



## Enhancing Technical Skills of Electrical Power and Machines Graduates for Optimal Performance in Nigerian Manufacturing Industries

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### ABSTRACT

*Industries serve as powerful catalysts for economic growth, driven by skilled engineering personnel. Despite their significant contribution to Nigeria's GDP over the years, these sectors face a challenge in revolutionizing production due to a shortage of trained manpower. Various studies have been conducted to enhance the skill acquisition of industrial workers; however, none have focused on integrating cutting-edge technical skills into the curriculum. Thus, this study aims to investigate the essential technical skills required for proficient performance in industries, specifically focusing on electrical power quality and motor torque control. Employing a descriptive research design, data was collected from 242 respondents. The research findings highlighted several novel technical skills deemed crucial for inclusion in the electrical engineering curriculum. These skills encompass the utilization of diverse instruments to monitor electrical power quality, techniques for installing fast protection devices to prevent faults in transmission and distribution systems, and methods for controlling the firing angle of silicon-controlled rectifiers to vary the voltage applied to an electric motor, among others. It's worth noting that this study adopts a purely quantitative approach, with face-to-face perceptions of respondents left unexplored. This limitation may pose a potential threat to the result's validity. Nevertheless, the study provides the Departments of electrical engineering with valuable new technical skills in electrical power quality and motor torque control, encouraging their integration into the curriculum. In doing so, this research sets a precedent for identifying and incorporating innovative technical skills across various aspects of electrical engineering to enhance industry performance.*

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### INTRODUCTION

The positive implications and influence of industrialization in

industrialized nations globally have compelled many developing countries to devise policies and development plans

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aiming to shift their status from mere consumers of finished goods to becoming producers and manufacturers. This strategic step is crucial to achieve economic growth, development, and job creation, empowering people for sustainable livelihoods. According to Iwuagwu (2011), industrialization plays a critical role in economic development, as practically no country has achieved development without embracing industrialization. The economies experiencing rapid growth today are marked by flourishing manufacturing industries (UNIDO, 2009). Likewise, historically, countries that have achieved significant growth in productivity and living standards have done so through industrialization. Therefore, industrialization is the driving force behind economic development, as it fosters employment, wealth creation, and poverty alleviation.

Manufacturing, as one of the most powerful engines for economic growth, acts as a catalyst in transforming the economic structures of nations. It drives countries from simple, slow-growing, and low-value activities to more productive endeavors with higher growth prospects, fueled by technology and innovation. Modern manufacturing is a byproduct of industrialization, evolving alongside scientific and technological advancements. Ukaegbu (1991) defined industrialization as the process by which inanimate energy or mechanical power

replaces human energy. The advantages of industrialization include increased employment opportunities, improved balance of payments, higher income and living standards, and the dissemination of technical and managerial skills. Additionally, industrialization generates production, leading to an abundance of goods and services.

In the Nigerian context, prior to the 1950s, large-scale manufacturing plants were rare, and the country primarily relied on trading companies that imported manufactured goods. The manufacturing sector's contribution to GDP was modest, but it experienced significant growth over the years. However, it faced challenges in subsequent years, experiencing a decline in its contribution to GDP and struggling to maintain competitiveness in the global market. During the oil boom era, industrialization surged, but it later faced a precipitous decline in the 2000s. Manufacturing export remained low, and imports of manufactured goods were considerably high.

Table 1 below illustrates the contribution of the Nigerian manufacturing sector to GDP in the last decade, indicating fluctuations and challenges faced by the sector in recent times. Overall, industrialization remains a vital driver of economic development, and enhancing the manufacturing sector's capabilities is crucial for Nigeria's sustainable growth and prosperity.

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**Table 1:** Nigerian Manufacturing Sector Contribution and the GDP growth rate

Year	Manufacturing Sector Contribution to GDP (%)	GDP growth rate (Value)	GDP growth rate (Percentage)
2008	24.71	330.22*	6.8
2009	21.24	297.46*	8.0
2010	25.32	369.06*	8.0
2011	28.28	414.10*	5.3
2012	27.07	460.95*	4.2
2013	25.74	514.97*	6.7
2014	24.64	568.50*	6.3
2015	20.16	493.84*	2.7
2016	18.17	405.44*	-1.6
2017	22.32	376.36*	0.8
2018	25.75	398.19*	1.9

\*Billion USD

Source: World Bank (December, 2019)

The table 1 shows that the contributions of Nigerian manufacturing industries to the country's gross domestic product (GDP) in the last decade is more than 20 percent for each year (except for 2016), which is higher than the global average GDP contribution from the sector. Other countries whose GDPs exceeds 20 percent includes China, South Korea, Japan, Germany and Indonesia. While countries such as Mexico, India, Italy, Spain, US, Russia, Brazil, Canada and the UK recorded less than 17 percent as a share of manufacturing to their countries' GDPs. The Nigerian government has also expressed commitment towards the industrial policy in a bid to improve local production and enhance competitiveness, thereby increasing the contribution of manufacturing to GDP.

Even though manufacturing sector contributed significantly to the Nigeria's GDP over the years, Nigeria's industries are typified by their failure to modernize production. While industries in

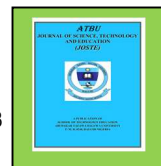
the developed world aim at generating, accumulating and reproducing capital, Nigerian industry is premised on import-substitution (Anya, 1982). To achieve the later objective, industrial equipment and raw materials are transported into Nigeria, installed, and used for routine production activities either by multinational corporations, the state, or indigenous private businessmen. Manufacturing in Nigeria consists largely of a handful of factories producing construction material, clothing, textiles, footwear and processed foods using simple assembly processes (Cody and Hughes, 1980). Nigeria's manufacturing industries consist of assembly plants with little backward linkages in the economy, since most of the inputs are imported. Apart from their assembly line structure, Nigerian industries lack raw materials (Ijomah, 1988), and their general structure does not require high-level technological skills. Despite the simplicity of their operations, their performance is inhibited by a lack of

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ancillary industries for the efficient production of intermediate inputs and spare parts for manufacturing. Ancillary industries are particularly important because the potential economies of scale of a new technology are left unexploited as needed. Cooperating inputs are not available locally or their purchase is constrained by lack of foreign exchange.

The growth, performance and productivity of Nigeria's manufacturing industries have deteriorated at present and even beyond the rate at which they grow in the past three decades when manufacturing still play significant role in the Nigerian economy (Sangosanya, 2011). In 2009, the Manufacturers Association of Nigeria (MAN) declared that 820 manufacturing industries have closed down in the past nine years and rendered thousands of people jobless even as the Federal Government said the solution may not be very quick in coming. This implies that there are not growth propelling resources at the disposal of manufacturing firms in Nigeria over the years and tends to deteriorate their growth mechanisms. High productivity in the Nigerian manufacturing industries has been constrained by many factors including low capacity utilization; unstable infrastructure; absence of venture capital for business start ups; high cost of capital especially from banks and other financial institutions; lack of long term loans; absence of enabling macroeconomic environment; multiple taxation by the different agencies of government, and above all, skilled manpower shortages. In view of the foregoing challenges, this paper argued that adequate inculcation of requisite technical skills in electrical power and machines to the graduates of electrical

engineering in the university will help in reducing the skilled manpower shortages needed for industrial development.

Electrical power and machines essentially form the pivot of engine of growth for both industrialized economies and countries with high industrial aspirations. However, Nigeria presently lacks the critical elements to support its aspirations of becoming an industrialized nation. Among them is lack of skilled electrical engineering personnel. For any country to remain in production, it would require the services of competent electrical engineers to install machines that are electrically operated and maintain such machines and equipment. They play critical roles in specifying, designing, constructing, analyzing and testing of electrical components and systems, and are responsible for their safe operation. They are involved in the development, manufacture, or application of a wide variety of electrical devices, circuits, systems, products and equipment. Thus, electrical engineers can be rightly described as the catalyst of any meaningful development and transformation of industrial sector. Moreover, Mukhtar, (2014) emphasized that the functional growth, development, productivity and modernization of any industry are the result of effective attainment of skilled electrical engineers. Trained electrical engineers with key technical skills in electrical power and machines are inevitable for the sustained development of industries. Even with abundant material resources, the nation's industrial sector cannot perform effectively without skilled electrical engineering graduates. It is generally believed that the acquisition of requisite technical skills by

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these graduates is a means of increasing the productive power of a nation's industrial sector.

Obviously, the manufacturing industries, as stressed by Ayyakkannu (2018), need competent skilled electrical engineers to overcome the challenges previously outlined, as well as that of 21<sup>st</sup> century. This is because in the contemporary business environment, manufacturing industries have to tackle the twofold challenges of fast technological expansion and upgrading the skilled manpower to use such newest technology for improving the organizational effectiveness (Ayyakkannu 2018). In spite of the constant outcries from many quotas that engineering training institutions in Nigeria (particularly universities) should update or review their programs of study, most of the universities have not done so in the last decade (Mukhtar, 2019). This ensures that the technical skill deficit still exist at the entry level of Bachelor of Engineering holders entering the industries after passing five years of study. This is further confirmed by the assertion made by Manufacturers Association of Nigeria in the 2018 annual report that industries spend hundreds of Millions of Naira in retraining fresh engineering graduates before they could be assigned responsibilities. Electrical engineering graduates are always in constant need to update their knowledge, skills, and abilities in tune with the recent advances in electrical engineering, because the industries are dynamic organizations whose ever-changing needs of technology, machines, materials and products cannot be over-emphasized. It is against this backdrop, this study is set up to identify requisite technical skills of

electrical engineering graduates of universities for effective performances in manufacturing industries.

## LITERATURE REVIEW

The literature related to the identification of requisite technical skills in electrical power and machines of electrical engineering graduates is discussed under the following: theoretical framework, the concept of skills, technical skills, and technical skills in electrical power and machines.

### *Theoretical Framework*

This study is hinged on Human Capital Theory (HCT) as a theoretical standpoint that has influences people's acquisition of knowledge, skills and attitudes/abilities leading to sustainable global society. HCT was defined as the knowledge and skills that people acquire through education and training being a form of capital, and that this capital is a product of deliberate investment that yields returns (Schultz, 1961). HCT is significant in addressing the key challenges of 21<sup>st</sup> century which is to develop sustainable economic and social system capable of ending poverty, youth unemployment and enhances industrial development. HCT predicts that individuals or groups who possess greater levels of knowledge, skills and other competencies will achieve greater performance outcomes than those who possess lower levels (Ployhert and Moliterno, 2011). This, by extension, implied that they also stand better chance for employability especially in the modern trend of employment. The theory further explains that employability skills are not only about shaping talent, technique and

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experience for an individual to get a job, but more toward the ability to do the work (Schultz, 1961). Nafukho, Hairston and Brooks (2004) stressed that the basic principle underpinning HCT is the belief that people's learning capacities are of comparable value to other resources involved in the production of goods and services. When the resources are effectively utilized, the results are profitable for the individual, organization and society at large. HCT therefore, seeks to explain the gains of education and training as a form of investment in human resources (Aliaga, 2001), and the main proposition is that people are considered a form of capital for development (Aliaga, 2001; Becker, 1993; Benhabib and Spiegel, 1994; Engelbrecht, 2003; Hendricks, 2002).

The HCT strongly supports this study as new technical skills in electrical power and machines were discovered for incorporation into the electrical engineering curriculum in Nigeria. It is worth stressing here that the said curriculum has not captured these novel technical skills, and with growing calls and needs to update and review engineering curricula in Nigeria, this study is seen as timely. From this perspective, education and schooling are viewed as deliberate investments that prepare labour force and increase productivity of individuals and organizations as well as encouraging growth and development at the international level.

### ***The Concept of Skill***

Zukersteinova and Wilson (2007) described skill as a learned capacity to carry out pre-determined results often with the minimum out lay of

time, energy or both. Skill can also be defined as the qualities that enable a person to apply knowledge in a practical way to get something. Encyclopedia Britannica defined skill as an ability and capacity acquired through deliberate, systematic, and sustained effort to smoothly and adaptively carry out complex activities or job functions involving ideas (cognitive skills), things (technical skills) and people (interpersonal skills). Skills usually require certain environmental stimuli and persuasions to assess the level of expertise being shown and used. Aringa (2007) opined that skills can often be divided in to domain-general and domain-specific. For example in the domain of work some general skills would include time management, team-work and leadership, self-motivation and others; whereas domain-specific skills would be useful only for a certain job.

### ***The Concept of Technical Skill***

Technical skills refer to the talent and expertise person possess to perform a certain job or task. They are abilities acquired through learning and practice. Technical skills are the ability to perform kinesthetic activity in an easy, precise, harmonious way with the constant changing circumstances. They are often job or task specific; in other words, a particular skill set or proficiency required to perform a specific job or task. Technical skills are key part of the infrastructure of the economy, and the choice made by both policy-makers and individuals about investment in education, and so undoubtedly help in determining the path of the economy. In developing technical skills, the emphasis is necessarily upon students' activity. Every moment shall be

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devoted to meaningful drilling in the skill. Okorie and Ezeji (1988) observed that technical skill development involves muscular dexterity, must lend itself to the coordination of activities, require that the amount of work to do should be performed with competency, implies that performance should be by keen sense of direction and intellectual content, and emphasizes accuracy as an important characteristic. All these are described as the pattern of an expert which expresses confidence of the observer. These qualities or characteristics should be reckoned with in the process of evaluation.

Technical skills, according to Stubbs (2013) are the ability of graduates to perform several activities which are needed in the process to find solutions in the work place. These skills are classified by Bloom to belong to psychomotor domain of learning objectives. Bloom (1956) described activities in psychomotor domain as skill based. It is steeped in a demonstration and three practical instructional levels of imitation, practice, and habit. Ogwo and Oranu (2006) stated the principles and theories guiding technical skills development as follows:

1. The training environment is the working environment itself or replica of the working environment;
2. The training helps the trainee to capitalize his/her interests and abilities to the highest possible degree;
3. Adequate repetitive training in experience form the occupation enables right habits of doing and thinking to the degree necessary for employment;
4. Training is carried out to the extent where it gives the trainee a

productive ability with which he/she can secure or hold employment;

5. Training is given on actual jobs and not on exercise pseudo job.

### ***Technical Skills in Electrical Power Quality***

Electrical power quality has become an important issue in recent times when many utilities around the world find it very difficult to meet energy demands which lead to load shedding and power quality problems. Mazlumi (2011) sees power quality as the measure, analysis, and improvement of a load bus voltage, to maintain that voltage to be a sinusoid at rated voltage and frequency. The phenomena related to power quality are generally physical stochastic events in the sense that, in many cases, are appearing and disappearing arbitrarily. Therefore, power quality measure is more than a simple measurement of an electrical parameter; i.e. it is necessary to record them over an enough long time interval. In order to reduce the huge amount of data by recording and analyzing several electrical parameters over a long period of time, some recording limits are set. If these limits are exceeded, the monitoring instruments evaluate the raw data and record only the essential data of the important events.

Grisby (2001) noted that there are several reasons for monitoring power quality. The most important reason is the economic damage produced by electromagnetic phenomena in critical process loads. Effects on equipment and process operations can include malfunctions, damage, process disruption, and other anomalies. Grisby noted that monitoring, alone, is not the solution for

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power quality problems, but some other remedies more than the installation of power quality monitors are needed. In fact, monitoring provides the essential data which are needed for the improvement of power quality. In many projects related to finding a solution for power quality problems, monitoring plays a decisive role, and, therefore, managing monitoring properly helps to minimize the cost of solving problems. The recorded power quality data according to Olguin (2005) depends on the way the instruments record the disturbance levels and interpretation of the signals. In order to have a correct interpretation of the recorded data, users need to know the specifications of the monitoring instruments such as sampling rate, accuracy, resolution, and anti-aliasing filter.

The misinterpretation may result in nonexistent errors and recording disturbances which in turn may lead to incorrect conclusions and costly decisions. Effective monitoring programs are important for power reliability assurance for both utilities and customers. It is worth pointing out that most customer power quality problems originate within the customer facility. Monitoring power quality ensures optimal power system performance and effective energy management. Voltage sags, harmonics, interruptions, high-frequency noise, etc., are the most important power quality problems which are seen in industrial and commercial installations. Troubleshooting these problems requires measuring and analyzing power quality and that leads to the importance of monitoring instruments in order to localize the problems and find solutions.

### **Voltage Sags**

Voltage sags are short duration reductions in rms voltage (Mazlumi, 2011). It is 'a decrease in voltage at the power frequency for durations of half a cycle to 1 minute'. It is a multi-dimensional disturbance; i.e. it is mainly characterized by duration and retained voltage. The duration of voltage sag is the amount of time during which the voltage magnitude is below the sag threshold. The retained voltage of the voltage sag is the lowest rms voltage in any of the three phases. Voltage sags are mainly caused by short circuits, starting (or re-accelerating) of large motors, and transformer energizing. It is noted that when an induction motor starts, it can draw very high currents until the rotor comes up to speed. Many disturbances are due to normal operations such as switching loads and capacitors or faults and the opening of circuit breakers to clear faults. Faults are usually caused by natural or accidental events outside the utility's control such as lightning, birds flying close to power lines and getting electrocuted, and trees or equipment contacting power lines.

### **Electrical Power Quality Monitoring**

The process of power quality analysis consists of four steps: detection, classification, characterization, and location (Bollen, 1999). Power quality monitoring is used to detect the power quality problems. For example, monitoring of the voltage sags caused by remote faults requires a long-time monitoring. To monitor the power quality problems, the instruments such as multi-meters, oscilloscope, disturbance analyzers, flicker meters, and energy monitors may be used. Some other measuring devices are

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used for monitoring power quality problems. Although the main purpose of these devices is not the monitoring of the power quality problems, they can be used for this reason. Digital Fault Recorders (DFRs), and power meters are in this category. DFR is a monitoring device usually used for monitoring the faults related to the power system disturbances. The DFR is used for metering the bus voltages and line currents. The high sampling rates (between 6 and 10 kHz) of the DFRs make them possible to record almost all of the events as the transient faults. The DFRs have huge memories for recording and storing the events for a long time. Monitoring may be used for locating the origins of the power quality disturbances such as voltage sags, harmonics, flickers, etc.

### ***Optimal Placement of Voltage Sag Monitors***

In order to find optimal monitor locations for a monitoring program, the following two premises are considered:

1. A minimum number of monitors should be used.
2. No essential data concerning the performance of load buses in terms of sags should be missed.

The number of voltage sags recorded at a substation during a given monitoring time depends upon the critical threshold setting of the power quality monitor. It is considered the threshold level as the voltage  $p$  in pu at which the monitor starts recording. If the threshold is set too low (e.g., 0.5 pu), then the monitor do not capture an important number of disturbances. On the other extreme, if the threshold ( $p$ ) is set high (e.g., 0.9 pu or higher) then the number of voltage sags

recorded are excessive and even exceed the storage capability of the monitor. This increase or decrease in the number of events captured can be explained from the growth of the exposed area with increasing sensitivity of the monitor. The MRA is defined as the area of the network that is observed from a given monitor position. The exposed area of a bus  $k$  is exactly the monitor reach area of a monitor installed at that bus. The ability of the monitor to sense the remote faults is determined by the voltage threshold setting  $p$ . The MRA is greater for small voltage changes than for big ones. In other words, one monitor is theoretically able to capture all faults in the network for  $p$  equal to 1 pu. Similarly, only solid faults occurring at the monitor position is seen for a threshold  $p$  equal to 0 pu.

### ***Technical Skills in Electrical Motor Torque Control***

Energy plays an important role in the paradigm of sustainable development. Nowadays energy consumption is one of the key factors to measure the development of a country. According to World Energy Council (WEC, 2009), in industrialized countries, three main sectors are responsible for three quarters of electricity consumption: electric motors, 45%, lighting, 15%, and home appliances and consumer electronics, 15%. Global energy consumption of electric motors is around 9000 TWh per year. These show the impact that electric motors produce on electrical energy consumption. Therefore, the manufacturers in this sector are investing heavily in the energy efficiency of their products. From the establishment of the vector control approach for field-oriented

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control and the evolution of microelectronics and power electronics, the induction motor has come to occupy a prominent position among variable-speed electric drives (Leonhard, 1988). The same technological developments that allowed the use of induction motors in variable speed drives to replace DC motors also enabled the development of soft starting electronic devices that allow better control of the induction motor starting and stopping process. This equipment, beyond controlling the starting current value suited to the demands of the energy utilities, allows better control of motor acceleration and deceleration.

#### **Induction Motor Starting Characteristics using a Soft Starter:**

Oliveira, Nied, Farias-Santos and Dias (2011), described soft starters as devices that use silicon-controlled rectifiers (SCRs) for providing a low voltage to the motor from a grid voltage at fixed frequency. The value of the voltage applied to the motor can be varied over a wide range, from very small values up to the value of the grid by controlling the firing angle of the SCRs. The consequences of this reduction in the value of the applied voltage are the decrease in electric current drawn from the grid and the reduction of the torque developed during the process of starting or stopping. The interface circuit is responsible for acquiring and processing measured voltage and current signals, which are processed digitally by the control program. The command signals from the digital processing are then sent by control to a firing circuit, responsible for driving the SCRs and consequently, the induction motor. Soft start devices provide

two major benefits in their application (Gritter, Wang and Habetler 2000):

1. Less stress on the motor mechanically coupled to the load due to the reduced amplitude of the pulse of the starting torque motor;
2. Smoothing the motor acceleration and reducing the demand for energy flow in electric power systems due to the reduction of peak current when starting the motor.

#### **Torque Control Technique**

Torque is a measure of how much force acting on an object causes that object to rotate. The difficulties related to implementing a soft-starter with torque control are more related to limitations resulting from hardware (inability of the drive frequency variation due to SCRs) than the theoretical knowledge associated with the control design. In a torque controlling technique such as the one popularized by Zenginobuz, et al., (2001), the motor voltages and currents are measured, the flux estimation is calculated, and from that, one obtains the estimated electromagnetic torque. The error signal generated from the difference between the torque reference signal and the estimated torque signal is applied to a controller, which generates the appropriate signal to the soft-starter trigger circuit.

#### **Objectives of the Study**

The main purpose of this study is to identify requisite technical skills of electrical engineering graduates for effective performance in manufacturing industries. Specifically, the study answered the following question:

1. What technical skills in electrical power quality do electrical

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- engineering graduates require for effective performances in manufacturing industries?
2. What technical skills in electrical motor torque control do electrical engineering graduates require for effective performances in manufacturing industries?

### RESEARCH METHODOLOGY

The researchers employed a survey design method. The population of the study is made up of 669 subjects involving 319 industrial electrical engineering personnel, 57 lecturers in electrical engineering departments and 293 electrical engineering graduates. The researchers used purposive sampling technique to select 106 engineers, as well as simple random sampling technique to select 49 lecturers and 161 graduates. The instrument used was a 15-item structured questionnaire developed by the authors for eliciting the information from the respondents. The initial draft of the questionnaire was presented to 4 lecturers in the electrical engineering department, Federal University of Technology, Minna, Nigeria, to check the face and content validity of the instrument. Based on their suggestions and observations, the final draft of the questionnaire was produced. The reliability of the instrument was later

established through pilot-testing the questionnaire on 36 staff and students of electrical engineering of the same institution, as well as 8 industrial electrical engineers in Niger State, Nigeria. The reliability coefficient was computed with the aid of SPSS statistical software version 20, using cronbach's Alpha method to ascertain the extent of the homogeneity of the items. The reliability coefficient of the questionnaire was found to be 0.764, which indicates that the items in the questionnaire are internally consistent in measuring what was intended to be measured for the study. The researchers used mean and standard deviation in analyzing the research data and answering the research question, as well as one-way analysis of variance in testing the formulated hypotheses.

### RESULTS

The researchers analyzed and presented the result of the data collected based on the research questions and hypotheses that guided the study.

**Research Question 1:** What technical skills in electrical power quality do electrical engineering graduates require for effective performances in manufacturing industries?

**Table 2:** Mean Responses of Respondents on Technical Skills in Electrical Power Quality Required by Electrical Engineering Graduates  $N_1=115$   $N_2=21$   $N_3=106$

S/No	ITEMS	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_t$	REMARK
1	Appropriate use of various instrument in monitoring electrical power quality, such as Digital Fault Recorders (DFR), Oscilloscope Flicker meters, etc.	2.91	3.00	3.20	3.03	Required
2	Coordinate the selection of monitoring locations depending on the facility design, critical loads, power conditioning equipment, and the specific objective	2.83	2.53	3.60	2.98	Required
3	Interpret instrument recording of signals and disturbance level	2.33	3.60	2.60	2.84	Required
4	Rectify various problems related to power quality in industrial installations, such as voltage sags, harmonics, interruptions and high frequency noise	2.66	2.06	2.80	2.50	Required
5	Install fast protection devices to prevent faults in transmission and distribution systems	2.75	3.06	2.75	2.85	Required
6	Replace voltage sag monitor for a monitoring program	3.58	2.60	2.87	3.01	Required
7	Select appropriate tools and material for specific	3.33	2.73	3.18	3.08	Required

KEY:  $N_1$ ,  $N_2$  and  $N_3$ =Number of Engineers, Lecturers and Graduates respectively.  $\bar{X}_1$ = Mean responses of Engineers  $\bar{X}_2$ = Mean responses of Lecturers,  $\bar{X}_3$ = Mean responses of Graduates,  $\bar{X}_t$ = Mean responses of all respondents

Table 2 illustrates the mean responses of the three groups of respondents which revealed that all the seven (7) technical skills in electrical power quality are required by electrical engineering graduates for effective performances in industries. The grand mean rating ranges from 2.50 – 3.08.

**Research Question 2:** What technical skills in electrical motor torque control do electrical engineering graduates require for effective performances in manufacturing industries?

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**Table 3:** Mean Responses of Respondents on Technical Skills in Electrical Motor Torque Control Required by Electrical Engineering Graduates  $N_1=115$   $N_2=21$   $N_3=106$

S/No	ITEMS	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_t$	REMARK
1	Vary the value of voltage applied to an electric motor by controlling the firing angle of Silicon-Controlled Rectifiers (SCRs).	3.16	3.00	2.50	2.88	Required
2	Construct basic soft starting device for an induction motor	2.91	3.06	2.93	2.96	Required
3	Troubleshoot and rectify the interface unit in soft starters	3.25	2.93	3.25	3.14	Required
4	Assemble the torque producing and flux producing voltage reference components	2.75	2.86	3.66	3.09	Required
5	Identify, inspect and clean various induction motor parts and components	2.83	2.53	3.00	2.78	Required
6	Construct and build pulse-width modulator (PWM) for switch pulse pattern implementation	3.08	2.26	2.75	2.69	Required
7	Apply and maintain safety rules in electrical machine work environment	3.00	2.66	3.37	3.01	Required
8	Carryout experiments to verify the performances of various torque control techniques	3.58	3.06	2.31	2.98	Required

KEY:  $N_1$ ,  $N_2$  and  $N_3$ =Number of Engineers, Lecturers and Graduates respectively.  $\bar{X}_1$ = Mean responses of Engineers  $\bar{X}_2$ = Mean responses of Lecturers,  $\bar{X}_3$ = Mean responses of Graduates,  $\bar{X}_t$ = Mean responses of all respondents

Table 3 displays the mean responses of the three groups of research participants which showed that all the eight (8) items addressing required technical skills in electrical motor torque control are considered required with a grand mean rating ranging from 2.69 – 3.14. This implies that these technical skills presented to the respondents are required by the electrical engineering

graduates for effective performance in industries.

#### HYPOTHESES

**H<sub>01</sub>:** There is no significant difference among the mean responses of Lecturers, Engineers and Graduates with respect to technical skills in electrical power quality required by electrical engineering graduates for effective performance in industries.

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**Table 4:** One- way Analysis of Variance (anova) of the Mean Responses of Respondents on the Technical Skills in Electrical Power Quality Required by Electrical Engineering Graduates for Effective Performances in Industries

Source of variation	Sum of squares	df	Mean squares	f.cal	f. critical	Decision
Between Group	169.02	2	84.51			
Within Group	7134.3	313	22.79	3.71	3.00	S*
<b>Total</b>	<b>7303.32</b>	<b>315</b>				

\* Significant

The result of analysis as presented in table 4 shows that there is significant difference ( $p < 0.05$ ) between the responses of engineers, lecturers and graduates on the technical skills in electrical power quality required by electrical engineering graduates for effective performance in industries. Hence, the null hypothesis is rejected since the

critical f-value is less than the calculated F-ratio value.

**H0<sub>2</sub>:** There is no significant difference among the mean responses of Engineers Lecturers, and Graduates with respect to technical skills in electrical motor torque control required by electrical engineering graduates for effective performance in industries.

**Table 5:** One- way Analysis of Variance (anova) of the Mean Responses of Respondents on the Technical Skills in Electrical Motor Torque Control Required by Electrical Engineering Graduates for Effective Performances in Industries

Source of variation	Sum of squares	df	Mean squares	f.cal	f. critical	Decision
Between Group	169.02	2	84.51			
Within Group	7134.3	313	22.79	3.71	3.00	S*
<b>Total</b>	<b>7303.32</b>	<b>315</b>				

\* Significant

The result of analysis as presented in table 5 shows that significant difference ( $p < 0.05$ ) exists among the responses of engineers, lecturers and graduates on the technical skills in electrical motor torque control required by electrical engineering graduates for effective performance in industries. Thus, the researcher rejected the null hypothesis

because the critical f-value is less than the calculated F-ratio value.

## DISCUSSION

The results obtained from this study on technical skills required by electrical engineering graduates as presented in Table 2 and 3 revealed that the respondents adjudged all the 15 items

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as required necessary skills for effective performance in industries. These findings are consistent with the work of Onwuka (2009) who inferred that the current program of study of electrical engineering used by Nigerian universities have been criticized as lacking some aspects of application of electrical engineering that are prevalent in today's modern industries. He further stressed that electrical engineering graduates must have adequate technical skills to enable them use standard and specialized laboratory instruments to conduct experiments, design, construct, test and evaluate electrical circuits and computer systems. The overwhelming acceptance of technical skills is consistent with the objectives of electrical engineering program in Nigeria, which specifically stated "the program is aimed to provide skilled electrical engineering manpower which is regarded as a principal factor for economic development and the prosperity of a nation" (NUC, 2007).

Analysis of results from within table 2 indicates that the entire 7 items addressing technical skills in electrical power quality were rated as required. Olguin (2005) lamented that the phenomena related to electrical power quality are generally physically stochastic events in the sense that in many cases are appearing and disappearing arbitrarily. As a result adequate technical skills are needed in order to measure, analyze and improve the load bus voltage, and to maintain the voltage to be at sinusoid. Grisby (2001) noted that there are several reasons for an electrical engineer to receive adequate practical training in electrical power quality. The most important reason is to prevent the

economic damage produced by electromagnetic phenomena in critical process loads.

Results from Table 3 also indicated that all the 8 items suggested as technical skills in electrical motor torque control are accepted. The mean ratings of the items ranged between 2.69 - 3.14. The overwhelming support accorded to these items is not coming as a surprise, as global energy consumption of electric motors is around 9000TWh per year. Consistent with this finding is the work of King (1995), who opined that an electrical engineering graduates require skills to install machines, operate and maintain such machines and its associated equipment. It was observed that these skills are very relevant considering the nature of the industries in Nigeria. These industries rely heavily on electric motors for almost all their activities.

Furthermore, the one-way analysis of variance used in testing hypotheses revealed that there is significant difference in the mean responses of lecturers, engineers and graduates on the technical skills in both electrical power quality and electrical motor torque control required by electrical engineering graduates for effective performances in industries. This is not coming as a surprise because it is expected that trained engineers should have a deeper and wider scope of technical skills needed for effective performance in their industries than lecturers and graduates who are mainly concerned with the theoretical skills in the training institutions.

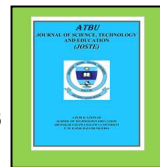
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## CONCLUSION

Investigating the technical skills in electrical power quality and electric motor torque control, coupled with effective implementation of the recommendations of the study will go far in equipping the electrical engineering graduates with requisite technical skills needed for effective performances in Nigerian industries, thereby ensuring efficient technological and socio-economic development. The findings of the study revealed that the technical skills presented to the respondents were adjudged necessary for effective performance in industries. These include Use of various tools in monitoring electrical power quality, such as Digital Fault Recorders, Oscilloscope, Flicker meters, etc; Coordinating the selection of monitoring locations depending on the facility design, critical loads, power conditioning equipment, and the specific objective; Install fast protection devices to prevent faults in transmission and distribution systems; Vary the value of voltage applied to an electric motor by controlling the firing angle of Silicon-Controlled Rectifiers; Carryout experiments to verify the performances of various torque control techniques; among others. Consequently, the departments of electrical engineering in the Nigerian universities, as well as the National Universities Commission should as a matter of urgency, review the results of this study with the aim of incorporating the findings into the Bachelor degree program of electrical engineering. This will facilitates acquisition of requisite technical skills that will enable the graduates to innovate, create, and use wealth of knowledge for the industrial and economic

advancement, and for the benefit of humankind.

## REFERENCES

- Aliaga, A.O. (2001). 'Human Capital, HRD and the knowledge organization', in O.A. Aliaga (ed) *Academy of Human Resource Development 2001: Conference Proceedings*, Baton Rouge, LA: AHRD, pp 427 – 34
- Anakom, U. (2008), "Post Independence Nigeria and Industrialization Strategies: Four and Half Erratic Decades" <http://ssrn.com/abstract=1266633>
- Anya, A.O (1982). *Science, Development and the Future: The Nigerian case*. University of Nigeria Press, Nsukka, 74.
- Aringa, D.C. (2007). Skills Needs in a Wider Context. European Labour market: Prospects and Challenges. In A. Bulgareti (eds). *Skills for Europe's Future: Anticipating Occupational Skills Needs*. Proceedings of the Agora Conference 'skills for Europe's Future' Organized by cedefop , Luxembourg, February 2008 15-21
- Ayyakkannu, A. (2018). Technical and soft skill competencies mapping at the entry level of Diploma holders in mechanical and automobile engineering for auto and auto components industries, *International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)* ISSN

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- (P): 2249-6890; ISSN (E): 2249-8001 Vol. 8, Issue 1, 1209-1220
- Becker, G.S. (1993). 'Nobel lecture: the economic way of looking at behavior', *Journal of Political Economy* 10(1), 385 - 489
- Benhabib, J. & Spiegel, M.M. (1994). The role of human capital in economic development: evidence from aggregate cross-country data, *Journal of Monetary Economics* 34 (1), 43 - 73
- Bollen, M.H.J (1999). *Understanding Power Quality Problems: Voltage and Interruptions*. New-York: Wiley IEEE Press ISBN 978-0-7803-4713-7.
- Cody, J.H & Hughes, D.W (1980). *Policies for Industrial Progress in Developing Countries*. London: Oxford University Press, 128.
- Engelbrecht, H. (2003). Human capital and economic growth: cross section evidence for OECD countries, *Economic Record* 79 (Special Issue), 40 – 51
- Grigsby, L.L. (2001). *The electric Power Engineering Handbook*. Florida: CRC Press. ISBN 978 -1-4200-3677-0.
- Gritter, D., Wang, D & Habetler, T.G (2000). Soft Starter Inside Delta Motor Modeling and its Control. *Proceedings of Industry Applications Conference*. Rome, October 2000. Italy
- Hendricks, L. (2002). How important human capital for development? Evidence from immigrant earnings, *America Economic Review* 92 (1), 198 - 219
- Ijomah, S.I.C (1988). Technological Development. A False Start in Africa. Paper Presented at the 1988 General Assembly of the Social Science Council of Nigeria. University of Ibadan, July 18<sup>th</sup> -19<sup>th</sup>, 1988.
- Ikpeze, N., Soludo, C., and Elekwa, N. (2004), "Nigeria: The Political Economy of the Policy Process, Policy Choice Implementation" in C. Soludo, O. Ogbu and H. Chang (eds.), *The Politics of Trade and Industrial Policy in Africa: Forced Consensus?*, New Jersey: Africa World Press/IDRC
- Iwuagwu, O. (2011). The cluster concept: Will Nigeria's new industrial development strategy jumpstart the country's industrial takeoff. *Afro Asian Journal of Social Sciences*, 2(2.4), 1-24.
- King, I. (1995). Means of Strengthening Relation Between Vocational and Technical Education and Industrial Sector. In E.U Anyakoha and E.C Osuala (eds). *Vocational and Technical Education (VTE) and Technology Growth*. University of Nigeria Nsukka VTE Publication 192- 199
- Leonhard, W. (1988). Field-Orientation for Controlling A.C machines— Principles and Applications. *Third International Conference on Power Electronics and Variable-speed Drives*. London, July, 1988.
- Mazlumi, K. (2011). Electrical Power Quality Monitoring. In A.H Zobaa, M.M Carteli and R. Basel

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© 2023. Faculty of Tech. Education, ATBU Bauchi. All rights reserved



- (eds). *Power Quality Monitoring, Analysis and Enhancement*. Janeza Trdine 9,51000, Rijeka, Croatia.
- Mukhtar, N. (2014). Occupational skills required by electrical engineering graduates of universities for effecting performance in industries of Kano and Kaduna states, Nigeria. *Unpublished M.Tech Thesis* submitted to Department of Industrial Technology Education, Federal University of Technology Minna, Nigeria.
- Mukhtar, N. & Atsumbe, B.N. (2019). Cognitive Skills Required by Electrical Engineering Graduates of Universities for Effective Performance in Industries of Kano and Kaduna States, Nigeria, *International Journal of Innovative Science, Engineering & Technology*, Vol. 6 Issue 9, September 2019 ISSN (Online) 2348 – 7968
- Nafukho, F. M., Hairston, N., & Brooks, K. (2004). Human capital theory: Implications for human resource development. *Human Resource Development International*, 7(4), 545-551.
- National Universities Commission (2007). Benchmark for Minimum Academic Standards for Engineering programmes. Abuja, N.U.C Publication.
- Ogwo, B.N & Oranu, B.N. (2006). *Methodology in Formal and Non-Formal Technical and Vocational Education*. Uwani, Enugu: Ijejas Printers and Publishing Company, 146
- Okorie, J.U & Ezeji, S.C.O.A (1988). *Elements of Guidance, Vocational and Career Education*. Onitsha: Summer Educational Publishers (Nig.) Limited., 192
- Olaniyan, D., & Okemakinde, T. (2008). Human capital theory: Implications for educational development. *Pakistan Journal of Social Sciences*, 5(5), 479-483.
- Olguin, G. (2005). Voltage Dip (sag) Estimation in Power Systems Based on Stochastic Assessment and Optimal Monitoring. Unpublished PhD Thesis, Chalmers University of Technology, Gotesberg, Sweden.
- Oliveira, J.D., Nied, A., Farias-Santos, M.H & Dias, R.P (2011). Study on The energy Efficiency of Soft Starting of an Induction Motor Torque Control. In M. Ahmad (eds). *Advances in Motor Torque Control*. Janeza Trdine, 9,51000, Rijeka, Croatia.
- Onwuka, E.N. (2009). Reshaping Engineering Education Curriculum to Accommodate the Current Needs of Nigeria. *Educational Research and Review*. 4 (7), 334-339
- Ployhart, R. E., & Moliterno, T. P. (2011). Emergence of the human capital resource: A multilevel model. *Academy of Management Review*, 36(1), 127-150.
- Sangosanya, A.O. (2011). Firms Growth Dynamics in Nigeria's Manufacturing Industry: A Panel

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- Analysis. *Journal of Applied Econometric Review*. 1 (1) 1-18.
- Schultz, T.W. (1961). Education and economic growth, in N.B. Henry (ed.) *Social Forces influencing American Education*, Chicago, IL: University of Chicago Press.
- Stubbs, W. (2013). Addressing the business-sustainability nexus in postgraduate education. *International Journal of Sustainability in Higher Education*, 14(1), 25 – 41, doi: 10.1108/14676371311288930
- United Nations Industrial Development Organization. (2009). *Industrial Development Report 2009*
- World Energy Council (2009). *Energy Efficiency Can Lead the Economic Recovery*, in WEC Comment. Available from: [www.worldenergy.org/news--events/wec=comment/2218.asp](http://www.worldenergy.org/news--events/wec=comment/2218.asp).
- Zenginobuz, G., Cardici, I. Ermis, M. & Barlak, C.(2001). Soft Starting of a Large Induction Motors at Constant Current with Minimized Starting Torque Pulsations. *IEEE Transactions on Industry Applications*. 37 (5), 1334-1347.
- Zukersteinova, A. & Wilson, R. (2007). Medium Term European Occupational Skills Needs. In A Bulgareti (eds). *Skills for Europe's Future: Anticipating Occupational Skills Needs*. Proceedings of the Agora conference 'skills for Europe's future' Organized by cedefop , Luxembourg, February 2008, 15-21

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