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Diagnostic Assessment of Students' Achievement in Automobile Electrical Works in Technical Colleges in a Developing Country

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Abstract: The study assessed mastery of automobile electrical works skills of 102 students in nine technical colleges in one state using an Automobile Electrical Works Diagnostic Test (AEWDT). It also determined association of the students' mastery level with school type and location. A diagnostic assessment was conducted and data was analyzed using Q-matrix and diagnostic classification model (Posterior marginal probabilities for skills of a threshold of 0.5), frequency counts, percentages and Chi-square. Findings of the study revealed that students have low mastery of all the automobile electrical works skills and that their mastery level is associated with the location and type of school they attend. This study provided empirical evidence on students' learning difficulties in automobile electrical works that will help teachers in carrying out effective remedial instructions for students who are having learning difficulties, so that no child is left behind in the teaching and learning of the trade.

Key words: Student Evaluation · Evaluation Methods and Electrical Works

INTRODUCTION

Automobile electrical works, which covers electrical/electronic systems of the motor vehicle, is one of the modules of the Technical College Motor Vehicle Mechanics Technology curriculum that teaches the principles of electricity and the application of such in the motor vehicle system. Automobile electrical works is an aspect of motor vehicle mechanics technology curriculum, which is designed to equip trainees with the skills to be able to trace faults in the electrical/electronic systems of the motor vehicle and effect necessary repairs [1]. The automobile electrical works module covers four major units of the motor vehicle, which include starting system, charging system, ignition system and lighting and accessory system. The usefulness of automobile electrical works in the professional training of motor vehicle craftsmen in this technological age has been acknowledged by researchers. However, the mastery of this aspect of motor vehicle mechanics technology by the students, for optimal performance in today's automobile industry in the country is yet to be explored. Over the years, National Technical Certificate Examination Chief Examiners' Reports have consistently revealed poor performance of students in Motor Vehicle Mechanics Technology. According to the available reports of 2010, 2011, 2012, 2013, 2014 and 2015, the poor performance is attributed to weakness of students mostly in automobile electrical works aspect of motor vehicle mechanics technology. The reports also revealed that students have inadequate knowledge of electrical/electronic concepts, poor computation skills, poor drawing skills and poor presentation of answers. Supporting the view [2] shows that students at the technical college level have difficulties in learning concepts in motor vehicle trade especially in electrical/electronic aspect. Consequently, there is great need to diagnose their learning difficulties in order to identify their strengths and weaknesses in the trade for remediation.

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The electrical/electronic systems in the motor vehicle are important systems of the vehicle, which 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 automobiles electrical technologies were only used for distributing power to other parts of the vehicle but today's electrical system performs sensor functions for efficient operations of the vehicle. Alimi *et al.* [3] asserted that the enormous advancement in electronic technology throughout the 1980s and 1990s, have brought about many changes in the status of automobile electronic systems. He stressed further that those changes are driven by safety as well as environmental reasons. Supporting the view, Arul and Vimala [4] affirmed that today's microelectronics have enabled advanced safety features, information and entertainment services and greater energy efficiency in the vehicle. He pointed out that electrical/electronic share of value added to a state-of-the-art vehicle is already at 40 percent for internal combustion engine cars and jumped as high as 75 percent for electric or hybrid electric vehicles.

Similarly, Byoung-Suk [5] admits that today's vehicles engine control systems are On-Board Diagnostic system. In the same vein, Chang *et al*. [6] pointed out that current motor vehicle engines are controlled by microprocessors (Engine Control Unit or Brain Box). These microprocessors are electronic micro-components or sensors that sense engine demands (Fuel, speed, temperature etc.) and communicate to the appropriate vehicle component(s) for response. They help in providing clean fuel burning, fuel efficiency and powerful engines. The engine control unit controls such things like fuel injection rate, emission control, N_x control, regeneration of oxidation catalytic converter, turbocharger control, cooling system control; throttle control amongst others in the diesel engine; while in gasoline engine, the engine control unit controls such things like Lambda control, On-Board Diagnostic, cooling system control, ignition system control amongst others [7].

Furthermore, the automobile electrical/ electronic systems also function in conjunction with other components of the motor vehicle like transmission (Gear box and clutch), chassis (Anti-lock braking system, traction control system electronic brake distribution, electronic stability programme), passive safety (Air bags, hill descent control, emergency brake assist system etc) (William & Norman). In addition, faults in motor vehicles are now diagnosed using electronic gadgets like computer exhaust analyzers to identify the exact fault(s) in the vehicle for effective and efficient repairs.

Considering the enormous and important functions of electrical/electronic systems as well as the inter-dependency of it with the mechanical system in the effective operation of modern vehicles, the skills of automobile electrical works have become imperative and indispensable in the training of motor vehicle craftsmen. For the present craftsmen to be able to function optimally in today's automobile industry, they need to acquire sufficient skills in the principle and operation of electrical/electronic and mechanical systems skills. However, poor performance of students in automobile electric works aspect of the motor vehicle trade is a thing of concern, hence the need to diagnose their learning difficulties in order to identify their strengths and weaknesses in the trade for remediation.

Consequently, the poor performance has hindered the achievement of the objectives of teaching motor vehicle mechanics technology, which include; the production of competent maintenance craftsmen with sound theoretical and practical knowledge, who should be able to set, diagnose, service and repair faults in motor vehicle main units and systems to manufacturers' specification (National Board for Technical Education, NBTE 2001). It has also hindered the production of technical college graduates who can either be employed in the industries or become self-employed and have opportunity for further technical education. Students' poor performance in the trade is an indication that they are not adequately knowledgeable in the subject matter, hence the need to diagnose their strengths and weaknesses in the subject for remediation. There is also the need to examine the extent to which students' mastery level of the four attributes or skills are associated with the type of schools they attend and location. This is because studies on poor performance have shown that students' academic performance is not only a function of their cognitive ability but can also be influenced by factors like school type, school location, facilities, gender, class size amongst others [8-13].

Researchers have established that diagnostic assessment is a potent method for identifying students' learning difficulties in a given area of instruction. Haki and Ali [14] conducted a diagnostic assessment on students' pre-knowledge of basic electrical principle in motor apprentice at the beginning of the training course and at the end of the course in Dublin Institute of Technology,

Ireland. The data obtained from the diagnostic test provided useful information regarding students' strengths and weaknesses in the subject area. Similarly, Imo [15] conducted a diagnostic test on students' understanding of key concepts of electric circuits in Malta and found that students had problems with parallel circuits, distinguishing between potential difference (p.d) and current. Furthermore, Iwuagwu *et al*. [16] developed and validated a diagnostic test for assessing students' misconceptions about electric circuits in Physics, at high school level in Turkey.

Evidence of the efficacy of diagnostic assessment in identifying students' learning difficulties even in other areas of studies has also been established. Kenny [17] also conducted a diagnostic assessment on students' learning difficulties in inverse function in Turkey and found that students had difficulty in demonstrating subjection of function when finding the inverse of a given function and other misconceptions. The result of the study by Ketterlin *et al.* [18] on diagnostic assessment of senior secondary two students' achievement in quantitative aspect of Economics revealed students' areas of difficulties in the aspect of Economics as well as the relationship between their mastery level of some content areas of the subject and other variables like school type, gender, amongst others. In view of the efficacy of diagnostic assessment in identifying students' learning difficulties, it is imperative that students' learning difficulties in automobile electrical works be investigated for remediation. This is necessary because electricity in its nature is full of abstract concepts, skills and facts and students are expected to develop conceptual models of the relationship between non-observables quantities (Current, potential difference and resistance) in terms of other non-observables such as energy and electrons [19]. In the same vein, a study on secondary school students' misconceptions about simple electric circuits by Marks [20] revealed that almost all the students interviewed were found to have the misconception that "Current decreases when it passes through the bulb". When asked why the current decreases, they reasoned, "When the current passes through the bulb and it lights up, it should decrease''. The study also revealed that the students were confused about some concepts like potential difference, current and energy as they used them interchangeably as if they all mean the same thing.

In the light of the foregoing, it is assumed that the poor performance of students in automobile electrical works is due to their inadequate knowledge of electricity concepts and their application in the motor vehicle system. There is therefore the need to diagnose students' understanding of automobile electrical works to identify their areas of difficulties for remediation.

The purpose of this study was to determine the areas of automobile electrical works that students have mastered and not mastered using Automobile Electrical Works Diagnostic Test (AEWDT). The study also investigated the influence of school type and location on students' mastery of the four areas or skills of the automobile electrical works. To achieve the purpose, the following research question was answered: What aspects of automobile electrical works skills have students mastered and not mastered? In addition, the following hypotheses were tested:

- There will be a significant association between number of students that mastered the automobile electrical works skills and their school type. 2. There will be a significant association between number of students that mastered the automobile electrical works skills and their school location.

MATERIALS AND METHODS

Descriptive survey research design was adopted in the study of a population of 102 Technical college III students in the nine technical colleges (5 public; 4 private) in a state, offering motor vehicle mechanics technology participated in the study. Fifty-two students were from five public, while 50 were from private technical colleges. The entire population of students participated in the study because of its small size. The instrument used for data collection was a 30-item multiple choice test tagged Automobile Electrical Works Diagnostic Test (AEWDT) developed by the researchers. Three experts from university of Jos, Nigeria established the content validity of the instrument; two from the field of Motor Vehicle Mechanics Technology and one from Research, Measurement and Evaluation. The experts rated the test items using four-point Likert type scale of Very Appropriate (4), Appropriate (3), Inappropriate (2) and Very Appropriate (1). Consequently, the ratings of the experts were subjected to statistical analysis to ascertain whether they were in agreement with one another, using Kendall's Coefficient of Concordance and it yielded coefficient of concordance of 0.50, which considered significant [21].

The instrument was pilot tested by administering it on 46 students. The data obtained were analyzed using IRT 3parameter logistic model and the reliability index of the instrument was 0.81. This reliability index laid credence on the assertion of National Board for Technical Education [22] that if the value of reliability is ≥ 0.75, the instrument is considered reliable. The responses of the 102 students to the 30 multiple choice items of the AEWDT were presented and analyzed using Q-matrix method and Posterior marginal probabilities for skills of a threshold of 0.5 [23]. On the Q-matrix, 0 represents a student's wrong response and 1 stands for a student's correct response to an item in a skill. The frequency counts, simple percentages and Chi-square were used for data analysis. Specifically, diagnostic classification model (DCM) of the Item Response Theory (IRT) was used in classifying learners' mastery level of the skills or attribute [24].

RESULTS

The research question was answered using frequency counts and simple percentages of students' mastery level of automobile electrical works skills according to the four systems (Charging system, starting system, ignition system and lighting and accessory system) as measured by Automobile Electrical Works Diagnostic Test. A student who achieved a marginal probability of 0.5 for an attribute or skill was considered to have mastered the skill. Any probability below the marginal probability of 0.5 was considered as non-mastery. The result is presented in Table 1.

Table 1 shows a very low percentage mastery of students in all the automobile works skills with none up to average of 50 percent. The highest percentage was 14.71 on ignition system skill, the rest were 9.80% for charging system skill, 7.84% for starting system skill and 5.88% for lighting and accessory system skill. This implies that students have low mastery of all automobile electrical works skills.

Tables 3, shows example of a student Y's skills mastery profile using Q-matrix. While Figure 1 below shows the student's skills mastery standing. Each skill's mastery standing of the student Y was determined using the posterior marginal probabilities for attributes or skills with the determinant threshold of 0.5 for each skill and it was obtained using this;

$$\text{Formula:} \frac{\text{Outcome}}{\text{Expected}}$$

where, Outcome = student's correct answers
Expected = total number of items per skill
For the student Y, responses to each skill/items

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

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

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

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

The bar chart in Figure 1 presents the student's skill mastery standing and the following can be deduced from the chart:

- On skill i (Charging system) the student needs improvement as the probability threshold he achieved was below 0.5, signifies non-mastery and needs improvement.
- On skill ii (Starting system), the student has mastery of the skill as the probability threshold he achieved was above 0.5.
- On skill iii (Ignition system), the student also has mastery of the skill as the probability threshold he achieved was above 0.5.
- On skill iv (Lighting and accessory system), the student needs serious efforts to improve on the skill as the probability threshold he/she achieved was 0, signifies non-mastery.

Table 4 shows the association between students' mastery of automobile electrical works skills and the type of school they attend using Chi-square test of independence. The Table shows that there is significant association between number of skills mastered by students in automobile electrical works and their school type. The result yielded χ^2 (*8, N=39*) = 43.326 and *p*-value = .000, since the *p*-value (.000) is less than the level of significant 0.05, the hypothesis was retained. This implies that the type of school a student attends has significant influence on his/her mastery level of automobile electrical works skills. A further look at the table reveals that students from private schools mastered more skills compared to students from public schools.

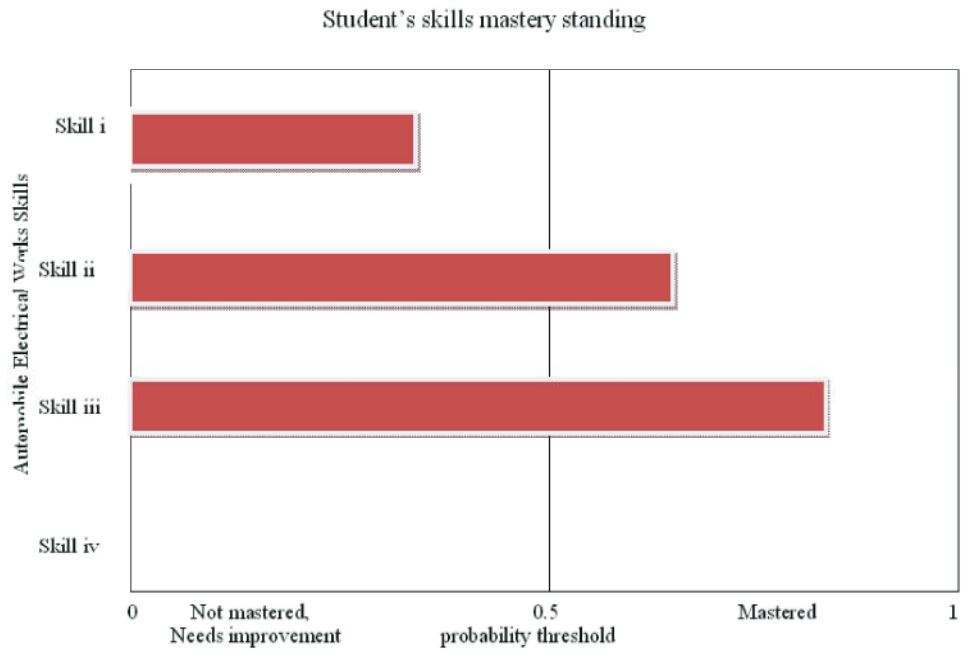

Fig. 1: Student's skills mastery standing

Table 1: Overall percentage mastery and non-mastery of students in the four attributes or skills

	Mastery		Non-mastery	
Skill	n	%	n	%
Charging System i	10	9.80	92	90.2
Starting system ii	8	7.84	94	92.16
Ignition system iii	15	14.71	87	85.29
Lighting and accessory system iv	6	5.88	98	94.12

Table 2: Diagnosis: Skill description and number of items/skill of the multiple choice items of ADWDT

Skill	Skill description	Items
1.	Charging system	2, 5, 15, 16, 21, 24, 29, 30
2	Starting system	6, 7, 8, 10, 14, 18, 22, 26, 27, 28
3	Ignition system	1, 3, 9, 11, 12, 17, 19, 25
4	Lighting and accessory system	4, 13, 20, 23

Table 3:Example of a Q-matrix showing a student Y's skills mastery diagnosis

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Student's responses	1	0	1	0	0	1	0	1	0	1	1	1	0	1	1	1	0	0	1	0	0	-	0	0	1	0	1	1	0	0

1=Correct Response, 0=Wrong Response.

Table 4: Summary Table for χ^2 test analysis for school type and students' mastery of automobile electrical works skills

School Type	N	Df	χ^2	*P*-value
Public	19	8	43.326	.000
Private	20			

P< 0.05

Table 5: Summary Table for χ^2 test analysis for school location and students' mastery of automobile electrical works skills

School Location	N	Df	χ^2	*P*-value
Urban	26	8	40.615	.000
Rural	13			

p< 0.05

Table 5 shows the association between students' mastery of automobile electrical works skills and the location of their school, using Chi-square test of independence. The Table shows that there is significant association between number of skills mastered by students in automobile electrical works and their school location. The result yielded χ^2 (*8, N=39*) = 40.615 and *p*-value = .000. Since the *p*-value (.000) is less than the level of significant 0.05, the hypothesis was retained. This implies that the environment where a school is situated has a significant influence on students' mastery of automobile electrical works skills. The result revealed further that students from urban schools have mastery of the skills more than students from rural schools.

DISCUSSION

The purpose of this study was to conduct a diagnostic assessment of students' achievement in automobile electrical works in technical colleges in a developing country. The findings from research question one revealed that students have low mastery of all automobile electrical works skills, namely; charging system, starting system, ignition system and lighting and accessory system. This finding is in consonance with the outcome of the study of Marks [20] 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 of the automobile electrical works module, which has the least students' mastery level. The low students' mastery in the skill could also be attributed to the abstractness or non-observable nature of electric quantities like current, potential difference or voltage and resistance, that demand students to develop conceptual models of the relationship between non-observable quantities and other quantities as was confirmed by Okoria and Ezeh [25]. Therefore, we can say that the conduct of this diagnostic assessment has helped in understanding in detail the students' mastery level of automobile electrical works skills that could be of benefit to teachers and other practitioners in improving students' understanding of the subject through a holistic remediation process.

The findings from the test of hypothesis one shows that the students' mastery of automobile electrical works skills are influenced by the type of schools they attend, in favour of private schools. These findings are supported by the study of Olatunji [26] on the diagnosis of pupils learning difficulties in division aspect of Mathematics. She found that students' mastery in the division of Mathematics was affected by the type of school they attend in favour of pupils from private schools. Corroborating the views, others studies [27, 28] also revealed that students from private schools are more likely to achieve higher scores in standardized assessment than their counterpart in public schools. This implies that the type of school a student attends has significant influence on his/her mastery level of automobile electrical works skills. Contrarily, the studies [29, 30] found that school type had no influence on students' mastery of a subject. This implies that whether a student attends private or public school, it does not affect his/her academic performance. Based on these findings, the provision of remediation to improve students' mastery of automobile electrical works skills should be inclusive of the factors that create the differences in the academic achievement of public and private schools students, to achieve a holistic and better remediation as well as improve their performance in the subject.

The results from the test of hypothesis two shows that students' mastery of automobile electrical works are influenced by the location of the schools they attend in favour of urban schools. These findings are in consonance to the study of Zaiontz [31] on students' achievement in chemical bonding in relation to their school location in Enugu State. Their findings revealed that school location has influence on students' achievement in chemical bonding. Thus, this signifies that students' mastery of automobile electrical works is associated with the location of their schools. In contrast, study by De la Torre [8] on students' achievement in chemistry in relation to school location found no significant difference in the academic achievement of students in urban and rural schools. This implies that the environment where a school is located does not affect students' academic performance. Therefore, the implication of these findings is that students' academic achievement is not only a function of their cognitive ability, other factors like school location could also affect their academic achievement, hence, the need for remediation of students' learning difficulties to be conducted in relation to the environment where the schools are located.

Therefore, from the findings, it can be deduced that the conduct of diagnostic assessment on students' achievement in automobile electrical works has helped to identify students' mastery level in the subject. The findings should therefore be considered in providing

remediation to students in ensuring that no child is left behind in the teaching and learning of automobile electrical works.

The present research has some limitations that also suggest directions for future research in this area. The study was aimed at identifying students' learning difficulties in automobile electrical works in technical colleges in the country using diagnostic assessment. However, the researchers were only able to determine the students' mastery level of the automobile electrical works skills using multiple-choice items without testing their mastery of the practical skill aspect of the trade. Therefore, future research should diagnose students' practical mastery of the trade skills as the subject is practical oriented. Furthermore, the researchers only investigated the effect of two school environmental variables (School type and school location) on the students' mastery of automobile electrical works skills; other variables were not considered and might have effect on the students' mastery of the trade. Nevertheless, it may be important for researchers to conduct a diagnosis of students' learning difficulties in the subject in relation to other variable like facilities, or instructional materials to have a holistic assessment of their learning problems in the trade. Finally, in view of the low students' enrolment in technical colleges in the state, the sample size for the study was very small to decrease the standard error and increase the power of the test. Based on this limitation, a similar research could be conducted to cover two or three states in order to have a large sample that will reduce the standard error and increase the power of the test.

CONCLUSION AND RECOMMENDATIONS

A diagnostic assessment of students' achievement in automobile electrical works in technical colleges was conducted in a developing country. The study was motivated by poor performance of students in automobile electrical works, which is one of the important aspects of Motor Vehicle Mechanics Technology trade. Diagnostic test was administered to students to identify their areas of difficulties in the four skills of automobile electrical works (Charging system, starting system, ignition system and lighting and accessory system). The findings revealed that students have low mastery level of automobile electrical works skills and that their mastery level was associated with the type of school and location of school they attend. Based on the findings of the study, it was concluded that students have low level mastery of all the automobile electrical works skills which need to be enhanced through remediation to enable the products of the trade acquire sufficient skills in the principles and operations of electrical/electronic and mechanical systems skills to be able to function optimally in today's automobile industry.

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

- 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 organize by experts in the field of measurement and evaluation. When this 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 outcome.
- 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 assessments, thereby making teachers to give it the needed attention in achieving the stated learning objectives.
- The students should be encouraged to put in more efforts in their study of automobile electrical works 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 enhanced their mastery of the subject.

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