Development of Automobile Battery and Charging System Maintenance Training Manual for Technical College Students

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Abstract: The purpose of this study is to develop automobile battery and charging system maintenance training manual for technical college students. Research and Development (R and D) design was adopted for the study. The population of the study is 348, comprising of 76 auto-mechanics teachers, 36 automobile supervisors and 237 students from all the technical colleges in North-Western States of Nigeria. There was no sample for the study; however, purposive sample was used for the students used for trial testing. Seven specific purposes, six research questions and a null hypothesis guided the study. The instruments for data collection are; Auto-Electricity Training Manual Questionnaire (ATMQ), Auto-Electricity Psychomotor Test (APT) and Auto-Electricity Rating Scale (ARS). The ATMQ, APT and ARS were subjected to face validation by five experts from the University, Technical Colleges and the Automobile Industry. The ATMQ was trial tested on students of Government Technical College Minna and Automobile Supervisors in automobile companies in Minna to establish its reliability. Cronbach Alpha was used to establish the reliability of ATMQ, sections B, C, D, E and F yielded coefficient of 0.72, 0.81, 0.76, 0.78 and 0.73 respectively. Kendall's coefficient of concordance was used to establish the internal consistency of APT and yielded coefficient of 0.75. Data were analyzed using mean and standard deviation, while ANCOVA was used to test the hypothesis which yielded a coefficient of 0.044 at 0.05 level of significance. The study developed training manual for automobile battery and charging system with pictorial illustrations for technical colleges. The use of automobile battery and charging system of training manual is therefore recommended for practical skills training in technical colleges, so as to achieve their objectives.

Keyword: Automobile, Battery, Charging System, Maintenance, Training Manual, Technical College

INTRODUCTION

THE programme for motor vehicle mechanics work in Nigeria technical colleges is designed to produce competent craftsmen that can test, diagnose, service and completely repair any fault on motor vehicle to the manufacturer's specification (National Board for Technical Education (NBTE) 2001). The aim of motor vehicle mechanics practice is to give training and impart the necessary skills leading to the production of craftsmen, technicians and other skilled personnel who will be enterprising and self reliant (NBTE, 2003). Technical colleges are post primary schools where students learn skills in various occupations. According to Bakare (2009), technical colleges are charged with the responsibility of producing craftsmen. Auto-mechanics craftsmen who undergo training in motor vehicle mechanics work are expected to posses work skills for success in automobile battery and charging system and other aspect of automobile maintenance and repairs. However, in spite of the turnout of auto-mechanics students from technical colleges over the years, it has been observed that most of the auto-mechanics students could not apply their knowledge and skills to solve problems in automobile battery and charging system effectively (Opeyemi, 2005). Umar (2009) stated that in most technical colleges, classes are mostly conducted in theoretical form and students do not have the opportunity to apply what they learnt in solving new/unfamiliar problems. There appears to be gaps between the training acquired by technical college students and the skills required for new technologies in motor vehicle electrical system. This inadequate skills acquired by technical college students could be because of insufficient time allocated for practical classes,

lack of materials, tools and equipment to conduct practical and expertise to conduct practical classes in technical colleges. This is evident in technical colleges where several subjects offered in the schools are contending for time, this insufficient time necessary for practical work may have resulted in poor skills acquisition (Audu & Umar, 2006). In addition, technological advancement in the work place and industries also necessitated a need to equip auto-mechanics students with workplace basic skills which will make them adaptable to the present and envisaged future changes in motor vehicle.

However, urgent steps need to be taken to address this ugly trend. One way of doing this, will be the development of a training manual to fall back on during and after classes. Training manual which can also be self-instructional manual is an instructional guide developed to help the learner or user acquire mastery of certain technical skills or tasks. Training manual according to Lan (2007) is a set of instructional manual that provide guidelines on how to carry out specific and general operations on assigned job. A good training manual should focus on the basic components of auto-electricity such as battery and charging system. The battery serves as a source of energy to the vehicle. The battery also provides the energy for the starting system (Kia Motors, 1999). To ensure reliability and extend useful service life, the battery should receive periodic inspection and maintenance. The effectiveness of the battery depends on the charging system.

The charging system keeps the battery charged and supplies the electrical needs of various units during engine operation. Denton (2004) stipulated the procedure for charging maintenance to include loosens battery terminals; loosen the alternator clips, adjusting the tension bolts, removing the alternator, dismantling it and rectifying the fault. In addition to the battery and alternator, a training manual should include the; Objective of the training manual, teaching strategy, training materials and method of evaluating the trainees. The objective of any educational process determines the content, method and materials needed for achieving such objectives. Alabi, (2005) stated that, objectives are stated in a precise, clear, and measurable terms in order to achieve the goal for which it is meant to achieve. The objective of this training manual is to develop adequate skills necessary for smooth transition of auto-electricity/electronics students from to school to workplace. Objectives of the training manual could be achieved by employing different teaching strategies. Teaching strategy refers to a plan that is intended to achieve a particular purpose (Okwori, 2009). Audu & Umar (2006) noted that strategies adopted by teachers are contributing factors to the knowledge and skills acquisition of technical college students. Evaluation connotes examining or judging the worth or quality of something. Okoro (2002) defined evaluation in education as the process of passing judgment on the adequacy of the scores or marks obtained by a student in a measurement process. Evaluation therefore, refers to appraisal of skills in automobile battery and charging system with the objective of measuring learning outcome and improving instruction, and providing feedback in automobile battery and charging system maintenance.

Maintenance can be described as a way of repairing or servicing used equipment or machine in order to make for enhanced functioning capacity. Maintenance training manual is a complete self-directed training system or text of instruction addressing a broad range of maintenance and skills related topics (Mohammed, 2008). The training manual in automobile battery and charging system maintenance provides organized skills delivery system to assist auto-mechanics technology teachers in their lesson delivery and also enhance student's skills acquisition.

Statement of the Problem

A well trained auto-technician is expected to carry out operation in all electrical components of motor vehicle, trace and rectify fault. However, most auto-mechanics students and auto-electricians do not seem to adequately achieve this. This is because most of them who are employed do not have adequate and requisite practical skills and knowledge necessary to progress in their chosen field and to carry out automobile battery and charging system repair, they mostly engage in trial and error to rectify faults. One ways to curb these problems will be to develop a training manual in automobile battery and charging system that will provide enough information to guide both the teachers and learners in the course of auto-electricity/electronics maintenance. The use of training manual may guide and overcome these problems when carrying out maintenance in automobile battery and charging system and also help auto-mechanics students learn more quickly and acquire necessary skills and knowledge thereby making them to be employable.

Therefore, the problem of this study is that auto-mechanics students do not have the requisite practical skills in automobile battery and charging system maintenance and repairs. The general purpose of the study is to develop automobile battery and charging system maintenance training manual for technical college students.

Research Questions

The following research questions were formulated to guide the study.

i. What are the objectives for automobile battery and charging system training manual?
ii. What is the content of automobile battery and charging system training manual?
iii. What teaching strategies are required for automobile battery and charging system training manual?
iv. What training materials are required for automobile battery and charging system training manual?
v. What evaluation criteria are required for automobile battery and charging system training manual?
vi. How effective is the developed automobile battery and charging system training manual?

Hypothesis

The null hypothesis formulated was tested at 0.05 level of significance:

Ho. There is no significant different between the mean performances of students taught with the developed manual and those taught without manual.

Methodology

This study adopted Research and Development (R and D) design. Gall, Gall & Borg (2007) described Research and Development as an industry based development approach involving the use of research findings to design and develop new programmes and materials which assist in improving knowledge and skills. In this study, the seven steps of Gall et al (2007) were articulated into three phases as follows: Need

assessment, Development of the manual and Validation of the manual. The study was conducted in North-Western States of Nigeria. Also, accredited National Board for Technical Education (NBTE) technical colleges offering auto-mechanics work at NTC level in these States was covered. The population for this study is 348, comprising of all the 75 auto-mechanics teachers, 237 NTC III students (2012/2013) session of the 17 technical colleges offering motor vehicle mechanics and 36 automobile supervisors. The entire population was studied, while a purposive sampling was adopted for selecting students for the study. Government Technical College, Malali, Kaduna and Kano NTC III students were used to determine the effect of the developed training manual. The instruments used for data collection in this study were developed by the researcher, these are; Auto-Electricity/electronics Training Manual Questionnaire (ATMQ), Auto-Electricity/electronics Psychomotor Test (APT) and Auto-electricity/electronics Rating Scale (ARS). The Auto-Electricity/electronics Training Manual Questionnaire (ATMQ) was a structured questionnaire containing 273 items divided into six sections, A to F respectively.

The instruments were face validated by five experts in auto-mechanics. Cronbach Alpha was used to determine the internal consistency of the instrument. Sections B, C, D, E and F yielded a reliability coefficient of 0.72, 0.81, 0.76, 0.78 and 0.73 respectively. While the inter-rater reliability APT was obtained using Kendall's Coefficient of Concordance. A coefficient of 0.75w was obtained. The researcher personally administered copies of the questionnaires to the respondents (auto-mechanics teachers and automobile supervisors) with the help of seven research assistants (RAs). Research questions, 1, 2, 3, 4 and 5 was analyzed using mean and standard deviation, While the hypothesis formulated to guide the study was tested at 0.05 level of significance using ANCOVA.

Results

Research Question 1

What are the objectives for automobile battery and charging system training manual?

Table 1

Mean and Standard Deviation of Respondents on the Objectives for Automobile Battery and Charging System Training Manual N = 105

	Objectives	Mean	SD	Remarks
1	Provide a step by step outline of the procedures for troubleshooting problems in an automobile electrical system	4.16	1.12	Agree
2	Provide auto students and auto technician with the skills and knowledge required to diagnose and repair vehicle with electrical system malfunction	4.36	1.16	Agree
3	Develop adequate skills necessary for smooth transition from school to workplace	4.77	0.52	Strongly Agree
4	Enhance teacher's skills in teaching auto-electricity/electronics	4.59	0.94	Strongly Agree
5	Provide employability skills to auto-electricity/electronics students	4.74	0.56	Strongly Agree
6	Enhance the use of diagnostic tools/facilities/equipment	4.90	0.38	Strongly Agree
7	Accurately troubleshoot the problem, and avoid misdiagnose	1.53	0.68	Disagree

8	Supplement job experience of students from the industry	4.31	1.03	Agree
9	Improve students' interest in auto-electricity/electronics	4.83	0.38	Strongly Agree
10	Enhance opportunity to progress in their educational pursuit	1.55	0.66	Disagree
11	Guide the students in acquiring auto-electricity/electronics technology skills	4.84	0.44	Strongly Agree

Table 1 revealed that, of the 11objectives of automobile battery and charging system maintenance, the respondents strongly agree with 6 out of the 11 items. Their mean responses were between 4.50 – 5.00. Items 1, 2, and 8 with mean responses of 4.16, 4.36, and 4.31 respectively were considered agree by the respondents. However, they disagree with items 7and 10 due to low mean responses of 1.53 and 1.55 respectively. The standard deviation (SD) of the items ranged from 0.38 to 1.16, implying that the respondents were very close in their rating.

Research Question 2

What is the content of automobile battery and charging system training manual?

Table 2

Mean and Standard Deviation of Respondents on the items for Battery Maintenance N = 105

	Battery	Mean	SD	Remarks
1.	Switch off or turned off the vehicle ignition	4.83	0.38	Strongly Agree
2.	Open the vehicle bonnet	4.84	0.37	Strongly Agree
3.	Select the right (tools) spanners. Wait for two to three minutes before loosing	4.90	0.31	Strongly Agree
4.	Loose the battery cables starting with ne140gative cable first	4.32	1.09	Agree
5.	Move the terminal from side to side and gently pull them up	4.81	0.42	Strongly Agree
6.	Clean the battery terminals with a wire brush and corrosion removal fluid	4.79	0.53	Strongly Agree
7.	Gently scrub the terminals to achieve a shine and remove dried acid build-up	4.89	0.32	Strongly Agree
8.	Rinse the cleaning fluid with water and dry with a rag	4.86	0.45	Strongly Agree
9.	Apply grease to protect the battery terminals from rust and corrosion	4.72	0.53	Strongly Agree
10.	Reinstall the battery terminals starting the with positive (+) one first by tightening them into place with a rubber mallet	4.83	0.45	Strongly Agree
11.	Turn off the vehicle ignition	4.67	0.53	Strongly Agree
12.	Put on protective wear (cloth)	4.28	1.02	Agree
13.	Open the hood (bonnet)	4.22	1.06	Agree
14.	Remove the vent caps if the battery is not a sealed type	4.36	0.99	Agree
15.	Check the electrolyte levels in each cell using hydrometer	4.57	0.82	Strongly Agree
16.	Fill the hydrometer and drain twice for each cell before taking a reading	4.05	1.32	Agree
17.	Drain the electrolyte back into its own cell	4.43	1.12	Agree
18.	Record the number for each cell	1.66	1.00	Disagree
19.	Test all cells and then replace the vent covers	4.10	1.18	Agree
20.	Specific gravity reading (hydrometer) for each cell should be between 1.235 and 1.277	4.27	0.97	Agree
21.	If cell reading is below 1.277 or more (between the highest and lowest cell), then charge the battery or replace	4.26	1.19	Agree
22.	Get the correct battery of the vehicle	4.10	1.45	Agree
23.	Turn the ignition off	4.18	1.16	Agree
24.	Open the hood (bonnet)	4.24	1.18	Agree
25.	Gather all the necessary tools	4.44	1.11	Agree
26.	Disconnect the negative (-) cable first	4.63	0.99	Strongly Agree

27.	Then disconnect the positive (+) cable	4.32	1.10	Agree
28.	Remove the battery hold-down or clamping device	4.48	0.87	Agree
29.	Lift the battery out of its compartment (seat)	3.95	1.34	Agree
30.	Keep the battery upright on the floor	4.41	1.02	Agree
31.	Clean thoroughly the battery compartment using the wire brush and baking soda	4.62	0.81	Strongly Agree
32.	Put the new battery in its compartment (seat)	4.59	0.87	Strongly Agree
33.	Apply grease to the terminals	4.35	1.02	Agree
34.	Replace the connections, starting with the positive (+) terminal	4.23	1.05	Agree
35.	Open the hood (bonnet)	4.44	1.03	Agree
36.	Turn on your voltmeter	4.59	0.90	Strongly Agree
37.	Select DC voltage	4.39	1.10	Agree
38.	Place the voltmeter's red lead on the battery's positive (+) terminal	4.43	1.12	Agree
39.	Place the black lead on the battery's negative (-) terminal	4.79	0.51	Strongly Agree
40.	Read the screen or indicator (if meter is not digital)	4.76	0.55	Strongly Agree
41.	If meter reading is less than 12.5 or 6.35 volts, charge battery or replaced	4.39	1.03	Agree
42.	Locate the vehicle interface connection port (outlet)	4.60	0.78	Strongly Agree
43.	Connect the interface to the computer USB port and vehicle connection port	4.11	1.24	Agree
44.	Turn the vehicle ignition on	4.29	1.13	Agree
45.	The computer will display a home page, then select the type of vehicle	4.10	1.48	Agree
46.	Enter the vehicle information number (VIN), locate by the front windscreen or front door hinge	4.46	0.88	Agree
47.	Vehicle information will be display on the computer	4.32	0.98	Agree
48.	Navigate using computer keyboard and locate fault reading	4.72	0.61	Strongly Agree
49.	Fault codes will be displayed as shown, reading permanent fault. Repairs are to be carried out at this point	4.50	1.01	Strongly Agree
50.	After repairs, the fault codes will displayed as shown, reading intermittent fault	4.72	0.56	Strongly Agree
51.	Navigate to select clear fault codes	4.81	0.50	Strongly Agree
52.	Carrying out clearing fault will be displayed	4.54	0.83	Strongly Agree
53.	No fault found will be displayed after clearing of fault	4.44	0.96	Agree

Table 2 revealed that, of the 53 items on battery maintenance, 23 items were considered strongly agrees, whose mean responses range from 4.50 – 5.00, while 29 items with mean responses ranging from 3.50 – 4.49 were considered agree. However, item 18 was considered disagree due to low mean response of 1.66 by the respondents. The standard deviation (SD) of the items ranged from 0.31 to 1.48, indicating that the respondents were close in their rating.

Table 3

Mean and Standard Deviation of Respondents on the items for Charging System Maintenance N = 105

	Charging (Alternator)	Mean	SD	Remarks
54.	Disconnect the battery terminals	4.54	0.83	Strongly Agree
55.	Disconnect the alternator terminals	4.22	1.24	Agree
56.	Loosen the alternator clips	4.12	1.28	Agree
57.	Loosen the alternator tension adjustment bolts	4.16	1.21	Agree
58.	Remove the belt by pressing the alternator inward	4.88	0.53	Strongly Agree
59.	Loosen the mounting and remove the alternator assembly	4.88	0.53	Strongly Agree
60.	After removing the mounting nuts, remove the alternator cover using a screwdriver	4.80	0.71	Strongly Agree
61.	Loosen the three mounting screws and disconnect the brush	4.76	0.73	Strongly Agree

	holder assembly			
62.	Remove the slip ring guide	4.94	0.23	Strongly Agree
63.	Remove the nut, pulley and spacer	4.90	0.39	Strongly Agree
64.	Loosen 4 through bolts	4.98	0.14	Strongly Agree
65.	Separate the rotor, stator and cover	4.78	0.68	Strongly Agree
66.	Installation is in reverse order of removal	4.90	0.39	Strongly Agree
67.	Inspect the rotor coil for continuity and check for continuity between slip rings. If resistance is too low, circuit is short and if resistance is too high, circuit is opened. So replace the rotor assembly in both cases.	4.76	0.70	Strongly Agree
68.	Inspect the rotor coil ground and check for continuity between the slip ring and the core	4.82	0.62	Strongly Agree
69.	Inspect the rotor and coil ground and check for continuity between slip ring and core. If there is continuity, replace the rotor assembly	4.70	0.76	Strongly Agree
70.	Inspect the stator coil for continuity and check for continuity between coil leads. If there is no continuity, replace the stator assembly	4.85	0.50	Strongly Agree
71.	Inspect the coil ground and check for continuity between the coil and the core. If there is continuity, replace the stator assembly	4.77	0.65	Strongly Agree
72.	Inspecting continuity between (+) rectifier and stator coil lead terminal using ohmmeter, there must be only one direction continuity. If there is both direction continuity, replace the rectifier assembly owing to short circuit diode	4.75	0.69	Strongly Agree
73.	Inspecting continuity between (-) rectifier and stator coil lead terminal using ohmmeter, there must be only one direction continuity. If there is both direction continuity, replace the rectifier assembly owing to short circuit of diode	4.75	0.57	Strongly Agree
74.	Pry off the soldered leads	4.82	0.41	Strongly Agree
75.	Unscrew the three mounting screws	4.81	0.39	Strongly Agree
76.	Remove the screw that holds one of the brush leads	4.84	0.37	Strongly Agree
77.	Take out the old rectifier	4.80	0.40	Strongly Agree
78.	Install the new rectifier with the three mounting screws	4.77	0.42	Strongly Agree
79.	Solder the three heavy leads earlier pried off back into place	4.81	0.39	Strongly Agree
80.	Attach the holding screw	4.89	0.32	Strongly Agree
81.	Undo the screws holding each brush assembly in place	4.92	0.27	Strongly Agree
82.	Remove the brushes by simply pulling them out of their channel	4.90	0.29	Strongly Agree
83.	Clean the contact area on the armature shaft where the brushes make contact	4.97	0.17	Strongly Agree
84.	Install the new brushes, making sure the spring for each is exactly on the back of each brush and pushes directly into the brush slot	4.93	0.35	Strongly Agree
85.	Remove the screw that holds the brush in place	4.92	0.36	Strongly Agree
86.	Remove the screw that holds the lead to the grounding screw in place	4.90	0.29	Strongly Agree
87.	Pull out the brush	4.94	0.23	Strongly Agree
88.	Fit back a new brush and reinstall the screws in the reverse order of the removal	4.94	0.23	Strongly Agree
89.	Connect the interface to the computer USB port and diagnostics socket outlet under the vehicle dashboard	4.89	0.32	Strongly Agree
90.	Locate the vehicle interface connection port (outlet)	4.90	0.31	Strongly Agree
91.	Connect the interface to the computer USB port and vehicle connection port	4.81	0.39	Strongly Agree
92.	Turn the vehicle ignition on	4.86	0.35	Strongly Agree
93.	The computer will display a home page, then select the type of	4.81	0.42	Strongly Agree

	vehicle			
94.	Enter the vehicle information number (VIN), locate by the front windscreen or front door hinge	4.85	0.36	Strongly Agree
95.	Vehicle information will be display on the computer	4.70	0.54	Strongly Agree
96.	Navigate using computer keyboard and locate fault reading	4.81	0.42	Strongly Agree
97.	Fault codes will be displayed as shown, reading permanent fault. Repairs are to be carried out at this point	4.78	0.48	Strongly Agree
98.	After repairs, the fault codes will displayed as shown, reading intermittent fault	4.88	0.33	Strongly Agree
99.	Navigate to select clear fault codes	4.78	0.52	Strongly Agree
100.	Carrying out clearing fault will be displayed	4.89	0.32	Strongly Agree
101.	No fault found will be displayed after clearing of fault	4.88	0.33	Strongly Agree

Table 3 indicated that, of the 48 items on charging system maintenance, 45 items were considered strongly agree, whose mean responses were between 4.50 – 5.00, while items 55, 56 and 57 whose mean responses are 4.23, 4.12 and 4.16 respectively were considered agree. The standard deviation (SD) of the items ranged from 0.17 to 1.28, indicating that the respondents were close in their rating.

Research Question 3

What teaching strategies are required for automobile battery and charging system training manual?

Table 4

Mean and Standard Deviation of Respondents on Teaching Strategies Required for Automobile Battery and Charging System Training Manual N = 105

	Strategies	Mean	SD	Remark
1.	Carrying out demonstration in all practical activities involved in auto-electricity/electronics maintenance	3.30	1.00	Required
2.	Employing learning and doing in teaching concept of auto-electricity/electronics	3.56	0.87	Highly Required
3.	Field trip/excursion to see well established auto-electricity/electronics industries and workshops	3.60	0.80	Highly Required
4.	Using discussion method in teaching the learner auto-electricity/electronics	3.28	0.93	Required
5.	Employing modeling in teaching various aspects of auto-electricity/electronics to enable the learner to imitate	3.83	0.38	Highly Required
6.	Role play to show steps in various aspects of auto-electricity/electronics	3.56	0.59	Highly Required
7.	Employing simulations in auto-electricity in teaching the learners	3.70	0.48	Highly Required
8.	Asking probing questions for teaching auto-electricity/electronics	3.57	0.53	Highly Required
9.	Encouraging students on workshop practice	3.48	0.68	Required
10.	Applying guided observation in practical lesson	3.44	0.65	Required
11.	Using discovery method in training of students in auto-electricity/electronics	3.56	0.65	Highly Required
12.	Learning by imitation enhance the students to learn all aspect of auto-electricity/electronics	3.39	0.75	Required
13.	Applying programmed learning in teaching auto-electricity/electronics to the student	3.10	0.73	Required
14.	Encouraging individualized instructions in auto-electricity/electronics for slow learners	3.36	0.68	Required
15.	Involving and encouraging group discussion in small groups to ensure student participation in auto-electricity/electronics maintenance practice	3.23	0.71	Required
16.	Use of video, tape, television, and other technological devices in	3.50	0.64	Highly Required

	teaching concepts of auto-electricity/electronics			
17.	Giving assignment to students on auto-electricity/electronics	3.52	0.76	Highly Required
18.	Employing lecture method in teaching some aspect of auto-electricity/electronics	3.46	0.78	Required
19.	Using jigsaw method in teaching the learner auto-electricity/electronics	3.05	0.79	Required
20.	Mentoring students in carrying out real life practical for teaching all steps involved in auto-electricity/electronics	3.10	0.78	Required
21.	Using modern equipment, replica of what the learner will meet in real life situation in teaching auto-electricity/electronics	3.11	0.82	Required
22.	Involving auto-electricity/electronics experts in teaching some specialize areas of auto-electricity/electronics	3.18	0.93	Required
23.	Employing coaching in teaching various steps in auto-electricity/electronics maintenance	3.16	0.91	Required
24.	Using concept of mapping in teaching all aspect of auto-electricity/electronics	3.17	0.98	Required
25.	Developing computer assisted instructions on some aspects of auto-electricity/electronics	3.14	0.84	Required
26.	Always apply surveying technique to students to ask questions during classes	3.12	0.90	Required
27.	Involving students in selection of suitable tools and materials for every practical to be taught in auto-electricity/electronics/	3.15	0.89	Required
28.	Always explaining various aspects of auto-electricity/electronics to the learner for more understanding	3.17	0.99	Required

The data presented in Table 4 revealed that, of the 28 items on teaching strategies, only 9 items whose mean responses are above 3.50 – 4.00 on a 4 point scale were considered highly required. 19 items with mean responses of 2.50 – 3.49 were considered required by the respondents. It therefore shows that the respondents agree with all the items on teaching strategies. The standard deviation (SD) of the items ranged from 0.38 to 1.00, implying that the respondents were very close in their rating.

Research Question 4

What training materials are required for automobile battery and charging system training manual?

Table 5

Mean and Standard Deviation of Respondents on Training Materials Required for Automobile Battery and Charging System Training Manual N = 105

	Materials	Mean	SD	Remark
1.	Hammer (Assorted)	3.15	0.94	Required
2.	Pliers	3.30	0.77	Required
3.	Long nose pliers	3.27	0.84	Required
4.	Grapping pliers	3.24	0.81	Required
5.	Rubber mallet	3.41	0.73	Required
6.	Files (Assorted)	3.41	0.65	Required
7.	G-clamp	3.19	0.82	Required
8.	Punch	3.14	0.92	Required
9.	Wire brush	3.43	0.73	Required
10.	Testing lamp	3.23	0.82	Required
11.	Ammeter	3.41	0.74	Required
12.	Voltmeter	3.36	0.75	Required
13.	Grease gum	3.28	0.87	Required
14.	Set of chisels	3.40	0.74	Required

15.	Socket spanners	3.33	0.87	Required
16.	Open ended spanners	3.27	0.85	Required
17.	Ring spanners	3.52	0.67	Required
18.	Allen keys	3.44	0.68	Required
19.	Set of screwdrivers	3.31	0.86	Required
20.	Gloves	3.32	0.80	Required
21.	Engine oil	3.31	0.85	Required
22.	Bench vice	3.25	0.92	Required
23.	Work bench	3.18	1.02	Required
24.	Cables (wire)	3.25	0.85	Required
25.	Oil can	3.27	0.90	Required
26.	Aprons	3.20	0.93	Required
27.	Portable drilling machine	3.22	0.90	Required
28.	Hacksaw frame and blade	1.69	0.89	Required
29.	Hand vice	1.69	0.91	Moderately Required
30.	Hand drill	1.67	0.85	Moderately Required
31.	Wire brush	2.97	1.14	Moderately Required
32.	Sand paper	2.96	1.06	Required
33.	Dwell meter	3.06	1.09	Required
34.	Oscilloscope	3.06	1.02	Required
35.	Electrical soldering iron	3.02	1.07	Required
36.	Solder	3.10	0.97	Required
37.	Battery charger	3.15	0.98	Required
38.	Goggle	2.95	1.01	Required
39.	Electrolyte	2.97	1.08	Required
40.	Scan tool	3.03	1.07	Required
41.	Computer interface	3.05	0.96	Required
42.	Computer	2.93	1.10	Required
43.	OBD connector	3.27	0.82	Required
44.	Computer software	3.09	0.94	Required

The data presented in Table 5 show that, of the 44 items on training materials, 41 items whose mean responses are above 2.50 – 3.49 at 4 point scale were considered required. While items 28, 29 and 30 with mean responses of 1.69, 1.69 and 1.67, respectively were considered moderately required. The standard deviation (SD) of the items ranged from 0.65 to 1.14, this imply that the respondents were close in their rating.

Research Question 6

What evaluation criteria are required for automobile battery and charging system training manual?

Table 6

Mean and Standard Deviation of Respondents on Evaluation Criteria Required for Automobile Battery and Charging System Training Manual N = 105

	Evaluation	Mean	SD	Remark
1.	Quality of work and maintenance in auto-electricity/electronics	3.15	1.02	Required
2.	Selection of right tools and equipment	3.18	0.90	Required
3.	Application of technical knowledge and skill in auto-electricity/electronics	3.57	0.72	Highly Required
4.	Ability to adopt required skills in new situation	3.59	0.83	Highly Required
5.	Creativity in auto electricity maintenance	1.42	0.73	Not Required
6.	Effective use of tools and materials	3.59	0.65	Highly Required
7.	Acceptance and application of advices and correction in auto-electricity maintenance	1.38	0.67	Not Required

8.	Quality of finished work	3.82	0.39	Highly Required
9.	Efficient management of time in auto-electricity/electronics maintenance	3.84	0.37	Highly Required
10.	Sustainability of the steps adopted in auto-electricity/electronics maintenance	3.86	0.35	Highly Required
11.	Problem solving ability in the face of new challenges	3.81	0.39	Highly Required
12.	Ability to adapt to correct learnt skills to new situation	3.65	0.66	Highly Required
13.	Failure to follow procedures as initially planned	3.87	0.34	Highly Required
14.	Commitment through regular attendance to practical classes in auto-electricity/electronics	3.60	0.85	Highly Required
15.	Carefulness in handling auto-electricity/electronics maintenance	3.10	1.15	Required
16.	Aesthetic value of finished work	3.29	1.08	Required
17.	Workability of finished work	3.13	1.23	Required

The data presented in Table 6 indicates that, out of the 17 items on evaluation, 10 items whose mean responses are between 3.50 – 4.00 at 4 point scale were considered highly required. While items 1, 2, 15, 16 and 17 whose mean responses of 2.50 – 3.49 were considered required. However, items 5 and 7 whose mean responses are between 0.50 – 1.49 were scores low by the respondents. The standard deviation (SD) of the items ranged from 0.34 to 1.23, implying that the respondents were very close in their rating.

Discussions

The data presented in Table 1 provided answer to research question one. The finding revealed that 9 out of the 11 items on the objective of auto-electricity/electronics training manual were scored agreed by the respondents and found suitable for the manual. This finding is in line with the opinion of Mohammed (2008) that for effective skills acquisition in auto-mechanics the use of diagnostic tools and relevant facilities and equipment should be emphasized to increase student's practical knowledge and Donkor (2010) who stated that, defining goals and objectives serve as the foundation for the development of any activity.

The data presented in Table 2 and 3 provided answer to research question two. The finding revealed that 52 out of the 53 items on battery maintenance were agreed by the respondents as suitable for inclusion in the manual. This finding is in agreement with Femi & Abdulkadir (2008) who opine that battery terminals are still a little prone to corrosion and hence the usual service of cleaning with water and applying jelly grease is still recommended. Also data in Table 3 revealed that the respondents agreed with all the 48 items on charging maintenance as relevant to be included in the manual.. This finding is in line with Denton (2004) who stipulated the procedure for charging maintenance to include loosen battery terminals; loosen the alternator clips to removing the alternator, dismantling it and rectifying the fault.

Data in Table 4 answer research question three. This table revealed that, all the 28 items on teaching strategies are considered agree and suitable for inclusion in the manual by the respondents. The findings of this study is in agreement with Umar & Ma'aji (2011) who reported that potentials of students are developed with the use of different teaching strategies such as demonstration, simulation, role play among others for manipulation of workshop tools, equipment. Data presented in Table 5 answer research question four. The data implies that, all the 44 items on tools and equipment were required for inclusion in the auto-electricity/electronics

maintenance training manual as agreed by the respondents. In line with the findings of this study Robert (2012) stated that facilities help trainers to translate abstract ideas to concentrate ideas.

Data presented in Table 6 answer research question five. Table 6 reveals that, out of 17 evaluation criteria 15 were considered required for the auto-electricity/electronics maintenance training manual by the respondents. The finding of this study is in agreement with Wondo (2004) who stated that practical work by students should be evaluated from the selection of tools and equipment to how the finished. It therefore implies that evaluation of practical skills should be a systematic process. Training manual evaluation can be formative or summative; this is aimed at helping to improve training during and at the end of the programme.

Conclusion

Data obtained in this study indicate that the battery and charging system maintenance training manual is a valid and reliable manual that could be used by technical college students and individuals to increase their knowledge and skills performance in diagnosing faults and repairs in automobiles. This implies that, when students were taught using training manuals, their performance is enhanced. This could be owing to the fact that, the training manual is handy, which they make reference to at their own convenience and pace. Employing these findings, the developed training manual for teaching and learning of battery and charging system maintenance in the technical colleges helps in skills development, acquisition and retention.

Recommendations

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

1. To stimulate meaningful understanding and skills acquisition, students and teacher should adopt the use of training manuals in training, especially in technical areas, where competency-based learning is expected.
2. Though, students should be encouraged to read and practice, group activities tend to favor skills oriented activities rather than individual practice.
3. The Federal Ministry of Education, through the supervisory agency, NBTE should organize workshops, inviting specialists and students to develop training manuals in all skills requiring courses for technical courses.
4. Since education is a life-long skills demand, the Federal Government should as matter of priority, provide the technical colleges with adequate tools, facilities and fund for the consumables, to encourage skills acquisition, thus achieving the objectives their establishment.
5. Workshops, seminars and conferences should be organized for the technical college teachers to enlighten them on the importance and use of training manuals, either in print or electronics in facilitating skills acquisition.

6. Training Manuals should be used for all skills oriented training in the technical colleges, so that the objective could be achieved.

BATTERY AND CHARGING SYSTEM

MAINTENANCE TRAINING MANUAL

Objectives

1. Provide a step by step outline of the procedures for troubleshooting problems in an automobile electrical system
2. Provide auto students and auto technician with the skills and knowledge required to diagnose and repair vehicle with electrical system malfunction

Strategies

1. Carrying out demonstration in all practical activities involved in auto-electricity/electronics maintenance
2. Employing learning and doing in teaching concept of auto-electricity/electronics
3. Field trip/excursion to see well established auto-electricity/electronics industries and workshops
4. Using discussion method in teaching the learner auto-electricity/electronics
5. Employing modeling in teaching various aspects of auto-electricity/electronics to enable the learner to imitate
6. Role play to show steps in various aspects of auto-electricity/electronics
7. Employing simulations in auto-electricity/electronics in teaching the learners
8. Asking probing questions for teaching auto-electricity/electronics
9. Encouraging students on workshop practice
10. Applying guided observation in practical lesson
11. Using discovery method in training of students in auto-electricity/electronics
12. Learning by imitation enhance the students to learn all aspect of auto-electricity/electronics
13. Applying programmed learning in teaching auto-electricity/electronics to the student
14. Encouraging individualized instructions in auto-electricity/electronics for slow learners
15. Involving and encouraging group discussion in small groups to ensure student participation in auto-electricity/electronics maintenance practice
16. Use of video, tape, television, and other technological devices in teaching concepts of auto-electricity/electronics
17. Giving assignment to students on auto-electricity/electronics
18. Employing lecture method in teaching some aspect of auto-electricity/electronics
19. Using jigsaw method in teaching the learner auto-electricity/electronics
3. Develop adequate skills necessary for smooth transition from school to workplace
4. Enhance teacher's skills in teaching auto-electricity/electronics
5. Provide employability skills to auto-electricity/electronics students
6. Enhance the use of diagnostic tools/facilities/equipment
7. Supplement job experience of students from the industry
8. Improve students' interest in auto-electricity/electronics
9. Enhance opportunity to progress in their educational pursuit

20. Mentoring students in carrying out real life practical for teaching all steps involved in auto-electricity/electronics
21. Using modern equipment, replica of what the learner will meet in real life situation in teaching auto-electricity/electronics
22. Involving auto-electricity/electronics experts in teaching some specialize areas of auto-electricity/electronics
23. Employing coaching in teaching various steps in auto-electricity/electronics maintenance
24. Using concept of mapping in teaching all aspect of auto-electricity/electronics
25. Developing computer assisted instructions on some aspects of auto-electricity/electronics
26. Always apply surveying technique to students to ask questions during classes
27. Involving students in selection of suitable tools and materials for every practical to be taught in auto-electricity/electronics
28. Always explaining various aspects of auto-electricity/electronics to the learner for more understanding

Materials

1. Hammer (Assorted)
2. Pliers
3. Long nose pliers
4. Grapping pliers
5. Rubber mallet
6. Files (Assorted)
7. G-clamp
8. Punch
9. Wire brush
10. Testing lamp
11. Ammeter
12. Voltmeter
13. Grease gum
14. Set of chisels
15. Socket spanners

16. Open ended spanners
17. Ring spanners
18. Allen keys
19. Set of screwdrivers
20. Gloves
21. Engine oil
22. Bench vice
23. Work bench
24. Cables (wire)
25. Oil can
26. Aprons
27. Portable drilling machine
28. Hacksaw frame and blade
29. Hand vice
30. Hand drill
31. Wire brush
32. Sand paper
33. Dwell meter
34. Oscilloscope
35. Electrical soldering iron
36. Solder
37. Battery charger
38. Goggle
39. Electrolyte
40. Scan tool
41. Computer interface
41. Computer
43. OBD connector
44. Computer software

Evaluation

1. Quality of work and maintenance in auto-electricity/electronics
2. Selection of right tools and equipment
3. Application of technical knowledge and skill in auto-electricity/electronics
4. Ability to adopt required skills in new situation
5. Effective use of tools and materials
6. Quality of finished work
7. Efficient management of time in auto-electricity/electronics maintenance
8. Sustainability of the steps adopted in auto-electricity/electronics maintenance
9. Problem solving ability in the face of new challenges
10. Ability to adapt to correct learnt skills to new situation
11. Failure to follow procedures as initially planned
12. Commitment through regular attendance to practical classes in auto-electricity/electronics
13. Carefulness in handling auto-electricity/electronics maintenance
14. Aesthetic value of finished work
15. Workability of finished work

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