

DETERMINATION OF STUDENTS' MASTERY AND ERRORS IN AUTO-ELECTRICITY ASPECT OF AUTOMOBILE ENGINEERING PRACTICE IN TECHNICAL COLLEGES IN NORTH-CENTRAL NIGERIA.

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ABSTRACT

The study assessed mastery and errors in auto-electricity skills of 1120 students in 23 technical colleges in North-Central Nigeria, using Auto-electricity Diagnostic Test (ADT). A diagnostic assessment was conducted and data were analysed using Q-matrix and diagnostic classification model (Posterior Marginal Probabilities for skills of a threshold of 0.5), error analysis, frequency counts and simple percentages. Findings of the study revealed that students have low mastery of all the auto-electricity skills and the common errors they commit in solving problems in auto-electricity are; conceptual, careless, procedural, application and precision errors. Based on the findings, it was recommended among others that teachers need to be exposed to the knowledge of developing, conducting diagnostic assessment and how to provide remediation to students who are having learning difficulties in auto-electricity to improve their mastery of the trade, so that no child is left behind in the teaching and learning of the trade.

INTRODUCTION

Auto-electricity is one of the modules of the Automobile Engineering Practice curriculum that covers electrical/electronic systems of the motor vehicle. This aspect is designed to equip students with the skills to be able to diagnose faults and carryout repairs on the electrical and electronic components (battery, distributor, starter motor, wiring, headlamp and others) of the motor vehicle (National Board for Technical Education, 2013). The auto-electricity nodule covers four major units of the motor vehicle, these include: starting, charging, ignition, and lighting and accessory systems. The usefulness of auto-electricity in the professional training of motor vehicle craftsmen in this 21st century has been acknowledged by researchers. However, the mastery of this aspect of motor vehicle by the students for optimal performance in today's automobile industry in the country is yet to be explored. The electrical/electronic systems in the motor vehicle are important systems that are responsible for the generation of power for the operation of the vehicle's components and provide a control mechanism for smooth operation of the components. According to Automotive-online.com (n.d) the early day's automobile electrical technologies were only used for distributing power to other parts of the vehicle but today's electrical system performs sensor functions for efficient operation of the vehicle. Alimi, Ehinola and Alabi (2012) assert that the enormous advancement in electronic technology throughout the 1980s and 1990s, have brought about many changes in the status of the automobile electronic systems.

Supporting the view, Arul and Vimala (2012) affirmed that today's microelectronics have enabled advanced safety features, information and entertainment services and greater energy efficiency in the vehicle. They pointed out that electrical/electronic share of value added to the state-of-the-art vehicle is already 40 percent for internal combustion engine cars and jumped as high as 75 percent for electric or hybrid electric vehicles. In line with the assertion, Alfredas (2007) observed that currently, motor vehicle engines are controlled by microprocessors. These microprocessors also called Electronic Control Unit (ECU, or Brain Box) are electronic micro components that act as sensors for the engine demands (Fuel, speed, temperature among others.). In addition, faults in motor vehicles are now diagnosed using electronic gadget like computer exhaust analyzers that are used in identifying the exact fault in the vehicle for effective and efficient repairs. Therefore, the skills of auto-electricity works are very important in the training of motor vehicle craftsmen, to

enable them acquire the current skills the automobile industry needs to fit in the world of ever changing automobile equipment.

However, over the years, students' achievement in National Technical Certificate Examination (NTCE) in Automobile Engineering Practice has not been encouraging. An analysis of students' NTCE result from 2015 to 2019 as revealed by NABTEB Chief Examiners' Reports within the period, there has been consistent poor achievement in the following areas; charging system, starting system, ignition system, and lighting and accessory system. These areas of weaknesses are from the Auto-electricity aspect of Automobile Engineering Practice. The Chief Examiners attributed the poor/low achievement to candidates' inadequate knowledge of motor vehicle electrical/electronic concepts, poor computation skills, poor grammatical expression, poor drawing skills and poor presentation of answers. Similarly, Adebayo and Jimoh (2015) note that with advancement in technology, petrol engine automobiles are getting more and more complicated because of computerized systems and students especially at the technical colleges have difficulty in learning concepts in auto-electricity aspect of Automobile Engineering Practice.

Several efforts have been made towards improving students' achievement in Automobile Engineering Practice. Studies (Fadairo, 2009; Oyetunde, 2010; Kwaghgba, 2013 & Ogundola, 2014) have all shown that some approaches such as the use of models, inquiry teaching method, the use of simulation, concepts mapping amongst others have been applied to improve students' achievement and develop their interest in Automobile Engineering Practice. Despite these efforts, it appears that no much appreciable improvement has been recorded in students' achievement in the trade. Therefore, the researcher felt the need to explore alternative and a holistic strategy that could identify the problem(s) associated with students' poor achievement that could improve their outcomes in the subject. This could be done through diagnosis of their area of learning difficulties in the trade. The diagnosis is best achieved through the use of diagnostic assessment.

Diagnostic assessment is the type of assessment used to provide information about students' strengths and weaknesses about a subject domain. Similarly, Department of Education (2013) defined diagnostic assessment as the process of gathering and careful evaluation of students' achievement using diagnostic test data to identify their strength and areas of need in a given learning area. Teachers use diagnostic information to adjust instruction by identifying which area students have and have not mastered in a given subject area, so that no child is left behind in teaching and learning process.

Furthermore, several researchers have established that diagnostic assessment is a potent tool for identifying students' learning difficulties in a given area of instruction. Marks (2012) conducted a diagnostic assessment on students' understanding of key concepts of electric circuits in physics in Malta and found that students had problems with parallel circuit, distinguishing between potential difference (p.d.) and current. In the same vein, Gani (2015) conducted a diagnostic assessment on students' achievement in quantitative Economics in Akwanga Nasarawa state. The data obtained provided useful information on students' strengths and weaknesses in the subject area. The efficacy of diagnostic assessment in identifying students' learning difficulties will help in identifying students' learning difficulties in auto-electricity, which could be the reason(s) for their low achievement in the trade.

In the light of the foregoing, it is assumed that the poor achievement of students in auto-electricity is due to their inadequate knowledge of electricity concepts and applications in the motor vehicle. Thus, there is the need to diagnose students' understanding of auto-electricity their level of mastery and errors the make in the subject area.

Purpose of the study

The purpose of this study was to determine the area of auto-electricity that students have mastered, not mastered and errors they make in solving problems the subject area using Automobile Diagnostic Test (ADT). To achieve the purpose, the following research questions were answered:

What aspects of auto-electricity skills have students mastered and not mastered? What are the common errors committed by students in auto-electricity?

METHODOLOGY

Descriptive survey research design was adopted in the study of a population of 1914 Technical college II students in 32 Technical colleges in North-Central Nigeria offering Automobile Engineering Practice. The sample size for the comprised 1120 in 23 Technical colleges drawn from the population using simple random sampling technique. The instrument used for data collection was 82-item multiple-choice and 8 essay items test tagged Auto-electricity Diagnostic Test (ADT) developed by the researchers. Five experts from University of Jos, Nigeria established the content validity of the instrument; three from Automobile Technology Education unit and two from Measurement and Evaluation unit. The experts rated the items using a 5-point rating scale developed by the researcher. Thereafter, the ratings of the experts were analysed using logical validity method to determine the content index of the raters on the coverage of the instrument on the content required in the curriculum. Thus, a Content Validity Index (CVI) of 0.88 was obtained as the mean score of the raters for the instrument. This CVI laid credence to the assertions of Fleiss (1981) and Anikweze (2014) that if CVI value is $>.74$ is considered strong agreement among raters of an instrument and the content validity of the instrument is excellent. This implies that the ADT is significantly valid in terms of content coverage of the curriculum of the subject area. The Auto-electricity Diagnostic Test was trial tested on a sample of 521 NTCII Automobile Engineering Practice students. The data obtained were analysed using item response theory framework for test information function. In the application of item response theory framework for calibration of test items, test information function (TIF) serves as the reliability of the test. TIF is a graphical representation of the sum of item information function in a test and provides estimates of the errors associated with (maximum likelihood) ability estimation. This implies that the more or higher information provided by a test at a particular ability level, the smaller the error associated with ability estimation. From the analysis of the data of the trial testing of ADT items, the multiple-choice TIF graph the maximum information was 1.9 at $\theta = 0.01$. At a cut point of $\theta = 0.000$, the TIF equaled 2.0. Based on these, information is well spread within the ability range of -2.5 to $+2.5$. This implies that high information of the test items cut across all levels of θ . This means that the instrument is reliable.

RESULTS

Research Question 1

The research question one was answered by classifying the students' achievement in the ADT under mastery and non-mastery in each of the sub-skills or attributes presented in a Q-Matrix form. This means that a 0 mark represents wrong response and 1 stands for correct response to an item. The classification of students' achievement into mastery and non-mastery was done using Posterior Marginal Probability for Attribute Profile (PMPAP). PMPAP is a statistics obtained from diagnostic classification model used to determine learners' mastery level of set of skills in a given subject. The classification was that a statistics threshold of a probability (0.5) and above was considered mastery and 0.0 to 0.4 indicate non-mastery. The probability formula was: outcome/expected . This means that the number of items a student scored correctly divided by the total number of items in a given skill of the test. Thereafter, frequency counts and simple percentages were calculated to determine the number of skills mastered and not mastered by each individual student accordingly.

Table 1
Summary of the Frequency and Percentage Count of mastery and Non-mastery of students in the ADT According to the Four Auto-electricity Attribute or Skills

Attribute	Mastery		Non-mastery		Total	
	N	%	N	%	N	%
Charging System i	209	18	911	82	1120	100
Starting system ii	182	16	938	84	1120	100
Ignition system iii	234	20	886	80	1120	100
Lighting and accessory system iv	146	13	974	87	1120	100

Table 1 shows the summary of students' mastery and non-mastery of auto-electricity attributes (charging, starting, ignition and lighting and accessory systems). The result revealed very low percentage mastery of students in auto-electricity with none up to average. The percentage mastery for charging system was (209, 18%), starting system (182, 16%), ignition system (234, 20%) and lighting and accessory system (146, 13%). This implies that students have low mastery of all auto-electricity attributes

To determine a student's skills mastery standing using the posterior marginal probabilities for attributes or skills with the determinant threshold of 0.5 for each skill is obtained using this:

$$\text{Formula: } \frac{\text{Outcome}}{\text{Expected}} \quad \text{Outcome} = \text{student's correct answers} \\ \text{Expected} = \text{total number of items per skill}$$

For the student Y, responses to each skill/items

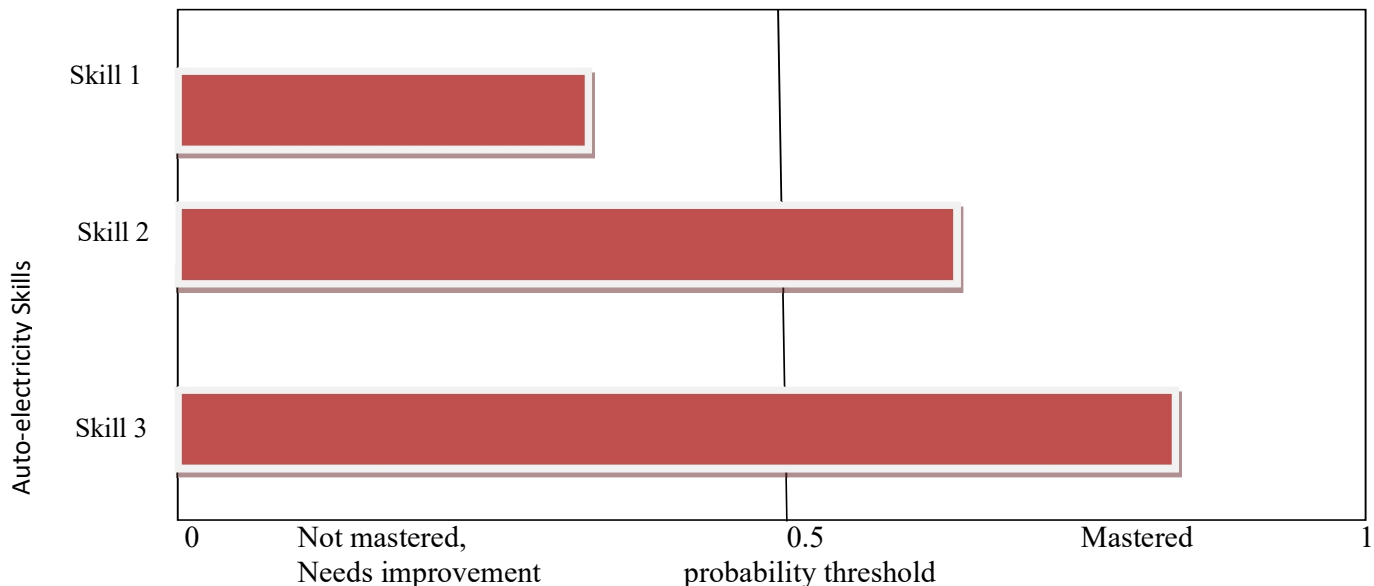
$$\text{Charging system} = \frac{2}{8} = 0.25$$

$$\text{Starting system} = \frac{6}{10} = 0.6$$

$$\text{Ignition system} = \frac{6}{8} = 0.75$$

$$\text{Highlighting and accessory system} = \frac{0}{4} = 0$$

Student's skills mastery standing



HOW TO INTERPRET A STUDENT'S SKILL MASTERY LEVEL FROM THE BAR CHART

The bar chart presented the student's skill mastery standing, and the following can be deduced from the chart

1. On skill 1 (charging system) the student needs improvement as the probability threshold he achieved was below 0.5, signifies non-mastery and needs improvement.
2. On skill 2 (starting system), the student has mastery of the skill as the probability threshold he achieved was above 0.5.
3. On skill 3 (ignition system), the student also has mastery of the skill as the probability threshold he achieved was above 0.5.
4. On skill 4 (lighting and accessory system), the student needs serious efforts to improve on the skill as the probability threshold he achieved was 0, signifies non-mastery.

Skill 4
 based on the diagnosis, the student has mastery of two skills; starting and ignition skills of auto-electricity.

Research Question 2

The research question was answered by grouping students' errors according to types and frequency of occurrence. To determine students' errors, error analysis of their responses to the ADT essay items was conducted using the marking scheme and classification to different error types (conceptual, careless, application, precision & procedural errors) based on the different skills (charging, starting, ignition and lighting and accessory systems). For example, if a student was unable to apply a formula of a concept to solve a calculation problem, such was categorized as application error.

Table 2**Summary of Frequency and Percentage Count of Students' Error in ADT Essay Item by Pattern According to Attributes**

Attribute	Item	N	Conceptual		Careless		Procedural		Application		Precision		Total	
			N	%	N	%	N	%	N	%	N	%	N	%
Charging System	1	200	811	44	162	10	100	6	730	40	-	-	1803	100
Starting System	2	150	665	63	158	15	-	-	220	22	-	-	1043	100
Ignition System	1	190	920	48	350	18	-	-	-	-	650	34	1920	100
Lighting and accessory System	2	300	1047	64	-	-	107	7	481	29	-	-	1635	100
Lighting and accessory System	1	210	173	13	401	29	-	-	-	-	793	58	1367	100
Lighting and accessory System	2	120	678	41	413	26	58	3	-	-	503	30	1652	100
Lighting and accessory System	1	87	501	37	278	20	89	8	-	-	462	34	1330	100
Lighting and accessory System	2	98	733	46	129	8	43	4	661	42	-	-	1566	100
Total			5528	44	1891	15	397	6	2092	16	2408	19	12316	100

Table 2 presents the summary of error analysis of students' responses to ADT. The result revealed that the most common errors made by students in the ADT were conceptual error, which occurred 5528 times representing 44%, careless error 1891 (15%), procedural error 397(6%), application error 2092 (16%) and precision 2408 (19%). This shows that the most common error committed by students in solving problems in auto-electricity was conceptual error and the least was procedural error.

DISCUSSION

The purpose of this study was to determination of students' mastery and errors in auto-electricity aspect of Automobile Engineering Practice in Technical colleges in North-Central Nigeria. The findings on the achievement profile of students in auto-electricity in terms of mastery and non-mastery of the objectives covered by the ADT multiple-choice items revealed that students have low mastery of all auto-electricity attributes or skills (charging, starting, ignition and lighting and

accessory systems). These findings are in consonance with the outcome of the study of Marks (2012) on the students' understanding of key concepts of electric circuits in Malta. The study revealed that students had problems with parallel circuits, potential difference and current. The three concepts are under the lighting and accessory system content. The findings of the present study are in line with the views of Adebayo and Jimoh (2015) that advancement in technology, petrol engine automobiles are getting more and more complicated because of computerized systems and students in the technical colleges have difficulties in learning concepts in auto-electricity.

The result of analysis on the common types of errors committed by students in auto-electricity shows that the most common errors committed by students was conceptual error, others were careless, procedural, application and precision errors. These findings are in consonance with the findings of NABTEB Chief Examiners' Reports of 2015-2019 in the achievement of students in auto-electricity. The reports revealed that candidates have inadequate knowledge of the subject area concepts. Similarly, Adebayo and Jimoh (2015) assert that the incorporation of advanced computerized technologies in petrol automobile equipment systems, students at the technical college level are having difficulties in learning concepts in auto-electricity, hence, the errors they make. Supporting the aforementioned, Luneta and Makonye (2010) posit that possible causes of mistakes learners make may be due to lapses in concentration and hasty reasoning. These findings are contrary to the outcome of the study of Bulus (2018) on the common errors students make in quantitative Economics. The findings revealed that the most common error students make in the subject was computational error.

CONCLUSION AND RECOMMENDATIONS

Based on the findings of the study, it can be concluded that students have low mastery of all auto-electricity skills (charging system, starting system, ignition system and lighting and accessory system). Furthermore, the causes of students' errors (conceptual, careless, precision, application and procedural errors) about automobile electrical works was due to inadequate knowledge of the subject, poor computation skills, poor drawing skills, lack of concentration and lack of practical experience. In addition, the students' level of mastery, errors and misconceptions about automobile electrical works are associated with the type of schools and location of schools they attend.

In view of the findings of this study, the researchers hereby recommend that:

1. Teachers need to be trained on how to develop, conduct diagnostic assessment and how to provide remediation to students who are having learning difficulties especially in the subject. This could be achieved through seminars and workshops organized by experts in the field of measurement and evaluation. When this is done, teachers will be equipped on how to identify students who are having problems with their subjects and take timely and appropriate remediation in achieving better learning outcomes.
2. Schools' administrators should provide teachers with the necessary learning diagnostic tools and fund for them to be able to conduct holistic and valid diagnosis of students' learning difficulties. This is necessary because diagnostic assessment is a multi-stage assessment technique that involves different methods of data collection with their correspondent measuring tools. Furthermore, schools' administrators should also provide adequate time for diagnostic assessment in their scheme of work just like other types of assessments, thereby making teachers to give it the needed attention in achieving the stated learning objectives.
3. The students should be encouraged to put in more efforts in their study of auto-electricity by providing schools with standard automobile workshops and libraries with internet services. This will enable them have access to current and relevant materials, in addition to what they have been given in the class, thereby broadening their knowledge of the trade, develop critical inquiry skills and enhance their mastery of the subject. Furthermore, teachers should give adequate attention to practical lessons to enable the

students to have a better understanding of theory lessons they have learnt. This will also help them reduce the errors make and misconceptions they have about auto-electricity as well as improve their performance in the subject.

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