



# Development and Validation of Auto Mechatronics Contents for Auto Mechanics Informal Apprenticeship Training

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## Abstract

This study developed and validated an auto mechatronics content for informal apprenticeship training in the auto mechanic trade, aiming to enhance the quality and relevance of such traditional training system. The ultimate goal is to equip auto mechanic apprentices with the technical skills that make them more employable and aligned with the demands of the modern automotive labor market. The study employed a research and development approach in Lagos State, Nigeria, using a study population of 469 participants, comprising 427 master mechanics and 42 technical educators specializing in automotive and mechatronics engineering from technical colleges and tertiary institutions in Lagos State. No sampling technique was used, as the population size was manageable. Data collection involved a contextual analysis of automotive literature, including textbooks, workshop manuals, curricula, and other relevant documents, to identify essential components for the auto-mechatronics content. Additionally, an Auto-Mechatronics Content Items Rating Instrument (AMCIRI) was developed and used to collect data from the research participants, who rated the relevance of identified content items, tools, equipment, and materials. A total of 469 copies of the instrument were distributed by the researcher and five assistants, and all were duly completed and retrieved. The data were analyzed using mean and paired sample t-tests. The findings revealed 52 items/components relevant for inclusion in the auto-mechatronics content and 120 tools, equipment, and materials essential for teaching the content. Furthermore, there was no significant difference between the mean ratings of master mechanics and educators regarding the relevance of the identified components, tools, equipment, and materials for inclusion in the auto-mechatronics content for informal auto mechanic apprenticeship training. Based on these findings, it was recommended that the developed auto-mechatronics content, along with the identified tools, equipment, and materials, be incorporated into the training curriculum for informal auto mechanics apprenticeship programmes. Informal training workshops, clusters, and mechanic villages, as well as master mechanics, should adopt the developed content to standardize and improve the quality of training in the sector.

**Keywords:** Automechatronics Content, Tools, Equipment and Materials, Informal Automechanic Apprenticeship Training, Development, Validation of Contents.

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## **INTRODUCTION**

In various parts of the globe, especially in developing countries, the informal apprenticeship training system plays a vital role in training skilled workers in various trades or occupations, including auto mechanics. However, despite the prevalent dependence on this training model, there is a noticeable gap in the formalization and standardization of the training content, especially in the emerging field of auto-mechatronics.

Auto-mechatronics incorporates automotive engineering with electronics, computer control systems, and mechanical systems. This union has led to the increasing complexity of modern vehicles, requiring automechanics to possess not only mechanical knowledge but also skills in electronics, robotics, and information technology (Leach, 2021). As the automotive industry becomes more complex with the incorporation of technologies such as electric vehicles (EVs), autonomous driving, and advanced diagnostic systems, there is an urgent need for auto mechanics to acquire the necessary corresponding competencies to repair and maintain these modern vehicles (Zhang et al., 2020).

In informal apprenticeship training systems, the teaching methods are often by observations, hands-on, and the curriculum is informal, relying on oral instructions and direct demonstrations by masters. While this approach is beneficial in terms of practical exposure, it often lacks structured content that can address the current and future demands of the auto-mechatronics field (Miller & Thomas, 2018). Therefore, there is a growing need to develop instructional materials that are aligned with contemporary technological developments and are adaptable to the informal learning environment of auto mechanics apprenticeship training.

The development of a formalized and validated auto-mechatronics instructional content can improve the skills and knowledge of apprentices, preparing them to meet the technological challenges of the automotive industry. Validation of these contents through industry experts and stakeholders ensures that informal apprenticeship training programmes are not only practical but also relevant, efficient, and up-to-date (Adams & Okunola, 2019). Such initiatives will contribute to the enhancement of a skilled workforce capable of navigating the complexities of modern automotive systems.

Therefore, the creation of auto-mechatronics instructional materials for informal auto mechanics apprenticeship training is a key area of focus to improve the quality and efficiency of skills development in the automotive sector.

### **Purpose of the Study**

The main purpose of this study was to develop and validate auto mechatronics contents for auto mechanic informal apprenticeship training. Specifically, the study sought to determine:

- The auto mechatronics contents for auto mechanic informal apprenticeship training.
- The tools, equipment, and materials for teaching the auto-mechatronics contents in informal auto mechanic apprenticeship training.

### **Research Questions**

The following research questions guided the study:

- What are the key components of the auto-mechatronics content for informal auto mechanics apprenticeship training?
- What are the tools, equipment, and materials required for teaching auto-mechatronics content in informal auto mechanics apprenticeship training?

## **Hypotheses**

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

- There is no significant difference in the mean ratings of educators and master mechanics on the contents considered relevant for inclusion in the auto mechatronics instructional task sheet.
- There is no significant difference in the mean ratings of educators and master mechanics on the tools, equipment and materials considered relevant for inclusion in the auto mechatronics instructional task sheet.

## **METHODS**

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. Therefore, R&D is suited for this study as it seeks to develop and validate a new product-auto mechatronic contents for auto mechanic informal apprenticeship training.

The area of the study is Lagos State. Lagos State is 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 and 427 master mechanics actively engaged in the formal automotive industry, in Lagos State, Nigeria. The population of 469 participants was utilised for the research, hence no sampling was used.

### **Instrument for Data Collection**

A rating instrument (AMCIRI) was used for data collection for this study. The Instrument was developed based on the information gathered from reviewed documents such as vehicle workshop and service manuals, occupational profiles, text books and job descriptions of auto mechanics. The instrument was divided into two parts. Part I collects the personal data of respondent category (educators or master mechanics from industry). Part II contained 52 content items and 120 tools, equipment and materials items,

## **Validation of the Instruments**

The instrument was face and content validated by three experts, two educators, both with specialization in mechanical (auto-mobile technology) from Technology and Vocational Education Departments, Nnamdi Azikiwe University, Awka and University of Uyo. An expert from Innoson Kiara Academy also validated the instrument. A copy of the instruments was given to the reviewers and the feedback from the validation led to the removal and addition of content items to the different sections of the instrument

## **Reliability of the Instrument**

The reliability of the instrument was established using the Fleiss multi-rater Kappa statistic. Fleiss' Kappa is a statistical tool for assessing agreement among multiple raters in rating items. It is designed for more than two raters. Fleiss values near 1 imply high agreement beyond chance, near 0 suggest chance-level agreement, and near -1 indicate systematic disagreement (Fleiss, 1971) The instrument was administered to 16 raters from academia and the SME group, and the data was collected and analyzed using the Fleiss multi-rater Kappa statistic. The Fleiss value calculated for the instrument is 0.62, establishing the questionnaire reliability.

## **Method of Data Collection**

The AMCIRI instrument 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 469 copies of AMCIRI instrument were administered to these experts by the researcher and research assistants for rating the instructional task sheet components. After completion by the experts, the instruments were retrieved, with all copies successfully collected.

## **Method of Data Analysis**

Descriptive statistics-mean was used to address the research questions, while the standard deviation was used to analyze the level of agreement or consensus among the experts (educators and master mechanics) who evaluated the components of the auto mechatronics contents. Content items with mean ratings of 4.0–5.0 and 3.5–3.9 were considered to reflect very relevant and relevant agreement, respectively, while items rated 3.0–3.4 were somewhat relevant. Conversely, items with mean ratings of 2.0–2.9 and 1.0–1.9 were categorized as indicating low relevant and very low not relevant 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 were less than the 0.05 alpha value.

## **PRESENTATION OF DATA**

**Research Question 1:** What are the contents of the auto mechatronics instructional task sheet?

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

S/N	Use Vehicle Service Information such as:	X	SD	Remarks
1	Use service manuals in diagnosis and repairs of automobiles by following manufacturer instruction and diagnosis chart	4.39	0.62	R
2	Locate and obtain information for vehicle diagnosis and repairs from technical service bulletin (TSB)	4.20	0.80	R
	Follow Procedures for Diagnosis and Repair Sensors			
3	Diagnosis and repair of oxygen sensor	4.53	0.50	VR
4	Diagnosis and repair of engine temperature sensor	4.10	0.41	R
5	Diagnosis and repair of crankshaft position sensor	4.59	0.60	R
6	Diagnosis and repair of camshaft position sensor	4.66	0.54	VR
7	Diagnosis and repair of knock sensor	4.63	0.54	VR
8	Diagnosis and repair of intake temperature sensor	4.61	0.49	VR
9	Diagnosis and repair of oil pressure sensor	4.55	0.63	VR
10	Diagnosis and repair of fuel pressure sensor	4.62	0.51	VR
11	Diagnosis and repair of exhaust gas recirculation (EGR) sensor	4.55	0.61	VR
12	Diagnosis and repair of manifold absolute pressure (MAP) sensor	4.16	0.51	R
13	Diagnosis and repair of throttle position sensor (TPS)	4.47	0.61	R
14	Diagnosis and repair of engine coolant temperature sensor (ECT sensor)	4.47	0.61	R
15	Diagnosis and repair of wheel speed sensor	4.53	0.56	VR
16	Diagnosis and repair of brake pad wear sensor	4.00	0.60	R
	Diagnosis and repair of wheel speed sensor	4.10	0.58	R
17	Diagnosis and repair of brake fluid level sensor	4.17	0.67	R
18	Diagnosis and repair brake pressure sensor	4.12	0.66	R
19	Diagnosis and repair of transmission fluid level sensor	4.14	0.65	R
20	Diagnosis and repair of transmission fluid pressure sensor/transmission oil pressure sensor/transmission line pressure sensor	4.35	0.88	R
	Diagnosis and repair of transmission/vehicle speed sensor	4.34	0.89	R
21	Diagnose and repair of transmission range sensor or PRNDL switch	4.29	0.87	R
22	Diagnosis and repair of steering angle sensor	4.36	0.93	R
23	Diagnose and repair of torque sensor	4.79	0.81	VR
24	Diagnosis and repair yaw rate sensor	4.76	0.89	VR
25	Diagnosis and repair of G-sensor	4.76	0.89	VR
26	Diagnosis and repair of tire pressure sensor	4.76	0.89	VR
27	Diagnosis and repair of ignition switch position sensor	4.83	0.91	VR
28	Diagnosis and repair of battery temperature sensor	4.80	0.80	VR
29	Diagnosis and repair of battery voltage sensor	4.20	0.53	R
30	Diagnosis and repair of battery current sensor	4.22	0.54	R
	Follow Procedures for Diagnosis and Repair Actuators			
31	Diagnosis and repair of power window actuator	4.21	0.61	R
32	Diagnosis and repair of seat adjustment actuator	4.15	0.36	R
33	Diagnosis and repair of mirror adjustment actuator	4.27	0.45	R
34	Diagnosis and repair of sunroof actuator	4.24	0.43	R
35	Diagnosis and repair of hydraulic brake actuator	4.28	0.45	R
36	Diagnosis and repair of power steering actuator	4.20	0.40	R
37	Diagnosis and repair of suspension actuator	4.16	0.37	R
38	Diagnosis and repair of transmission/turbocharger actuator	4.64	0.52	VR
39	Diagnosis and repair of thermostat actuator	4.13	0.58	R
40	Diagnosis and repair of HVAC actuator	4.43	0.88	R
41	Diagnosis and repair of fuel injectors	4.38	0.92	R
42	Diagnosis and repair of starter motor	4.76	0.90	VR
43	Diagnosis and repair of shift solenoid	4.39	0.93	R
44	Diagnosis and repair of pressure control solenoid	4.27	0.99	R
45	Diagnosis and repair of torque converter clutch (TCC) solenoid	4.74	0.96	VR
46	Diagnosis and repair of engine control unit (ECU)	4.74	0.69	VR
47	Diagnosis and repair of transmission control module (TCM)	4.76	0.65	VR
48	Diagnosis and repair of power train control module (PCM)	4.75	0.67	VR
49	Diagnosis and repair of Anti-lock braking system (ABS) control module	4.26	0.72	R
50	Diagnosis and repair of airbag control module	4.10	0.69	R
51	Diagnosis and repair of electronic stability control module (ESCM)	4.13	0.54	R
52	Diagnosis and repair of steer by wire (SBW) control module	4.13	0.42	R
	Grand Mean	4.41	0.66	R

N = 469. Key: X = Mean, VR = Very relevant, R = Relevant, SWR = Somewhat Relevant, LR = Lowly relevant, NR = Not Relevant

The analysis (Table 1) of Research Question 1, which examines the contents of the auto mechatronics for informal automechanic apprenticeship training, reveals significant insights into the tasks deemed essential by experts in the field. The data, derived from the responses of the raters, is encapsulated in Table 1, providing mean scores and standard deviations for various content items associated with vehicle service information, sensor diagnosis and repair, and actuator procedures. The overall grand mean score of 4.41, with a standard deviation of 0.66, categorizes the contents of the automechanics as relevant. This finding suggests a strong consensus among respondents regarding the importance of the listed content items in the context of auto mechatronics education and training for informal apprenticeship training. Among the specific content items, the utilization of service manuals for diagnosing and repairing automobiles is highlighted with a mean score of 4.39 (SD = 0.62), indicating that this practice is considered relevant by the respondents.

The emphasis on following manufacturer instructions and diagnostic charts underscores the necessity of adhering to established guidelines in automotive repair. Further analysis of sensor diagnosis reveals that several content items received very relevant ratings. Notably, the diagnosis and repair of the ignition switch position sensor (Mean = 4.83, SD = 0.91) and the diagnosis and repair of the battery temperature sensor (Mean = 4.80, SD = 0.80) demonstrate a high level of perceived importance. This reflects the critical role that these sensors play in vehicle functionality and safety, highlighting the need for auto mechanics to be adept in their diagnosis and repair. Conversely, tasks such as the diagnosis and repair of the brake pad wear sensor and the manifold absolute pressure (MAP) sensor, which garnered mean scores of 4.00 and 4.16, respectively, were classified as relevant but not very relevant. This indicates a recognition of their importance, though perhaps less urgency compared to other tasks. The presence of variability in responses, as suggested by the standard deviations, indicates differing levels of emphasis among participants, which may reflect variations in professional experience and educational backgrounds.

The analysis of actuator procedures also yields important insights. The diagnosis and repair of critical components, such as the starter motor (Mean = 4.76, SD = 0.90) and the transmission control module (Mean = 4.76, SD = 0.65), are regarded as very relevant, indicating the importance of these tasks in the auto mechatronic instructional task sheet. The relatively lower mean scores for other actuator tasks suggest that while they are recognized as relevant, they may not hold the same level of criticality in the training framework.

## Research Question 2

What are the tools, equipment, and materials required for teaching auto-mechatronics content in informal auto mechanics apprenticeship training?

Table 2: Mean Ratings of Experts (Educators and Master Mechanics) and Standard Deviations on Tools, Equipment and Materials for Inclusion in the Auto-mechatronic Instructional Task Sheet

S/N	Tools and Materials Items for the Instructional Task Sheet include:	X	SD	Remarks
1	Fuel Pressure Gauge Kit: Includes the gauge, adapters, and hoses.	4.08	0.27	R
2	Service Manual	4.06	0.45	R
3	Fuel Line Disconnect Tool	4.13	0.37	R
4	Click-Type Torque Wrench	4.10	0.50	R
5	Beam-Type Torque Wrench	4.22	0.61	R
6	Digital Torque Wrench	4.63	0.49	VR

7	Dial Torque Wrench	4.63	0.49	VR
8	Socket Set	4.64	0.48	VR
9	OBD II Scanner (Handheld or Bluetooth)	4.22	0.42	R
10	User Manual of the OBD II scanner	4.20	0.40	R
11	Smartphone/Tablet (if using a Bluetooth OBD II scanner)	4.25	0.44	R
12	Multi-meter	4.36	0.54	R
13	Flashlight	4.24	0.45	R
14	Inspection Mirror	4.73	0.47	VR
15	Smoke Machine	4.61	0.53	VR
16	Exhaust System Inspection Tools	4.95	0.22	VR
17	Digital Multi-meter	4.64	0.50	VR
18	Pliers	4.22	0.42	R
19	Wire Strippers	4.36	0.48	R
20	Crimping Tool	4.17	0.38	R
21	Soldering Iron	4.31	0.53	R
22	Mechanical Oil Pressure Gauge	4.36	0.48	R
23	Fuel Pressure Sensor	4.35	0.48	R
24	EGR Position Sensor	4.42	0.50	R
25	MAP Sensor	4.35	0.52	R
26	Vacuum Lines	4.38	0.49	R
27	Hose Clamps	4.42	0.68	R
28	Soft Brush	4.38	0.49	R
29	TPS Sensor	4.17	0.43	R
30	Electrical Tape	4.14	0.38	R
31	Connectors	4.20	0.43	R
32	Thermostat	4.12	0.59	R
33	ECT Sensor	4.19	0.39	R
34	Mass Airflow Sensor	4.12	0.50	R
35	Brake Fluid Level Sensor	4.19	0.42	R
36	Battery Terminal Wrench	4.15	0.46	R
37	Brake Pad Pressure Sensor (BPPS)	4.13	0.34	R
38	Screwdrivers	4.57	0.50	VR
39	Jack Stand	4.39	0.49	R
40	Heat Gun or Hair Dryer	4.57	0.54	VR
41	Transmission Speed Sensor	4.40	0.49	R
42	Jack	4.28	0.45	R
43	Trim Removal Tool	4.71	0.48	VR
44	Torque Sensor	4.11	0.40	VR
45	Yaw Rate Sensor	4.65	0.58	VR
46	Wire Connector	4.84	0.37	VR
47	G-Sensor	4.89	0.37	VR
48	TPMS Scan Tool	4.87	0.34	VR
49	Valve Core Tool	4.24	0.59	VR
50	Ignition Switch Puller	4.74	0.46	VR
51	Ignition Switch Position Sensor	4.54	0.52	VR
52	Battery Voltage Sensor	4.50	0.54	VR
53	Needle Nose Pliers	4.56	0.50	VR
54	Battery Terminal Cleaner	4.02	0.49	R
55	Panel Removal Tool	4.12	0.50	R
56	Jumper Wire	4.09	0.47	R
57	Mirror Actuator (Motor)	4.16	0.44	R
58	Sunroof Actuator (Motor)	4.32	0.65	R
59	Brake Line Wrenches	4.27	0.58	R
60	Hydraulic Brake Actuator (Motor)	4.31	0.49	R
61	Transmission Actuator	4.09	0.45	R
62	Power Steering Actuator (Pump, Motors)	4.25	0.44	R
63	Turbocharger Actuator	4.54	0.50	VR
64	Thermostat Actuator	4.60	0.49	VR
65	O-Ring/Gasket	4.58	0.50	VR
66	HVAC Actuator	4.31	0.46	R
67	Fuel Pressure Gauge	4.38	0.53	R
68	Fuel Injector	4.33	0.47	R
69	Noid Light	4.60	0.55	VR
70	Oscilloscope	4.19	0.42	R
71	Door Lock Actuator	4.63	0.56	VR
72	Starter Motor Actuator	4.72	0.49	VR
73	Starter Motor Solenoid	4.54	0.54	VR
74	Shift Solenoid	4.60	0.51	VR
75	Transmission Pan	4.24	0.45	R
76	Pressure Control Solenoid	4.24	0.43	R

77	Torque Converter Clutch (TCC) Solenoid	4.20	0.45	R
78	Engine Control Unit/Module	4.16	0.39	R
79	Torx and Allen Keys	4.17	0.43	R
80	Bench Power Supply	4.17	0.38	R
81	Desoldering Pump or Braid	4.28	0.45	R
82	Transmission Control Module	4.26	0.44	R
83	Power Control Train Module (PCM)	4.26	0.44	R
84	ABS Sensor	4.15	0.58	R
85	ABS Control Module	4.27	0.45	R
86	Fuses and Relay	4.30	0.46	R
87	Airbag Control Module	4.28	0.45	R
88	Impact Sensor	4.21	0.41	R
89	Wheel Speed Sensor	4.12	0.33	R
90	Electronic Stability Control (ESC) Module	4.35	0.50	R
91	Steer by Wire (SW) Control Module	4.29	0.50	R
92	Actuator Test Bench	4.37	0.54	R
93	Steering Angle Sensor	4.55	0.52	VR
94	Gloves	4.41	0.49	R
95	Safety Glasses	4.91	0.32	VR
96	Fire Extinguisher	4.28	0.51	R
97	Rags or Paper Towels	4.62	0.56	VR
98	Vehicle with OBD II Port	4.87	0.34	VR
99	Vehicle Key, Test Drive Route	4.92	0.34	VR
100	Penetrating Oil (if necessary)	4.89	0.31	VR
101	New Oxygen Sensor	4.37	0.63	R
102	Coolant	4.72	0.55	VR
103	Drain Pan	4.49	0.54	R
104	Funnel	4.44	0.52	R
105	Wiring Diagram	4.51	0.50	VR
106	CKP Sensor	4.14	0.45	R
107	Camshaft Position Sensor	4.13	0.49	R
108	Knock Sensor	4.11	0.45	R
109	Electronic Parts Cleaner or Isopropyl Alcohol	4.15	0.41	R
110	IAT Sensor	4.32	0.65	R
111	Heat Shrink Tubing	4.30	0.58	R
112	Engine Oil Dipstick	4.34	0.50	R
113	Brake Pad	4.10	0.44	R
114	12volts Battery	4.22	0.42	R
115	Window Actuator (Motor)	4.49	0.50	R
116	Brake Fluid	4.58	0.52	VR
117	Brake Cleaner	4.53	0.50	VR
118	Power Steering Fluid	4.37	0.49	VR
119	Fuel Injector Cleaner	4.42	0.50	R
120	Transmission Fluid	4.33	0.47	R
<b>Grand Mean</b>		<b>4.38</b>	<b>0.47</b>	<b>R</b>

N = 469. Key: X = Mean, VR = Very relevant, R = Relevant, SWR = Somewhat Relevant, LR = Lowly relevant, NR = Not Relevant

The results (Table 2) of research question 2 provide a comprehensive overview of the tools, equipment, and materials essential for teaching auto-mechanics content in informal auto mechanics apprenticeship training. The data presented in Table 2 reveal significant insights into the relevance of these items, with a grand mean score of 4.38 and a standard deviation of 0.47, suggesting a strong consensus among the respondents regarding their importance. The analysis indicates several items classified as “Very Relevant” (VR), which signifies their critical role in automechanic instruction. The Exhaust System Inspection Tools received the highest mean score of 4.95 with a remarkably low standard deviation of 0.22. This suggests that respondents universally recognize the importance of these tools in diagnosing and repairing exhaust systems, which are vital components in vehicle emissions control and performance. This emphasis reflects the industry’s increasing focus on environmental regulations and the need for technicians to be adept at using specialized diagnostic tools. Moreover, the Safety Glasses scored a mean of 4.91 (SD = 0.32), highlighting a consensus on the paramount importance of safety in automotive



environments. The integration of safety protocols in training is essential, as it prepares auto mechanics to operate in real-world settings where hazards are prevalent.

Items such as the Digital Torque Wrench (Mean = 4.63, SD = 0.49) and OBD II Scanner (Mean = 4.22, SD = 0.42) illustrate the shift towards modern technology in automotive repair. The high relevance of these tools indicates a necessity for educational programmes to incorporate advanced diagnostic techniques. The Digital Torque Wrench, for example, allows for precise measurements crucial in assembly and repair, reflecting industry practices that demand high accuracy. The Service Manual and Fuel Pressure Gauge Kit, while still relevant (mean scores of 4.06 and 4.08, respectively), scored lower compared to more technologically advanced tools. This suggests that while foundational tools remain important, there is a trend towards integrating digital and automated tools in training, potentially leading to improved outcomes in student competency and preparedness for the workforce. The variability in mean scores among the listed tools highlights the diverse needs within automotive education. For instance, while Screwdrivers (Mean = 4.57, SD = 0.50) are fundamental, their prevalence in training may lead to a perception of their importance being somewhat lower compared to specialized tools. Similarly, items like the Mechanical Oil Pressure Gauge (Mean = 4.36, SD = 0.48) and various sensors (e.g., MAP Sensor, TPS Sensor) received relevant ratings, yet their importance may vary based on specific instructional contexts.

The diverse range of tools included in the list; from basic hand tools to complex diagnostic equipment; underscores the multifaceted nature of modern automotive education. Items such as the G-Sensor (Mean = 4.89, SD = 0.37) and TPMS Scan Tool (Mean = 4.87, SD = 0.34) emphasize the need for Auto mechanics to develop a broad skill set that encompasses both traditional mechanical skills and advanced electronic diagnostics. This holistic approach is vital in preparing auto mechanics for a dynamic and evolving industry. The findings from Research Question 2 emphasize the crucial role of specific tools, equipment, and materials in auto mechatronics education. The high mean scores for most items reflect their necessity in fostering practical skills that align with current industry standards. Educational institutions and informal apprenticeship training providers in auto mechanics must prioritize the integration of these resources into their programs to enhance the learning experience and ensure that students are well-equipped for their future careers. By doing so, they significantly contribute to developing competent professionals capable of navigating the complexities of modern automotive technology. The results indicate a clear pathway for enhancing curricula through the strategic inclusion of relevant tools, ultimately benefiting both students and the automotive industry.

**Hypothesis 1:** There is no significant difference in the mean ratings of educators and master mechanics on the contents relevant for inclusion in the auto mechatronics contents

Table 3: t-Test Comparison of Educators' and Master Mechanics' Mean Ratings on Content Items for Inclusion in the Auto-Mechatronics Contents

Source of variation	N	X	SD	Df.	t-cal	P-value	Remark
Educators	42	3.47	.65				Accepted
Master Mechanics	427	3.51	.65	467	.45	.64	Not-Sig

Table 3 shows that the mean score for educators (M=3.47, SD=.65) was not significantly less than that of those with master mechanics (M=3.51, SD=.65);  $t = .45$ ,  $p = .64$ . The null hypothesis

of no significant difference between the two groups on the contents relevant for inclusion in the auto mechatronics instructional task sheet was therefore accepted.

**Hypothesis 2:** There is no significant difference in the mean ratings of educators and master mechanics on the tools, equipment and materials relevant for inclusion in the auto mechatronics contents.

Table 4: t-Test Comparison of Educators' and Master Mechanics' Mean Ratings on Tools, Equipment and Materials for Inclusion in the Auto-Mechatronic Contents

Source of variation	N	X	SD	Df.	t-cal.	P-value	Remark
Educators	42	3.07	.74	467	.23	.81	Accepted
Master Mechanics	427	3.09	.65				Not-Sig

The analysis in Table 4 shows that the mean score for educators (M=3.07, SD=.74) was not significantly less than that of those with master mechanics (M=3.09, SD=.65);  $t = .23$ ,  $p = .81$ . The null hypothesis of no significant difference between the two groups on the tools, equipment and materials relevant for inclusion in the auto mechatronics instructional task sheet was therefore accepted.

## DISCUSSION OF FINDINGS

### Contents of the Auto Mechatronics for informal auto mechanics apprenticeship training

The findings of the present study revealed comprehensive content for the auto mechatronics informal automechanics apprenticeship training, emphasizes the critical gaps in auto mechatronic skills possess by auto mechanics such as using automotive diagnostic and repairs tools, use of vehicle service information, follow procedures for diagnosis and repairs of sensors, actuators and electronic control units and modules. The data demonstrate that the majority of the content items related to use of automotive diagnostic and repair tools, use of vehicle service information and diagnosing and repairing sensors and actuators in automobiles were rated as either "relevant" or "very relevant," indicating their importance in the training auto mechatronics training contents. This agrees with previous research, which emphasizes the integration of comprehensive diagnostic tasks in mechatronics education to enhance the technical competencies of learners. For instance, Gamage (2020) emphasized the necessity for an inclusive automotive mechatronics training programme tailored to meet the evolving needs of both car manufacturers and suppliers. This is consistent with the current study's findings, where contents involving the use of service manuals and technical service bulletins for diagnosis and repairs were deemed relevant. These elements echo the importance of providing technicians with precise and up-to-date information to ensure effective diagnosis and repairs, aligning with Gamage's assertion that automotive training programmes must incorporate such content to remain industry relevant.

## **Tools, Equipment and Materials Needed for Teaching the Contents of the Auto mechatronics auto mechanic informal apprenticeship training**

The study identified and validated the tools, equipment, and materials deemed essential for the effective implementation of auto mechatronic contents. Experts rated a total of 120 tools, equipment, and materials as relevant for this purpose. These findings align with the study by Das and Mukherjee (2021), which demonstrated that students who utilized hands-on tools and simulation-based learning materials performed significantly better on comprehension tests and exhibited superior task performance compared to those who relied solely on traditional lectures. Consequently, the use of these validated tools, equipment, and materials is likely to enhance the auto mechatronic skills of auto mechanics in informal apprenticeship training programmes.

### **CONCLUSION**

Based on the findings of this study, it can be concluded that the identified auto-mechatronics content, along with the related tools, equipment, and materials, is highly relevant for enhancing the skills of informal auto mechanics. These resources are essential for equipping apprentices with the necessary competencies to meet the demands of modern automotive technologies. It is therefore recommended that the developed content and associated resources be adopted for training apprentices in informal auto mechanics apprenticeship programs to improve their technical expertise and employability.

### **Recommendations**

Based on the findings of this study, the following recommendations have been made:

- The developed auto-mechatronics content, alongside the identified tools, equipment, and materials be incorporated into the training curriculum for informal auto mechanics apprenticeship programmes.
- Informal training workshops/clusters/mechanic villages and master mechanics should adopt the developed content to standardize and enhance the quality of training
- Provide training for apprenticeship trainers/master mechanics to effectively utilize the auto-mechatronics content and handle the related tools, equipment and materials.
- Develop user-friendly manuals or guides such as instructional task sheets for master mechanics to facilitate easy integration of the materials into their teaching methods.

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