanic informal apprenticeship to integrate these technologies. Similarly, Gamage (2019) identified gaps in the competencies of auto mechanics informal apprentices. The studies identified the need for digital diagnostics in autonomous vehicles and recommended the inclusion of modules or tasks on computer aided diagnostics and hybrid technology in vocational training programme

3.2 Impact of a Developed Auto-Mechatronic Instructional Task Sheet on the Improvement of Auto-Mechatronic Skills in Auto Mechanics and Apprentices

The t-test results in Table 3 reveal a significant improvement in auto mechatronic task performance for most tasks after using the Auto Mechatronic Instructional Task Sheet (AITS), suggesting the instructional tool's positive impact on enhancing practical skills. For the task of testing the voltage of a battery using a multimeter, the findings show a significant improvement in performance, with mechanics demonstrating higher post-instruction scores compared to pre-instruction scores. This result aligned with the findings of Smith and Johnson (2024), who noted that integrating mechatronics training into project-based learning significantly boosts the ability to apply theoretical knowledge in hands-on situations. The improvement in task performance indicates that the AITS provided a structured approach to understanding and applying technical concepts, resulting in better practical outcomes. Similarly, for diagnosing and repairing sensors, there was a significant increase in performance following the use of the AITS. This supported the argument by vein, Kim and Lee (2022) that well-designed automotive training programmes can significantly enhance diagnostic and repair skills. The use of the instructional task sheet likely offered a systematic guide for troubleshooting, which helped mechanics develop a clearer understanding of sensor-related issues and effective repair procedures. The task involving the diagnosis and repair of actuators also showed a significant improvement in performance, further validating the effectiveness of AITS.

By providing a step-by-step framework, the AITS may have helped mechanics to better understand actuator functions and the associated diagnostic procedures, leading to improved outcomes. For diagnosing ECU/modules, the significant improvement observed indicates that the AITS enhanced the mechanics' capabilities in handling complex electronic control systems. The AITS may have simplified the diagnostic steps and provided a more accessible approach to resolving ECU-related issues, resulting in a marked enhancement in the mechanics' diagnostic skills.

4.0 CONCLUSION

Based on the findings of the study, it is concluded that the developed automechatronic instructional task sheet is effective and has the potential to significantly enhance the

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automechatronics skills of automechanics in the informal sector. If properly utilized by automechanic master craftspersons in the training of apprentices, it will lead to notable improvements in the apprentices' automechatronics competencies.

4.1 Recommendations

Based on the findings from the study, the following recommendations were made:

1. Training providers, both formal and informal, as well as policymakers, should prioritize the inclusion of these identified specific automechatronics task items for automechanic informal apprenticeship training. Doing so will improve the effectiveness of automechanic informal apprenticeship training and significantly enhance the competencies of the informal sector auto mechanics, ensuring they are better equipped for the demands of the industry.
2. Curriculum designers such as the National automotive design and development council (NADDC) and teachers/trainers, should integrate the task elements into automotive training materials. This approach will ensure that informal auto mechanics can effectively acquire the essential knowledge and technical skills needed for modern automotive repairs and maintenance.
3. Automechanic master craftspersons in the mechanic villages should be trained on the effective use of task items for training apprentices within the automechanic clusters. This initiative will enhance the automechatronics skills of apprentices graduating from informal apprenticeship programs.

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