RETOOLING NEEDS OF ELECTRICAL TEACHERS FOR THE MAINTENANCE OF ELECTRICAL LABORATORY EQUIPMENT IN TECHNICAL COLLEGES IN KANO STATE

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Abstract

The study finds out the retooling needs of electrical teacher for maintenance of electrical laboratory equipment in Technical Colleges in Kano State. The study used descriptive survey design and was aimed at re-tooling needs for electrical teachers in equipment maintenance of Technical Colleges laboratory in Kano State. To facilitate the achievement of the above objectives, four research question and four hypotheses were formulated. The population of the study consisted of 55 electrical teachers of technical colleges of Kano State. A 42 items structured questionnaire was developed and used for data collection. The questionnaire was validated by three experts, from department of Vocational Teacher Education, University of Nigeria, Nsukka. To establish the reliability of the instrument, the instrument was administered to five respondents comprising of electrical teachers from Government Technical College Malali Kaduna State. The Cronbach Alpha reliability was used to determine the internal consistency of the instrument. The reliability co-efficient of the instrument was found to be 0.83. The data collected were analyzed using mean and Standard Deviation for answering the research questions while t-test statistics was used to test the four null hypotheses at 0.05 level of significance. The study has the major findings as to review and update when there are changes in equipment; carryout weekly routine maintenance activities for all electrical equipment; identify physical variables (temperature, vibration, power consumption) and apply suitable safety preventions while working with electrical equipment. The study recommends that government should encourage the training and re-training of electrical teachers on re-tooling needs of teachers of electrical subject through attendance of conference, seminars and workshop in order to posses new skills of maintaining electrical equipments, modern electrical industrial employers should from time to time visit technical college to inform them about the new development and the required skill development.

1.0 INTRODUCTION

Vocational and technical education (VTE) is an integral part of educational system responsible for the production of low-level manpower such as (skilled labour) artisans, craftsmen and master craftsmen. Federal Government of Nigeria (FGN, 2004) defined vocational and technical education as that aspect of education which leads to the acquisition of practical and applied skills as well as basic scientific knowledge. Vocational and technical education is designed to prepare students for industry, agriculture, commerce, and home economics (Ugwuja, 2010). Vocational and technical education courses are taught at Universities, Polytechnics, Colleges of Education, and Technical Colleges.

Technical college is one of institutions established by the Federal Government of Nigeria to provide individuals with practical skills, basic scientific knowledge and attitude that enable them to live sucessfully in the world. Technical college provides technical training in a number of courses which include General education, Automobile trade, Building and Woodwork trade, Business trade, Computer trade, Hospitality trade, Mechanical trade, Printing trade, Textile trade and Electrical/Electronic trade. Electrical/Electronic Trade is subdivided into Appliance Maintenance and Repairs; Electrical Installations and Maintenance Works; Instrument Mechanics; and Radio, Television and Electronics Work (FGN, 2004).

Electrical trade involves theoretical and practical aspects. Primarily, laboratory is used to give basic practical knowledge and skills needed in electrical trades. According to Besmart-Digbori (2007), the venue for acquiring practical skills by technical college students is the workshop or laboratory. Laboratory is a place or building where equipment is installed for practical purposes. Laboratory sessions provide hands-on training on electrical equipment to reinforce the lesson taught in the classroom.

Electrical laboratory equipment are major appliances, microcontroller, power tool and small appliances. Peter (2006) referred to electricallaboratory equipment as the backbone of the teaching in science, technology, engineering, and vocational courses. Cannon (2001) stated that electrical equipment include any machine powered by electricity which usually consist of an enclosure, a variety of electrical components, and often a power switch. Typical electrical laboratory equipment are meter, test clips, deflection galvanometer, oscilloscopes, portable wheatstone bridge, A.C motors, DC motor alternator set, multimeter, wattmeter, DC motor, batteries, AC ammeter and voltmeter. Due to long year of usage of electrical equipment which causes deterioration or failure, maintenance of electrical equipment is essential.

Maintenance is one of the essential activities in electrical laboratories. Ogbuanya (2009) viewed maintenance as action taken to restore or keep an item in good functional order. Maintenance may be defined as actions necessary for retaining or restoring a piece of equipment, machine, or system to the specified operable condition to achieve its maximum useful life (Uche & Ogbonnaya, 2012). This signifies that the electrical teachers need to know how to maintain available laboratory equipment. This means that maintenance is a set of organised activities that are carried out in order to prolong the service life of equipment in

its best operational condition with minimum cost acquired. These activities have to be appropriate and timely to ensure equipment effectiveness and efficiency.

There are different types of maintenance activities which can be carried out in order to improve the service life of electrical laboratory equipment. Maintenance activities could either be repair or replacement of electical equipment which are necessary for the equipment to reach its acceptable productivity condition. Abbas in Mohammed and Abbas (2001) classified maintenance into three groups which are prenvetive, predictive and corrective maintenance. Sullivan, Pugh, Melendez and Hunt (2010) categorized maintenance as reactive, preventive, predictive, corrective, and reliability centered maintenance. Equipment that receives adequate maintenance is less likely to fail.

Electrical laboratory equipment failures can be prevented by a routine preventive maintenance schedule. Moore (2012) defined preventive maintenance as activity performed on a certain schedule which is intended to avoid breakdowns or deterioration. These activities can include regular inspection along with solving any discovered problems and regularly-scheduled parts changes. In this type of maintenance, the equipment are subjected to a regular schedule of maintenance tasks, such as inspections, cleaning, adjustments and calibration. Preventive maintenance is performed on a routine basis or as sensed by observing, listening, feeling or smelling at or near the equipment.

Predictive maintenance is another type of maintenance that can be carried out on laboratory equipment maintenance. Mobley (2002) defined predictive maintenance as monitoring the vibration of rotating machinery in an attempt to detect incipient problems and to avoid catastrophic failure; or monitoring the infrared image of electrical switchgear, motors, and other electrical equipment to detect developing problems. Schoomaker (2005) asserted that the goal of predictive maintenance is to develop an awareness of developing problems so that needed repairs can be made on a planned rather than on an emergency basis resulting from unpredicted equipment failure is avoided.

Corrective maintenance is another type of maintenance that can be performed on laboratory equipment. Ogbuanya (2009) referred to corrective maintenance as equipment repair or breakdown maintenance. It is performed whenever an equipment stops working or starts failing; hence, it is usually more costly than preventive maintenance. In this type of maintenance, Alshayea (2012) expressed that actions such as repair, replacement, or restore will be carried out after the occurrence of a failure in order to eliminate the source of this failure or reduce the frequency of its occurrence.

Reliability centered maintenance (RCM) is a process used to determine the maintenance requirements of any physical asset. Criscimagna (2012) defined reliability-centered maintenance (RCM) as a logical, structured framework for determining the optimum mix of applicable and effective maintenance activities needed to sustain the operational reliability of equipment while ensuring their safe and economical operation. It utilizes a systematic, structured approach that is based on the consequences of failure; as such it

represents a shift from time-based maintenance tasks and emphasizes the functional importance of system components and their failure/maintenance history. Criscimagna further stated that RCM is not overly concerned with simple failure rate; it seeks to know the conditional probability of failure at specific age. This type of maintenance can be applied to oscilloscopes and portable wheatstone bridge which at times often run to failure in the laboratory.

In practice, different types of maintenance are used in keeping the life span of equipment. For anybody to assume the duty of serving as electrical teacher, such a person is expected to possess adequate maintenance skills for imparting technical knowledge and skills, especially now that the emphasis is on competency-based learning (Davies, 2001). A qualified electrical teacher should possess required maintenance skill to keep the electrical laboratory equipment running safely and reliably. Teachers with a minimum of Bachelor of Science (B.Sc) or higher degree in vocational teacher training (Electrical option) may possess more maintenance skill due the level of qualification and the training received during training; as such may be regarded as qualified teachers. Teachers with vocational training such as Nigeria Certificate in Examination (NCE) Technical, B.Sc in Engineering or Sciences may not have adequate maintenance skill due to nature of training received. These categories of teachers may be regarded as less qualified teachers. This is because Engineers and Scientists are not usually trained to act as technical teachers but B.Sc technical teachers are trained to both carryout practical activities in workshops/laboratories as well as teach the theory involved in their respective area of specialization. Training students for higher quality skill requires appropriate maintenance of equipment by teachers.

Skill referred to ability to use ones knowledge effectively in doing something. Weller (2001) defined skill as the capability to accomplish a job with precision of certainty, practical knowledge in combination with the ability, cleverness and expertness. Okeke (2002) stated that to possess a skill is to demonstrate the habit of acting, thinking and behaving in such a way that the process becomes natural to individuals through repetitive or practice. According to Ogbuanya and Fakorede (2009), technical skill is the ability to do something expertly and well, in accordance to set standard or manufacturer's instruction. Improving maintenance skill is inevitable for electrical teachers in order to maintain laboratory equipment properly.

With proper maintenance skill, equipment downtime can be reduced and equipment efficiency increased. Adequate maintenance could also lead to improvement in equipment reliability which students can make use of effectively. Whereas when equipment are not properly maintained, the cost of replacing such equipment may be high or its part may not be available; as such students will not be able to acquire the necessary skills. Therefore, electrical teachers need to improve their maintenance skills as a result of advancement in technology. Although, most Technical Colleges in Kano State have adequate supply of laboratory equipment; but adequate supply of laboratory equipment cannot be enough if they are not properly maintained. The aim of Vocational and Technical education is to equip the teacher with the necessary knowledge and skills to guide the learning process. Despite this laudable objective, some teachers still lack adequate maintenance skills of laboratory

equipment which students can use for practical. The failure of electrical teacher to put laboratory equipment back to use shows that the teachers lack proper maintenance skills. In consequence, students who are in poorly trained cannot secure job in industries or establish one. It therefore becomes imperative to find out the skill improvement needs of electrical teachers for maintenance of electrical laboratory equipment in Technical Colleges in Kano State.

1.1 Statement of the Problem

The emerging world economy today is knowledge based and science and technology driven. Technical education programme in Nigeria has evolved in response to technological and industrial needs. In most industries, electrical equipment operator is directly involved in some level of maintenance. Mobley (2002) emphasized that maintenance involves better planning and scheduling, better preventive, predictive, corrective and reliability-centered activities. Maintenance is performed to keep equipment and systems running efficiently for the design life of the equipment. Acquisition of knowledge on maintenance of electrical laboratory equipment gives electrical trade graduates a more marketable skill.

The electrical trade program is designed to teach the basic principles of electricity. Through the various courses, a student will gain knowledge and practical hands-on experience in both technologies for troubleshooting and maintenance of equipment. Improper maintenance of electrical laboratory equipment for the training of the electrical students often hindered acquisition of skills needed for employment. The need for maintenance is predicated on actual or impending failure. The impact of inadequate educational facilities such as laboratory equipment in the training of students impedes their study and they end up not acquiring skill to go into the labor market. Students cannot gain the required practical skills needed for employment if they are not trained with functional equipment.

Electrical teachers have the mandate to provide quality technological training that keeps pace with quality control in technology education. Despite the huge amount of money spent on the provision of laboratory equipment by the Kano State government annually, some students of technical colleges in the state cannot make use of functional laboratory equipment. Electrical teachers lack adequate skill to maintain available electrical laboratory equipment. If the electrical teachers are equipped with adequate electrical equipment maintenance skills, students would be able to carry out their practical with functional equipment; as such electrical students can acquire adequate skill that can enable secure employment upon graduation. Hence, the problem of the study therefore is that electrical teachers lack adequate maintenance skill for proper maintenance of electrical laboratory equipment.

1.2 Purpose of the Study

The major purpose of this study is to find out the skill improvement needs of electrical teachers for the maintenance of electrical laboratory equipment in Technical Colleges in Kano State. Specifically the study seeks to determine the skill improvement needs of electrical teachers in:

1. Preventive maintenance of electrical laboratory equipment.
2. Predictive maintenance of electrical laboratory equipment.
3. Corrective maintenance of electrical laboratory equipment.
4. Reliability centered maintenance of electrical laboratory equipment.

1.3 Significance of the Study

The findings of this study will be beneficial to the Principals of Technical Colleges, Electrical trade teachers, Electrical trade students, State Ministry of Education and Science, National Board for Technical Education and the society. The findings of this study will be beneficial to Principals of Technical Colleges on the need to send electrical teachers for refresher course in the area of maintenance of electrical laboratory equipment where Electrical trade teachers will be trained on predictive or corrective maintenance of electrical laboratory equipment which in return will minimize the rate of failure of equipment.

The findings of the study will help Electrical trade teachers. The findings of this study will help Electrical trade teachers to know when to embark on preventive maintenance, proper planning and scheduling of preventive maintenance programme. Thus, reduce the probability of failure or the degradation of the electrical laboratory equipment.

Applying the findings of this study will be of immense benefit to electrical trade students in technical colleges. The students will be able to acquire different maintenance through their teacher and carry out practical with functional equipment. Electrical trade students can apply different types of electrical maintenance skills learnt in their places of work or establish a maintenance service company after graduation.

The findings of the study will assist the State Ministry of Education and Science to appreciate the relevance of skill improvement needs of electrical teachers the Ministry engaged in teaching. The Ministry can use the findings of the study to organize programme like workshop or seminar for technical teachers to update them with preventive and other maintenance skills of electrical laboratory equipment.

National Board for Technical Education is responsible for designing the curriculum for Technical Colleges in Nigeria. The findings of this study will help the curriculum planners in National Board for Technical Education to integrate identified reliability centered maintenance skills and of the maintenance skill of electrical laboratory equipment into the curriculum of electrical trades in Technical Colleges.

The findings of this study will also be of benefit to the society. The society will also benefit from the findings of the study in the sense that electrical teachers or electrical graduate can apply the identified preventive or corrective to help the people in the society in maintaining their electrical equipment.

1.4 Research Questions

The following research questions guided the study:

1. What are the skill improvement needs of electrical teachers in preventive maintenance of electrical laboratory equipment?
2. What are the skill improvement needs of electrical teachers in predictive maintenance of electrical laboratory equipment?
3. What are the skill improvement needs of electrical teachers in corrective maintenance of electrical laboratory equipment?
4. What are the skill improvement needs of electrical teachers in reliability centered maintenance of electrical laboratory equipment?

1.5 Research Hypotheses

In view of the above research questions, the following null hypotheses were formulated to guide this study and were tested at 0.5 level of significance:

Ho_1: There is no significant difference in the mean responses of qualified and less qualified electrical teachers on the skill improvement needs in preventive maintenance of electrical laboratory equipment.

Ho_2: There is no significant difference in the mean responses of qualified and less qualified electrical teachers on the skill improvement needs in predictive maintenance of electrical laboratory equipment.

Ho_3: There is no significant difference in the mean responses of qualified and less qualified electrical teachers on the skill improvement needs in corrective maintenance of electrical laboratory equipment.

Ho_4: There is no significant difference in the mean responses of qualified and less qualified electrical teachers on the skill improvement needs in reliability centered maintenance of electrical laboratory equipment.

1.6 Review of Related Literature

The relevant literature to this study will be reviewed under four main subheadings namely: Conceptual Framework, Theoretical Framework, Review of Related Empirical Studies and Summary of Reviewed Related Literature.

Conceptual Framework

i. Technical Colleges and Electrical Programme in Nigeria
   - Skills in Electrical Technology

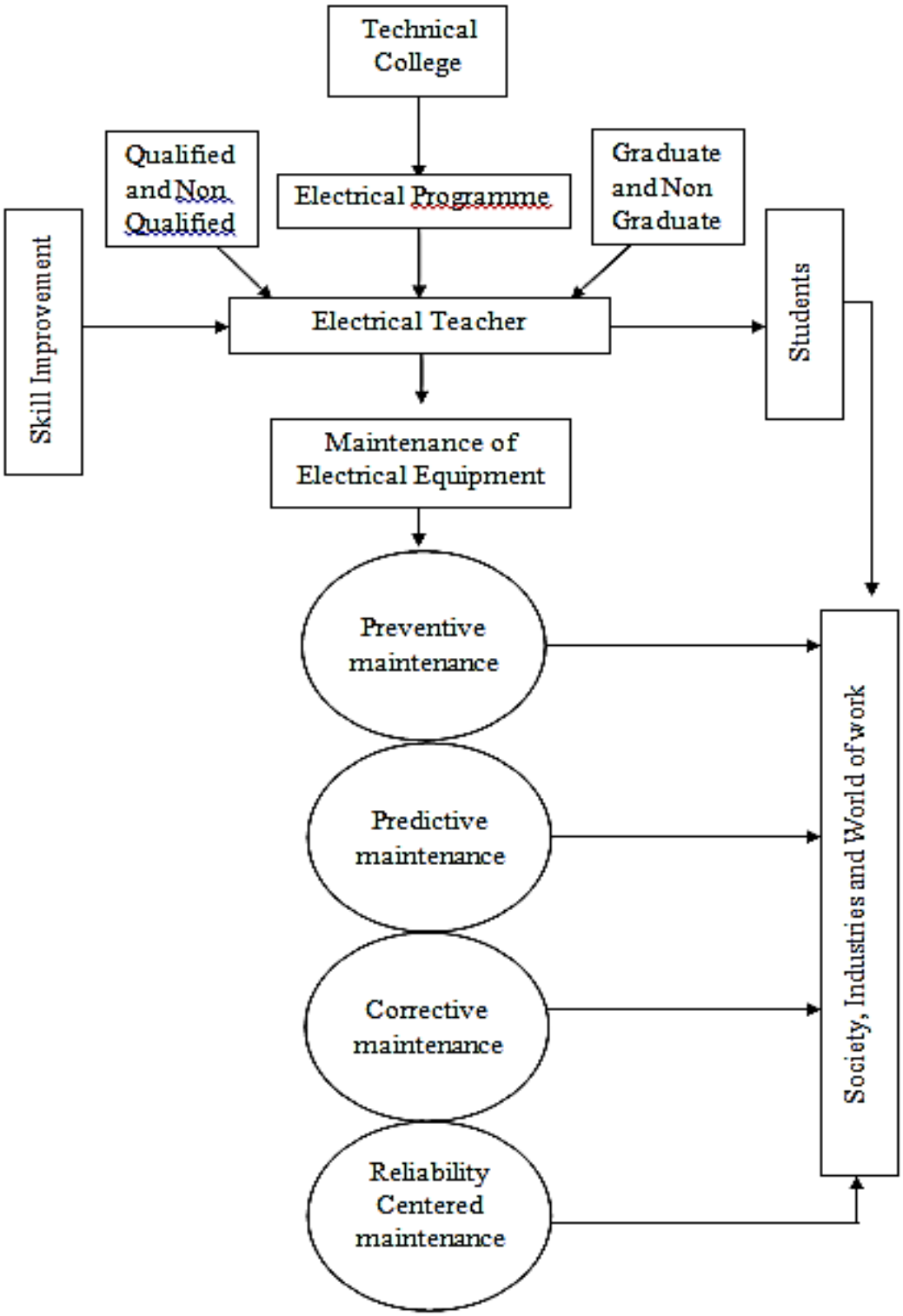
ii. Electrical Technology Teacher and Maintenance of Laboratory Equipment
   - Electrical Laboratory Equipment

iii. Concept of Maintenance
   - Preventive Maintenance
   - Predictive Maintenance
   - Corrective Maintenance
   - Reliability Centered Maintenance

Theoretical Framework

- Theory of Needs
- Skill Acquisition Theory

Source: Schematic diagram desiged by the Reseracher (2013)



Electrical Technology Teacher and Maintenance of Laboratory Equipment

The introduction of Technical and Vocational Education and Training (TVET) subject in the technical college curriculum is aimed at providing an opportunity to all learners to acquire relevant knowledge and skills in technical and vocational occupations and to impart in learners positive attitudes toward the world of work. Wanjala (2012) emphasized that technical college electrical technology teacher must have both technical skills and pedagogical/teaching methodology to effectively prepare students in TVET.

Electrical technology is an engineering technology field that implements and applies the principles of electrical engineering. Langdon, (2012) stated that like electrical engineering, electrical technology teacher deals with the design, application, installation, manufacturing, operation and/or maintenance of electrical/electronic(s) systems. However, electrical technology teacher is generally more focused on application and implementation, rather than placing more of an emphasis on theory and conceptual design.

Technical college electrical technology teacher provides graduates with the technical background and the manual skills necessary for careers in the installation and maintenance of modern electrical systems, electrical equipment, and electrical controls. Graduates are critical thinkers and are able to troubleshoot problems in residential, commercial, or industrial electrical environments. Technical college electrical technology teacher focuses on the understanding and application of electronic principles and the technological processes inherent in the production of products, services and systems.

Electrical Laboratory Equipment

Equipment is uniquely identifiable object that can be installed, maintained separately from building, laboratory or room location, and removed. Laboratory equipment can be described as various equipment used by scientists working in a mechanical, electrical or chemical laboratory. Laboratory equipment is generally used to either perform an experiment or to take measurements and gather data. Electrical laboratory equipment are equipment used in the training of electrical students, which include AC ammeter, DC ammeter, DC voltmeter, AC voltmeter, rheostats, deflection galvanometer, A.C motors, drilling machine, portable drilling machine, portable wheatstone bridge, shunt wound, DC motor, batteries, bushwork, portable digital multimeter, non-contact tachometer, transformers, cables, circuit breakers.

Electrical laboratory help students in getting a firsthand experience of the practical and industrial world. The establishment of electrically laboratories is aimed at giving the students hands-on adequate knowledge, which qualifies them to operate electric machineries and electric power system (transmission and distribution). This hands-on training introduces the students to basic electrical theory. For successful functioning of equipments, maintenance is one of the essential components in electrical teaching laboratories. The maintenance of the electrical laboratory equipment can represent significant operating expenses. One person is designated and responsible for the maintenance program.

Maintenance Schedule for Electrical Laboratory Equipment

Battery

Battery systems provide "last resort" power for performing communication, alarm, control, and protective functions (relaying and breaker tripping) when other sources of power fail. Battery system maintenance should have highest priority. Computerized, online battery monitoring systems can be installed to supplement a maintenance program and reduce costs. Battery chargers require regular maintenance as well.

Exciters and Voltage Regulators

Components of excitation systems (e.g., transformers, circuit breakers, protective relays, annunciators, and buswork) require maintenance. Exciter and voltage regulator manufacturer's instructions may recommend supplemental maintenance tasks. Automatic voltage regulator (AVR) performance testing ("alignment") is a specialty, requiring specialized training and unique equipment as well as knowledge of current power system stability requirements. It is recommended that performance testing be performed by qualified personnel.

Switches - Medium and High Voltage

When open, disconnect switches permit isolation of other power system components, thus, facilitating safety during maintenance procedures. Disconnect switches may be manually or motor operated and, in some cases, may integrate fuse protection. Preventive maintenance shall be considered synonymous with any type of general maintenance, major maintenance, or overhaul functions to be performed on the equipment.

Ground Connections

Grounding is an essential part of protecting staff and equipment from high potential caused by electrical faults. Grounding conductors of switchyard equipment and gate structures are subject to failure due to corrosion, loose connections, and mechanical damage. Grounding also may be compromised during equipment addition and removal or other construction type activities. Verifying grounding system integrity through periodic testing is an important maintenance activity.

Concept of Maintenance

Maintenance can be described as the act of keeping things something such as cars, equipment, or houses in good conditions by checking or repairing it regularly. Olaitan, Igbo, Ekong, Nwachukwu and Onyemachi (1999) defined maintenance as taking specific approved steps and precautions to care for a piece of equipment, machinery, or facility and ensure that it attain specific maximum functional self-life. Obi in Mohammed and Abbas (2001) defined maintenance as the totality of measures employed to ensure that a given piece of capital asset, equipment or infrastructure is kept in good operational order until it attains its maximum life span. Activities of maintenance function could be either repair or replacement activities, which are necessary for an item to reach its acceptable productivity condition and these activities, should be carried out with a minimum possible cost.

Basically, the purpose of maintenance is to extend equipment lifetime, or at least the mean time to the next failure whose repair may be costly. Furthermore, it is expected that effective maintenance as one of the strategies can reduce the frequency of service interruptions and the many undesirable consequences of such interruptions. Maintenance clearly has great impact on component and system reliability: if too little is done, this may result in an excessive number of costly failures and poor system performance and, therefore, reliability is degraded; if it is done often, reliability may improve but the cost of maintenance will sharply increase. In a cost-effective scheme, the two expenditures must be balanced. Many engineers use the concept of a maintenance season to describe the timeframe for performing maintenance scheduled on an annual interval.

Maintenance Strategies

The purpose of maintenance is to extend equipment lifetime, or at least the mean time to the next failure whose repair may be costly. Furthermore, it is expected that effective maintenance as one of the strategies can reduce the frequency of service interruptions and the many undesirable consequences of such interruptions. Maintenance clearly has great impact on component and system reliability: if too little is done, this may result in an excessive number of costly failures and poor system performance and, therefore, reliability is degraded; if it is done often, reliability may improve but the cost of maintenance will sharply increase. In a cost-effective scheme, the two expenditures must be balanced. Maintenance is just one of the devices for up keeping or, if necessary, improving the level of reliability of components and systems. Others include increasing system capacity, reinforcing redundancy and employing more reliable components. At a time, however, when these approaches are heavily constrained, electric power utilities are forced to get the most out of the devices they already own through more effective maintenance routines. In fact, maintenance is becoming an important part of what is often called asset management.

Electric power utilities have always employed maintenance programs to keep their equipment in good working condition for long as it is feasible. Traditional maintenance approaches mostly consisted of predefined activities carried out at regular intervals (schedule maintenance). However, such a maintenance policy may be quite inefficient: it may be overly costly (in the long run), and may not extend component lifetime as much as possible. In the last ten years, therefore, many utilities replaced their maintenance routine using fixed schedules with more flexible programs based on an analysis of needs and priorities, or on a study of information obtained through periodic or continuous condition monitoring (predictive maintenance).

Accurate and documentation is essential to an effective maintenance program. Whether performing preventive, predictive, corrective, or reliability-centered maintenance, keeping track of equipment condition and maintenance is critical. Maintenance schedules can be done as frequencies as multiyear, annually, monthly, weekly, etc.

- Weekly: Calendar week (Sunday to Saturday)
- Monthly: Calendar month (first day through the last day of the month)

- Quarterly: A calendar quarter consisting of 3 calendar months
- Semi-annually: Six calendar months
- Annually: A calendar year (January 1 through December 31)
- Multiyear: Multiple calendar years (e.g., 5-year – January 1, 2011, through December 31, 2015)

Preventive Maintenance

There are many definitions of preventive maintenance, but all preventive maintenance management programs are time-driven. Preventive maintenance mission is to maintain a level of certain service on equipment, programming the interventions of their vulnerabilities in the most opportune time. Preventive maintenanceis a set of activities that are performed on plant equipment, machinery, and systems before the occurrence of a failure in order to protect them and to prevent or eliminate any degradation in their operating conditions. It is used to be a systematic character, that is, the equipment is inspected even if it has not given any symptoms of having a problem.

Preventive maintenance (PM) measures are performed at relatively fixed intervals. The primary goal of PM is to prevent the failure of equipment before it actually occurs. It is designed to preserve and enhance equipment reliability by replacing worn components before they actually fail. Recent technological advances in tools for inspection and diagnosis have enabled even more accurate and effective equipment maintenance. The ideal PM program would prevent all equipment failure before it occurs. This type of maintenance is performed to circumvent equipment failure or malfunction. A preventive maintenance program can help improve reliability of equipment. Preventive maintenance is predetermined work performed to a schedule with the aim of preventing the wear and tear or sudden failure of equipment components.

Cleaning: The intent of cleaning is to remove all dirt and contamination, including any grease or oil film on the windings. Cleaning methods should not utilize high pressure flow or any abrasive methods that could cause damage to the windings.

Record Keeping: The electrical preventive maintenance program should be well-documented as to scope and frequency of maintenance. Record all routine maintenance activities and the results of routine testing for trending purposes. Document all repair and/or replacement of electrical components. When changes are made to the electrical distribution system, update all applicable drawings and maintenance schedules to reflect the changes. Ensure that spare parts inventories are updated for any new equipment added based on the manufacturer's recommendations.

Predictive Maintenance

Predictive maintenance is a type of maintenance used for measuring and/or monitoring of equipment in order to observe or predict equipment degradation or failure. Mobley (2002) defined predictive maintenance as monitoring the vibration of rotating

machinery in an attempt to detect incipient problems and to prevent catastrophic failure. It is also the monitoring the infrared image of electrical switchgear, motors, and other electrical equipment to detect developing problems. The common premise of predictive maintenance is that regular monitoring of the actual mechanical condition, operating efficiency, and other indicators of the operating condition of machine-trains and process systems will provide the data required to ensure the maximum interval between repairs and minimize the number and cost of unscheduled outages created by machine-train failures. When used properly, predictive maintenance can provide almost unlimited benefits; however, when the scope of the program is artificially limited by the scope or work or restrictions imposed by the plant, the benefits may be substantially reduced.

Typically, predictive maintenance is implemented for one of the following reasons:

1. As a maintenance management tool
2. As a plant optimization tool
3. As a reliability improvement tool

Tools that are used in this type of maintenance include vibration analysis, thermography and fluid analysis, among others. These measurements are able to detect the onset of problems or degradation of the equipment or a particular mechanism within the equipment before partial or total failure occurs. Predictive maintenance bases maintenance requirements on the actual state of the equipment, rather than a preset schedule. Predictive maintenance can increase the life of the equipment and decrease downtime, parts and labor costs, while providing energy savings. Through the monitoring, preemptive measures can be taken to prevent equipment failure, increasing the environmental safety as well.

Predictive maintenance is a significant component of the condition-based maintenance (CBM) strategy. Condition-based maintenance (CBM) is a proactive way to get in front of potential failures. It pursues constantly know and report the status and operational capacity of the installations by knowing the values of certain variables, which represent such state and operational ability. To apply this maintenance, it is necessary to identify physical variables (temperature, vibration, power consumption, etc.). Which variation is indicative of problems that may be appearing on the equipment. This maintenance it is the most technical, since it requires advanced technical resources, and at times of strong mathematical, physical and/or technical knowledge. The common premise of predictive maintenance is that regular monitoring of the actual mechanical condition, operating efficiency, and other indicators of the operating condition of machine-trains and process systems will provide the data required to ensure the maximum interval between repairs and minimize the number and cost of unscheduled outages created by machine-train failures (Mobley, 2002).

Evans (2007) emphasized that the primary diagnostic technologies utilized to assess equipment health include vibration analysis, infrared thermography, airborne ultrasound, oil analysis, and motor circuit evaluation. Vibration analysis uses sensors placed on equipment to provide a detailed spectrum of vibration frequencies. This technology can identify equipment imbalance, misalignment, bearing faults, and abnormal installation conditions like soft foot.

Ultrasonic equipment is used to measure sound frequencies outside human capacity and can be used to identify bearing problems, air system leaks, steam trap leaks, and valve leaks.

Infrared thermography is a technology that utilizes a thermal imaging system to provide a thermal profile of temperatures on operating equipment. It is useful for diagnosing electrical equipment and can identify loose or improper terminations, load imbalances, overload conditions, and other typical electrical problems. Thermography is also used to analyze mechanical equipment to assess steam trap performance and motor/belt temperature profiles. Infrared imaging is, without a doubt, the most cost effective technique for assessing the health of electrical equipment. Ranking equipment on a scale of criticality helps define how aggressive the proactive maintenance strategy should be, and anyone still going around tightening electrical connections as part of a preventive maintenance program should stop and take a look at the advantages of an infrared inspection program (Evans, 2007).

Predictive maintenance shifts the maintenance emphasis from a reactive approach to a proactive one that utilizes a blend of available building data and advanced diagnostic technologies to predict problem areas before they become liabilities. Equipment condition information is derived from a range of sources including routine inspections, scheduled diagnostic testing, problem response with root-cause analysis, collection of operational data with handheld barcode scanners, and integration of information pulled from building automation systems.

Mobley (2002) highlighted five nondestructive techniques that are normally used for predictive maintenance management: vibration monitoring, process parameter monitoring, thermography, tribology, and visual inspection. Each technique has a unique data set that assists the maintenance manager in determining the actual need for maintenance.

Corrective Maintenance

Corrective maintenance is another type of maintenance, it is aimed to restore an already repaired failed equipment (Ogbuanya, 2009). The set of corrective tasks is destined to correct the defects to be found in the different equipment and that are communicated to the maintenance department by users of the same equipment. This maintenance is often most expensive because worn equipment can damage other parts and cause multiple damage. Corrective maintenance is probably the most commonly used approach, but it is easy to see its limitations. When equipment fails, it often leads to downtime in production. In most cases this tends to be costly to the business. Also, if the equipment needs to be replaced, the cost of replacing it alone can be substantial. Corrective maintenance is carried out on all items where the consequences of failure or wearing out are not significant and the cost of this maintenance is not greater than preventive maintenance. This type of maintenance can be regarded as unplanned, emergency, breakdown maintenance.

This type of maintenance, according to Alshayea (2012) is subdivided into three types:

- *Remedial maintenance*, which is a set of activities that are performed to eliminate the source of failure without interrupting the continuity of the production process.
- *Deferred maintenance*, which is a set of corrective maintenance activities that are not immediately initiated after the occurrence of a failure but are delayed in such a way that will not affect the production process.
- *Shutdown corrective maintenance*, which is a set of corrective maintenance activities that are performed when the production line is in total stoppage situation.

The way to perform corrective maintenance activities is by conducting four important steps:

1. Fault detection.
2. Fault isolation.
3. Fault elimination.
4. Verification of fault elimination.

In the fault elimination step, several actions could be taken such as adjusting, aligning, calibrating, reworking, removing, replacing or renovation.

Corrective maintenance has several prerequisites in order to be carried out effectively. Alshayea (2012) enumerated them as follows:

1. Accurate identification of incipient problems.
2. Effective planning which depends on the skills of the planners, the availability of well developed maintenance database about standard time to repair, a complete repair procedures, and the required labour skills, specific tools, parts and equipment.
3. Proper repair procedures.
4. Adequate time to repair.
5. Verification of repair.

Reliability Centered Maintenance

Reliability-centered maintenance (RCM) have been developed and touted as the panacea for ineffective maintenance. Many domestic plants have partially adopted it as a quick-fix method in an attempt to compensate for perceived maintenance shortcomings. A basic premise of RCM is that all machines must fail and have a finite useful life, but neither of these assumptions is valid. If machinery and plant systems are properly designed, installed, operated, and maintained, they will not fail, and their useful life is almost infinite. Few, if any, catastrophic failures are random, and some outside influence, such as operator error or improper repair, causes all failures. With the exception of instantaneous failures caused by gross operator error or a totally abnormal outside influence, the operating dynamics analysis methodology can detect, isolate, and prevent system failures.

Reliability Centered Maintenance (RCM) analysis provides a structured framework for analyzing the functions and potential failure modes for a physical asset in order to develop a scheduled maintenance plan that will provide an acceptable level of operability, with an acceptable level of risk, in an efficient and cost effective manner. Reliability

techniques often utilize a logic diagram approach for evaluating the potential effects of failure and selecting the appropriate maintenance strategy. The RCM analyst may wish to use cost and availability based comparisons of potential maintenance strategies when selecting and assigning maintenance tasks.

Moore (2010) identified the following maintenance methodologies: typical inspection routines discover issues with roller and ball bearings, shaft/coupling alignment, loose cable and control wire terminations, generator core iron, windings, electrical connections, electrical insulation, and commutator/brush assemblies.

1.7 Theoretical Framework

Theory of Needs

Some individual theories have made great impacts with their conceptual scheme of improvement which have implication for classroom teacher. Madsen (1961) note that personality development can be described as a combination of a press and a need, According to Madsen each theme in an individual's life is characterized by the existence of a need in relation to a particular press, a stimulus – situation that has a potential influence upon the life of the organism.

In his view, Madsen (1961) saw need gratification as the basis for most human behaviors He argued that needs are arranged in a hierarchy (see Figure 1).

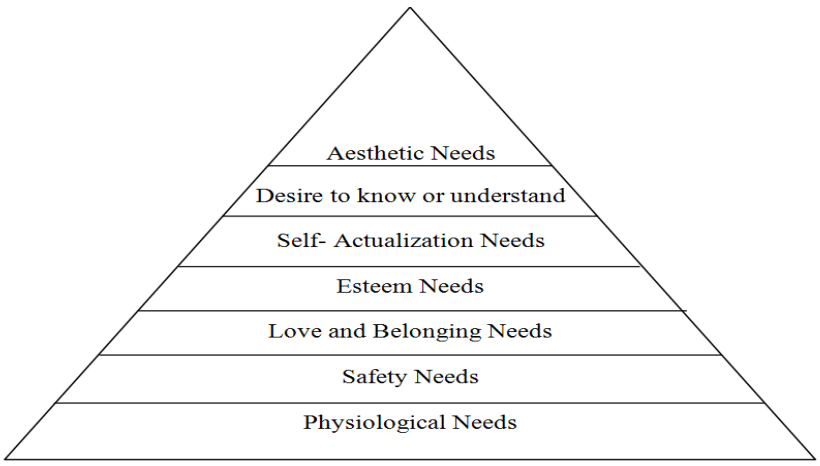


Fig 1 Maslows Hierarchy of Needs

Thus, as one general type of need is satisfied, another higher order of need will emerge and become operative in life. The deficiency needs can be satisfied only by others. This shows that an individual can depend on others as need gratification. That of self – actualization, desire to know or understand and aesthetics needs are the Being needs. A need, therefore, develops and motivate behavior only if an individual is expected to a certain press (Good & Brophy, 1977). Hence, the desire to satisfy or gratify these needs directs or dictates human behavior.

The above concept of need, have implications, among other things for teachers in general and the Electrical teacher in particular. The teacher teaching electrical installation should concern him-self with efforts to find out how best to structure his instructional activities so that to improve the college student. Students will be opportune and encourage satisfying their individual needs. Thus, the key concept to bear in mind is the occasional and appropriate involvement of technical college students interest and needs in planning of curriculum and instruction. Also, systematic exposure to environmental pressures will lead to reasonably strong interest in college students if improved by teachers.

Since these electrical teachers have the skills already but they needs to improve in skills. According to Maslow (1970) in Ugwu (2008) an individual needs are arranged in a hierarchical nature ranging from lower level physiological needs to higher level needs for self-actualization. In this case, an Electrical teacher need self-actualization to strive and improves their skill needs through mastery of their environment and pursuit of achievable goals. However, these electrical teachers got their certificate with relevant skills but they are supposed to improve skills in their working place.

Theory Skill Acquisition

Hubert and Stuart Dreyfus (1980) stated that as human beings acquire a skill through instruction and experiences, they do not appear to leap suddenly from rule-guided "knowing that" to experience-based knowledge "how", but there is gradual process involved for an agent to go through in order for him to reach the stage of expertise or knowing-how. Their skill acquisition process shows that a person goes through at least five stages of different knowledge of a specific task and ways of decision-making as he improves his skill. These five stages are novice, advanced beginner, competence, proficiency, and expertise.

(1) **Novice stage**: In this stage the learner or agent has some general ideas and is the process of learning rules.

(2) **Advance beginner stage:** This is a stage, where the learners performance improves to a relatively acceptable level only after the novice has had enough experience in the coping the real situation.

(3) **Competence stage:** In this stage, the beginner starts becoming personally involved with the task. He starts to see more than one option from which he has to choose the best one.

(4) **Proficiency stage:** This is a stage where the learner, while intuitively understand his task, still thinks analytically about his actions.

(5) **Expert stage:** In this stage, experts in general know what to do based on mature understanding of the task. An expert has had so much experience with the task that the skill of doing the task is a part of him.

The theory of skill acquisition by Hubert and Stuart Dreyfus help the researcher to articulate not only the skills to be acquired in maintenance of equipment but also the sequence of the acquisition of such skills. For example, preventive maintenance skills must be employed regularly in order to prevent equipment from running to failure. Although, these

electrical teachers may have the some skills already but they needs to improve in such skills to prolong the life of equipment.

Review of Related Empirical Studies

Gella (1993) conducted a study on improving technical teachers on the use of maintenance of technical equipment in secondary schools in Adamawa and Taraba States. The main purpose of the study was to find out those problems that technical teachers had which prevailed them from effective utilization and maintenance of technical equipment. The specific purposes of the study are as follows: The essential skills in maintenance needed by technical teachers or effective teaching and training students in maintenance course, the maintenance skills technical teachers acquired while training, the level of skill possessed by technical teacher in operation of technical equipments, some limiting factors that prevent technical teachers from carrying out effective maintenance on the technical equipment and ways of solving these problems. A structured questionnaire used for data collection; three hundred and fifty (350) copies of the questionnaire were administered. Three research questions were raised and three hypotheses were tested at ($P>0.05$) level of significance. The findings of the study show that the skill possessed by the technical teachers in the operation of technical equipment they work is very low, some other problems found out by the survey is non availability of spare part and lack of basic maintenance knowledge. This study is related to present study as it involves maintenance of technical equipment in secondary schools.

Abimbola (2007) conducted a research to investigate the skill improvement needs of technical teachers for maintenance of woodwork equipment in secondary schools in Ogun State. The aims of this study is identify the maintenance skills needed by technical teachers for improving their performance on the maintenance of woodwork equipment and specifically the purpose of the study seeks to find out: the extent of competencies required by technical teacher, the extent of competencies required by technical teachers to enable them to maintain woodwork equipment effectively, skill areas in woodwork equipment maintenance where technical teachers need improvement for their effectiveness. Maintenance constraints experienced by technical teachers in wood workshop in secondary schools.

Survey research design was adopted for the study. The population for the study was the same as sample for the study which was 68. The finding of the study shows that the technical teachers encountered problems in carrying out maintenance of equipment in secondary school wood workshops due to the lack of fund to procure maintenance materials, lack of spare parts; adverse climatic condition, improved equipment from different source, lack of incentives, poor maintenance culture, and inability to operate the equipment freely. Even though this study was conducted about wood work equipment, it involves skills and maintenance related to this study.

Mamman (2008) conducted a research on workshop practice management skill improvement needs of electricity/electronic teachers in technical colleges in Adamawa, Bauchi, Gombe State. The study made use of survey research design. Five research questions

were formulated, survey instrument of 75 items and reliability co-efficient of 0.98. His findings revealed that the respondents need planning as it is the bedrock on which all other management skills are laid. Organization and skill needs among others, with population of 81 Electrical/Electronic teachers, all questionnaires administered correctly completed and returned 100 percent with 19 items were found to be needed .This study is relevant to the present study because it involves skill improvement needs of electrical/electronic teachers in technical colleges.

Ogbuanya, and Fakorede (2009) conducted a study that sought to identify the technical skill improvement needs of metal work Technology Teachers for entrepreneurship in response to MDG for quality assurance. Structured questionnaire was used to collect data from the respondents. The population for the study consisted of 110 metalwork Teachers. No sampling made because of the relative small size of the population. Data were analyzed with mean and standard deviation. The findings of the study revealed that Metalwork technology teachers in technical colleges need modern metalwork technology skills for quality training of metalwork students in technical colleges for occupation in metalwork industry and productive self-employment. Finally, the study identified the pedagogical skills needed by metalwork technology teachers in the technical colleges in Lagos and Ogun State to enable them teach for entrepreneurship. Entrepreneurial skills identified by this study aimed at improving/eradicating poverty and hunger as well as to develop a global partnership for development. This is in line with the current study in the aspect of skill improvement needs but defer in the aspect of subject contain of metal and entrepreneurship.

Dimelu (2009) conducted a study that focused on identification of competency improvement needs of teachers of home economics in the use of ICT for effective teaching in technical colleges of education in southeastern Nigeria. Three research questions guide the study. Descriptive survey research design adopted for the study. The population was 105 teachers of home economics. A structured questionnaire used for data collection. The questionnaire was divided in to two categories of needed and performance. The needed category was assigned a four point response scale. High, needed four averagely, needed three slightly, needed two and not needed one, while the performance category was assigned a four point response scale. of highs performance four, average performance three low performance two and no performance one The questionnaire was face validated three experts from department of vocational teacher education, university of Nigeria, Nsukka. Split half technique and Cronbach Alpha method were used to determine the internal consistency of the item with a co-efficient of 0.8. The difference between the mean the questionnaire was administered to the respondents with a return rate of 100%. The data was analyzed using weighted mean of each of the items in each category constitute the gap that needed improvement i.e XN XP =PG(performance gap).It was found out that teachers of home economics in colleges of education needed improvement in 16 competency item in word processing; 13 competency items in internet usage and 15 competency items in presentation(power point). It was therefore, recommended that teachers of home economics should be improved in areas of their deficiencies identified by the study through short courses (in service) workshops and personal effort. Even though this study conducted on competency,

it involves improvement needs of teachers relevant to this study and no evidence of sample so the study will be generalized with caution.

Atsumbe, Saba and Abdullahi (2009) conducted a study on work-skill required for training of secondary school dropouts in Niger State. The purpose of this study was to develop a work-skill required for training of secondary school dropouts in Niger states. Specifically the study was designed to develop a programme of train in domestic wiring, battery charging and repairs and winding of electrical machines adequate for making dropout students self –reliant. The study made use of survey research design. Three research questions were raised and three hypotheses were tested at (P>0.05) level of significance. The population of this study comprised of 38 respondents, 28 Electrical Technical School teachers selected from all the seven technical colleges and 10 tertiary school lecturers that offer training for vocational and technical teachers. The data collected from the population was analyzed using mean, standard deviation and the t-test. Based on the findings, it is recommended that the training should be replica of the training environment where the trainees would subsequently work. And adequate repetition of training in experience from the training areas should be given to the trainees. Thus, these enable the right habits of doing and thinking to the degree necessary for employment. This study is relevant to the present study owing to the fact that it involves work skill relevant to that of technology teachers but the work of the study deals with Niger state not in my study area.

Olaitan, Alaribe and Ellah, (2009) study focused on capacity building needs of palm oil and kernel marketers for enhancing economic returns from oil industry in South Eastern Nigeria. Four research questions guided the study. The study was carried out in South Eastern Nigeria. The sample for the study was 456. A 45 skill item questionnaire was developed from literature reviewed. The questionnaire had two scales of needed and performance with a four point response scales each. The questionnaire was validated by three experts. Split half technique and Crombach alpha method were used to determine reliability of the questionnaire which yielded a co-efficient of 0.83. Four hundred and fifty six (456) copies of the questionnaire were administered on the respondents through the help of five assistants. All the copies of the questionnaire were retrieved and analyzed using weighted mean and improvement needed index (INI) to answer the research questions. It was found out that palm oil and kernel marketers needed capacity building in planning, reprocessing and marketing skills in palm oil and kernel enterprise. It was recommended that the finding of this study be utilized to develop building programs for retraining marketers of the palm oil and kernel for greater efficiency. This study was conducted on palm oil and kernel marketers for enhancing economic returns is relevant to the present study because it involves needs but differ in capacity building needs and skill improvement.

Abdullahi (2010) conducted a study was motivated by a great concern about the future and continuity of Electrical installation in all tiers of society and our education system particularly in technical colleges. The concern stemmed from poor performance, low and declining skill practice in performance and in National Business and Technical Education Board (NATEB) Examination. Pertinent questions and doubts were raised on the required

competencies of Electrical/Electronic Teachers currently teaching Electrical installation in technical colleges. The study therefore focused on the Electrical installation competencies required by Electrical/Electronic teachers in technical colleges using Bauchi and Gombe States of Nigeria as a frame of reference. Four objectives were stated, research questions asked, and hypotheses formulated and tested at 0.05 level of significance. A questionnaire, titled Electrical Installation Competencies Required by Electrical/Electronic Teachers in Technical Colleges (EICRETC), consisting of 112 items was structured, based on the four broad Electrical installation areas: Domestic installation, Industrial installation, Cable jointing and Winding of Electrical machines administered to 47 Electrical/Electronic teachers in Bauchi and Gombe States. Data thus collected were analyzed using the mean and t-test statistics. Respondents rated items as required in 112 competencies. The study has implication for re-training, in-service training for Electrical/Electronic teachers and therefore recommend involving continuous training not one but regular basis through workshops, seminars were made towards the implementation of the finding of the study. This study is relevant to the present study because it concern about electrical installation and declining of skill by electrical/electronic teachers.

Alaribe and Nwobu (2009) carried out a study aimed at determining the capacity building needs of teachers of Agriculture for effective teaching in junior secondary schools in Abia State. Two research questions were developed and answered in line with the purpose of the study. Evaluation and survey research designs were involved in the study. Sample for the study was 200 teachers of Agriculture in the junior secondary schools. A four item psycho-productive multiple choice test and a twenty cluster item questionnaire were developed for obtaining data. The instruments were validated by 3 experts. Even though this study was conducted on Agriculture, but is relevant to the present study because it involves needs of teachers.

Summary of Reviewed Related Literature

The aim of technical education is to give training and impart necessary skills that will lead to the production of technicians, craftsmen and other skilled personnel that will be self reliant. These trainees have to be taught through different technical teachers in various field of study (trades) but in the case of this study, electrical teachers are concerned and these teachers must possess the necessary skills in order to maintain their electrical laboratory equipment anytime for their students' activities. Maintenance is described as taking specific approved steps and precautions to care for a piece of equipment, machinery, or facility and ensure that it attain specific maximum functional self-life.

The literature reviewed revealed that many studies have been carried out on improving technical teachers on the use of maintenance of technical equipment in secondary schools; skill improvement needs of technical teachers for maintenance of woodwork equipment in secondary schools, workshop practice management skill improvement needs of electricity/electronic teachers in technical colleges; technical skill improvement needs of metal work Technology Teachers for entrepreneurship in response to MDG for quality assurance; competency improvement needs of teachers of home economics in the use of ICT

for effective teaching in technical colleges of education; work-skill required for training of secondary school dropouts, capacity building needs of palm oil and kernel marketers for enhancing economic returns from oil industry; Electrical installation competencies required by Electrical/Electronic teachers in technical colleges using Bauchi and Gombe States; and capacity building needs of teachers of Agriculture for effective teaching in junior secondary schools. These reviewed studies show that gap exist as no study has been conducted on maintenance of electrical laboratory equipment. There is therefore, the need for a study on skill improvement needs of electrical teachers for the maintenance of electrical laboratory equipment in Technical Colleges to fill the gap.

2.0 MATERIAL AND METHOD

A survey research design was adopted for the study. According to Gall, Gall and Borg (2007), survey research is a method of data collection using questionnaire or interviews to collect data from a sample that has been selected to represent a population to which the findings of the data analysis can be generalized. This design is appropriate for this study because it allowed the respondents i.e. electrical teachers to put down their views and opinions on skill improvement needs for the maintenance of electrical laboratory equipment using questionnaire.

Area of the Study

This study was carried out in in Kano State. The state has eight Technical Colleges that offer Electrical trades which are Goverment Technical College, Kano; Government Technical College, Baguda; Government Technical College, Ungogo; Government Technical College, Wudil; Government Girls Science Technical College, Kano; Government Technical College, Dambatta; Government Technical College, Karaye; and Government Technical College, Doguwa. Kano State was used for the study because it has many Technical Colleges with many electrical teachers. The colleges also have well equipped electrical laboratory that their teachers need to maintain to help the equipment last longer for equipping students with needed skills.

Population of the Study

The population for the study made up of 55 Electrical trade teachers in all the Technical Colleges in Kano State. This information was gathered from the eight Technical Colleges in Kano State (See Appendix A).

3.0 Results and Discussion

Research Question 1

What are the skill improvement needs in preventive maintenance of electrical laboratory equipment?

The data for answering this research question are presented in Table 1.

Table 1. ***Mean Rating of Responses of Teachers on Skill Improvement Needs in Preventive Maintenance of Electrical Laboratory Equipment***

N= 55

S/N	Items	$\bar{X}$	SD	Decision
1	Review and update when there are changes in Equipment.	4.29	0.66	SIN
2	Carryout weekly routine maintenance activities for all electrical equipment.	4.18	0.72	SIN
3	Clean all loose dirt with link free rags.	3.85	1.08	SIN
4	Examine for evidence of moisture that may lead to tracking or flashover	4.13	0.72	SIN
5	Inspect equipment before and after use for symptoms of any problem.	4.24	0.77	SIN
6	Proper storage of equipment to prevent degradation.	4.18	0.72	SIN
7	Inspect insulators and conductor supports for signs of cracking, broken pieces, and other physical damage or deterioration.	3.87	0.75	SIN
8	Ensure that spare parts inventories are updated for any new equipment.	4.05	0.73	SIN
9	Examine surrounding areas for signs of tracking, arcing, or overheating.	4.16	0.79	SIN
10	Update records when changes are made to equipment.	4.31	0.79	SIN

*SIN = Skill Improvement Needed

Key: $\bar{X}$= Mean, SD= Standard Deviation, (VHN) Very Highly Needed = 5, (HN) Highly Needed =4 (MN) Moderately Needed, (MN) =3, Slightly Needed (SN) =2 Not Needed (NN) =1

Data presented in Table 1 revealed that 1 of the items had mean value of 4.31, this value is within the real limit of 3.50-5.00 indicating that this preventive maintenance skill is highly needed by electrical teachers in technical colleges. The table also indicates that 10 items had their values ranged from 3.85-4.31. These values were within the real limit of 3.50-5.00, indicating that the preventive maintenance skills were highly needed upon by teachers of electrical installation in technical colleges.

The table also indicated that the standard deviation values ranged from (0.66-1.08) which showed that each of the value was below 1.96. This indicates that the respondents were not too far from the mean and from one another in their opinion. This information validates the values of each mean.

Research Question 2

What are the skill improvement needs in predictive maintenance of electrical/laboratory equipment?

The data for answering this research question are presented in Table 2.

Table 2. ***Mean Rating of Responses of Teachers on Skill Improvement Needs in Predictive Maintenance of Electrical Laboratory Equipment***

N= 55

S/N	Items	$\bar{X}$	SD	Decision
1	Monitor the infrared image of electrical switchgear, motors, and other electrical equipment	4.02	1.10	SIN
2	Measure sound frequencies outside human capacity.	4.02	1.06	SIN
3	Identify bearing problems, air system leaks, steam trap leaks, and valve leaks.	4.22	0.69	SIN
4	Employ thermal imaging system to provide a thermal profile of temperatures on operating equipment	4.04	0.69	SIN
5	Eliminate unnecessary downtime, both scheduled and unscheduled.	3.96	0.74	SIN
6	Develop maintenance database about standard time to repair equipment.	4.20	0.76	SIN
7	Evaluate the vibration energy created by these electromechanical systems.	4.24	0.67	SIN
8	Utilize microprocessor-based instrument to check vibration of equipment.	3.91	0.73	SIN
9	Detect thermal anomalies of equipment by using thermography.	4.05	0.87	SIN
10	Identify physical variables (temperature, vibration, power consumption)	4.29	0.71	SIN
11	Verify grounding system integrity through periodic testing.	4.09	0.67	SIN
12	Estimate amount of time that the equipment will operate.	3.78	1.03	SIN

*SIN = Skill Improvement Needed

Key: X = Mean, SD= Standard Deviation, (VHN) Very Highly Needed = 5, (HN) Highly Needed =4 (MN) Moderately Needed, (MN) =3, Slightly Needed (SN) =2 Not Needed (NN) =1

Data presented in Table 2 reveal that 1 of the items had mean value of 4.29, this value is within the real limit of 3.50-5.00 indicating that this predictive maintenance skill is highly needed by electrical teachers in technical colleges. The table also indicates that 10 items had

their values ranged from 3.78-4.29. These values were within the real limit of 3.50-5.00, indicating that the predictive maintenance skills were highly needed upon by teachers of electrical installation in technical colleges.

The table also indicates that the standard deviation values ranged from (0.67-1.10) which showed that each of the value was below 1.96. This indicates that the respondents were not too far from the mean and from one another in their opinion. This information validates the values of each mean.

Research Question 3

What are the skill improvement needs in corrective maintenance of electrical laboratory equipment?

The data for answering this research question are presented in Table 3.

Table 3. ***Mean Rating of Responses of Teachers on Skill Improvement Needs on*** **Corrective** ***Maintenance of Electrical Laboratory Equipment***

N= 55

S/N	Items	$\bar{X}$	SD	Decision
1	Repair damaged equipment parts.	4.38	0.68	SIN
2	Replace worn out parts which replacement.	4.16	0.66	SIN
3	Verify specific type of equipment repair.	3.73	1.06	SIN
4	Isolate beginning problem of equipment.	4.04	0.92	SIN
5	Isolate equipment after the occurrence of a failure.	3.96	1.17	SIN
6	Refurbish tools, parts and equipment when damaged	4.36	0.68	SIN
7	Rectify failure without interrupting the continuity use of the equipment.	4.18	0.67	SIN
8	Overhaul any laboratory equipment when in total stoppage situation	4.05	0.73	SIN
9	Overhaul the equipment on schedule after breakdown.	4.13	0.67	SIN
10	Eliminate the source of equipment failure without interrupting the continuity of the production process.	3.98	0.78	SIN

*SIN = Skill Improvement Needed

Key x = Mean, SD= Standard Deviation, (VHN) Very Highly Needed = 5, (HN) Highly Needed =4 (MN) Moderately Needed, (MN) =3, Slightly Needed (SN) =2 Not Needed (NN) =1

Data presented in Table 3 revealed that 1 of the items had mean value of 4.38, this value is within the real limit of 3.50- 5.00 indicating that this corrective maintenance skill is highly needed by electrical teachers in technical colleges. The table also indicates that 10 items had their values ranged from 3.98-4.38. These values were within the real limit of

3.50-5.00, indicating that the corrective maintenance skills were highly needed upon by teachers of electrical installation in technical colleges. The table also indicates that the standard deviation values ranged from (0.67-1.17) which showed that each of the value was below 1.96. This indicates that the respondents were not too far from the mean and from one another in their opinion. This information validates the values of each mean.

Research Question 4

What are the skill improvement needs in reliability-centered maintenance of electrical laboratory equipment?

Table 4. ***Mean Rating of Responses of Teachers on Skill Improvement Needs in Reliability-Centered Maintenance of Electrical/Laboratory Equipment***

N = 55

S/N	Items	$\bar{X}$	SD	Decision
1	Analyze the potential failure modes of equipment.	4.35	0.62	SIN
2	Apply suitable safety preventions while working with electrical equipment.	4.31	0.60	SIN
3	Utilize a logic diagram approach for evaluating the potential effects of equipment failure.	4.02	0.78	SIN
4	Understand the principles of grounding/protection and associated devices.	4.25	0.70	SIN
5	Conduct routine inspection of electrical connections of equipment.	4.09	0.75	SIN
6	Identify the presence of abnormal heat in electrical equipment.	3.98	0.78	SIN
7	Determine the functional importance of equipment components and their failure.	4.09	0.75	SIN
8	Effective use and carryout testing of a range of motors, solenoids, cables etc.	3.84	0.71	SIN
9	Access electrical enclosures and replace fuses, reset overloads etc.	4.13	0.82	SIN
10	Identify the conditional probability of equipment failure at specific age.	4.20	0.73	SIN

*SIN = Skill Improvement Needed

Key: X = Mean, SD= Standard Deviation, (VHN) Very Highly Needed = 5, (HN) Highly Needed =4 (MN) Moderately Needed, (MN) =3, Slightly Needed (SN) =2 Not Needed (NN) =1

Data presented in Table 4 revealed that 1 of the items had mean value of 4.35, this value is within the real limit of 3.50- 5.00 indicating that this reliability-centered maintenance skill is highly needed by electrical teachers in technical colleges. The table also indicates that 10 items had their values ranged from 3.84-4.38. These values were within the

real limit of 3.50-5.00, indicating that the reliability-centered maintenance skills were highly needed upon by teachers of electrical installation in technical colleges.

The table also indicates that the standard deviation values ranged from (0.62-0.82) which showed that each of the value was below 1.96. This indicates that the respondents were not too far from the mean and from one another in their opinion. This information validates the values of each mean.

3.1 Test of the First Hypothesis

Ho_1: There will be no significant difference in the mean responses of qualified and less qualified electrical teachers on the skill improvement needs in preventive maintenance of electrical laboratory equipment.

The data for testing hypotheses are presented in Table 5.

Table 5. ***The t-test Analysis of the Mean Responses of Qualified and Less Qualified Electrical Teachers on the Skill Improvement Needs in Preventive Maintenance***

N_1=35, N_2=20

S/N	Items	Qualified Teachers $n_1 = 35$		Less Qualified Teachers $n_2 = 20$		t-cal	Sig (2-tailed)	Decision
		$\bar{X}_1$	SD_1	$\bar{X}_2$	SD_2			
1	Review and update when there are changes in Equipment.	4.29	0.67	4.30	0.66	-0.08	0.94	NS
2	Carryout weekly routine maintenance activities for all electrical equipment.	4.17	0.71	4.20	0.77	-0.14	0.89	NS
3	Clean all loose dirt with link free rags.	3.83	1.04	3.90	1.17	-0.23	0.82	NS
4	Examine for evidence of moisture that may lead to tracking or flashover	4.14	0.77	4.10	0.64	0.21	0.83	NS
5	Inspect equipment before and after use for symptoms of any problem.	4.34	0.76	4.05	0.76	1.37	0.18	NS
6	Proper storage of equipment to prevent degradation.	4.17	0.75	4.20	0.70	-0.14	0.89	NS
7	Inspect insulators and conductor supports for signs of cracking, broken pieces, and other physical damage or deterioration.	3.83	0.75	3.95	0.76	-0.58	0.57	NS
8	Ensure that spare parts inventories are updated for any new equipment.	4.09	0.74	4.00	0.73	0.42	0.68	NS
9	Examine surrounding areas for signs of tracking, arcing, or overheating.	4.11	0.80	4.25	0.79	-0.61	0.54	NS
10	Update records when changes are made to equipment.	4.29	0.79	4.35	0.81	-0.29	0.78	NS

Key: NS = Not Significant, S = Significant, X_1 = Mean score of Qualified Teachers Less, X_2 = Qualified Teachers, SD_1= Standard Deviation of experience electrical teachers, SD_2= Standard Deviation of less experienced electrical teachers, t-cal =calculated value, tab= table value, N_1= Number of experienced teachers, N_2 = Number of less experienced teachers

The data presented in Table 5 showed that all the 10 item had t-cal value ranged from –0.61 to 1.17. These values were less than the t-tab value of 1.96. The null hypotheses of no significant difference were accepted for all the 10 items.

3.2 Test of the Second Hypothesis

There will be no significant difference in the mean responses of qualified and less qualified electrical teachers on the skill improvement needs in predictive maintenance of electrical laboratory equipment.

The data for testing hypotheses are presented in Table 6.

Table 6. ***The t-test Analysis of the Mean Responses of Qualified and Less Qualified Electrical Teachers on the Skill Improvement Needs in Predictive Maintenance***

N_1= 35, N_2 = 20

S/N	Items	Qualified Teachers n_1 = 35		Less Qualified Teachers n_2 = 20		t-cal	Sig(2-tailed)	Decision
		$\bar{X}_1$	SD_1	$\bar{X}_2$	SD_2			
1	Monitor the infrared image of electrical switchgear, motors, and other electrical equipment	3.97	1.07	4.10	1.17	-0.42	0.68	NS
2	Measure sound frequencies outside human capacity.	4.03	1.01	4.00	1.17	0.10	0.93	NS
3	Identify bearing problems, air system leaks, steam trap leaks, and valve leaks.	4.23	0.73	4.20	0.62	0.15	0.88	NS
4	Employ thermal imaging system to provide a thermal profile of temperatures on operating equipment	4.14	0.73	3.85	0.59	1.53	0.13	NS
5	Eliminate unnecessary downtime, both scheduled and unscheduled.	3.94	0.73	4.00	0.79	-0.27	0.79	NS
6	Develop maintenance database about standard time to repair equipment.	4.14	0.77	4.30	0.73	-0.74	0.46	NS
7	Evaluate the vibration energy created by these electromechanical systems.	4.26	0.70	4.20	0.62	0.30	0.76	NS
8	Utilize microprocessor-based instrument to check vibration of equipment.	3.97	0.79	3.80	0.62	0.84	0.41	NS
9	Detect thermal anomalies of equipment by using thermography.	4.09	0.85	4.00	0.92	0.35	0.73	NS
10	Identify physical variables (temperature, vibration, power consumption)	4.23	0.73	4.40	0.68	-0.86	0.40	NS
12	Verify grounding system integrity through periodic testing.	4.06	0.68	4.15	0.67	-0.49	0.63	NS
13	Estimate amount of time that the equipment will operate.	3.71	1.18	3.90	0.72	-0.64	0.53	NS

Key NS = Not Significant, S = Significant, x_1 = Mean score of Qualified Teachers Less, x_2 = Qualified Teachers, SD_1= Standard Deviation of experienced electrical teachers, SD_2= Standard Deviation of less experienced electrical teachers, t-cal =calculated value, tab= table value, N_1= Number of experienced teachers, N_2 = Number of less experienced teachers.

The data presented in Table 6 showed that all the 13 item had t-cal value ranged from -0.64 to 1.53. These values were less than the t-tab value of 1.96. The null hypotheses of no significant difference were accepted for all the 13 items.

3.3 Test of the Third Hypothesis

There will be no significant difference in the mean responses of qualified and less qualified electrical teachers on the skill improvement needs in corrective maintenance of electrical laboratory equipment.

The data for testing hypotheses are presented in Table 7.

Table 7. ***The t-test Analysis of the Mean Responses of Qualified and Less Qualified Electrical Teachers on the Skill Improvement Needs in Corrective Maintenance***

N_1= 35, N_2 = 20

S/N	Items	Qualified Teachers n_1 = 35		Less Qualified Teachers n_2 = 20		t-cal	Sig(2-tail-ed)	Deci-sion
		$\bar{X}_1$	SD_1	$\bar{X}_2$	SD_2			
1	Repair damaged equipment parts.	4.43	0.65	4.30	0.73	0.67	0.51	NS
2	Replace worn out parts which replacement.	4.14	0.65	4.20	0.70	-0.31	0.76	NS
3	Verify specific type of equipment repair.	3.71	1.02	3.75	1.16	-0.12	0.91	NS
4	Isolate beginning problem of equipment.	3.94	0.94	4.20	0.89	-1.00	0.32	NS
5	Isolate equipment after the occurrence of a failure.	3.86	1.31	4.15	0.88	-0.89	0.38	NS
6	Refurbish tools, parts and equipment when damaged	4.43	0.65	4.25	0.72	0.94	0.35	NS
7	Rectify failure without interrupting the continuity use of the equipment.	4.20	0.68	4.15	0.67	0.26	0.79	NS
8	Overhaul any laboratory equipment when in total stoppage situation	4.09	0.74	4.00	0.73	0.42	0.68	NS
9	Overhaul the equipment on schedule after breakdown.	4.11	0.72	4.15	0.59	-0.19	0.85	NS
10	Eliminate the source of equipment failure without interrupting the continuity of the production process.	3.94	0.87	4.05	0.60	-0.49	0.63	NS

Key NS = Not Significant S = Significant, x_1 = Mean score of Qualified Teachers Less, x_2 = Qualified Teachers SD_1= Standard Deviation of experienced electrical teachers, SD_2= Standard Deviation of less experienced electrical teachers, t-cal =calculated value, tab= table value, N_1= Number of experienced teachers, N_2 = Number of less experienced teachers.

The data presented in Table 7 showed that all the 10 item had t-cal value ranged from -0.49 to 0.94. These values were less than the t-tab value of 1.96. The null hypotheses of no significant difference were accepted for all the 10 items.

There will be no significant difference in the mean responses of qualified and less qualified electrical teachers on the skill improvement needs in reliability centered maintenance of electrical laboratory equipment.

The data for testing hypotheses are presented in Table 8.

Table 8. ***The t-test Analysis of the Mean Responses of Qualified and Less Qualified Electrical Teachers on the Skill Improvement Needs in Reliability Centered Maintenance***

N_1= 35, N_2 = 20

S/N	Items	Qualified Teachers $n_1 = 35$		Less Qualified Teachers $n_2 = 20$		t-cal	Sig(2-tailed)	Decision
		$\bar{X}_1$	SD_1	$\bar{X}_2$	SD_2			
1	Analyze the potential failure modes of equipment.	4.31	0.68	4.40	0.50	-0.49	0.62	NS
2	Apply suitable safety preventions while working with electrical equipment.	4.29	0.62	4.35	0.59	-0.38	0.71	NS
3	Utilize a logic diagram approach for evaluating the potential effects of equipment failure.	4.03	0.82	4.00	0.73	0.13	0.90	NS
4	Understand the principles of grounding/protection and associated devices.	4.29	0.67	4.20	0.77	0.43	0.67	NS
5	Conduct routine inspection of electrical connections of equipment.	4.09	0.78	4.10	0.72	-0.07	0.95	NS
6	Identify the presence of abnormal heat in electrical equipment.	3.97	0.75	4.00	0.86	-0.13	0.90	NS
7	Determine the functional importance of equipment components and their failure.	4.11	0.76	4.05	0.76	0.30	0.76	NS
8	Effective use and carryout testing of a range of motors, solenoids, cables etc.	3.83	0.71	3.85	0.75	-0.11	0.92	NS
9	Access electrical enclosures and replace fuses, reset overloads etc.	4.14	0.85	4.10	0.79	0.19	0.85	NS
10	Identify the conditional probability of equipment failure at specific age.	4.29	0.75	4.05	0.69	1.16	0.25	NS

Key: NS = Not Significant S = Significant, x_1 = Mean score of Qualified Teachers Less, x_2 = Qualified Teachers, SD_1= Standard Deviation of experienced electrical teachers, SD_2= Standard Deviation of less experienced electrical teachers, t-cal =calculated value, tab= table value, N_1= Number of experienced teachers, N_2 = Number of less experienced teachers.

The data presented in Table 8 showed that all the 10 item had t-cal value ranged from -0.49to 1.16. These values were less than the t-tab value of 1.96. The null hypotheses of no significant difference were accepted for all the 10 items.

4.0 Conclusion and Recommendations

The following were the findings of the study:

A. Skill improvement needs in preventive maintenance of electrical laboratory equipment

The respondents highly needed that quest for review and update when there are changes in Equipment. Also require to update records when changes are made to equipment. The study also revealed that teachers highly need improvement through 10 items which include:

1. Review and update when there are changes in equipment.
2. Carryout weekly routine maintenance activities for all electrical equipment.
3. Clean all loose dirt with link free rags.
4. Examine for evidence of moisture that may lead to tracking or flashover
5. Inspect equipment before and after use for symptoms of any problem.
6. Proper storage of equipment to prevent degradation.
7. Inspect insulators and conductor supports for signs of cracking, broken pieces, and other physical damage or deterioration.
8. Ensure that spare parts inventories are updated for any new equipment.
9. Examine surrounding areas for signs of tracking, arcing, or overheating.
10. Update records when changes are made to equipment.

B. Skill improvement needs in preventive maintenance of electrical laboratory equipment.

The respondents highly needed that quest to evaluate the vibration energy created by these electromechanical systems and detect thermal anomalies of equipment by using thermography. The study also revealed that teachers highly need improvement through 12 items which include:

1. Monitor the infrared image of electrical switchgear, motors, and other electrical equipment
2. Measure sound frequencies outside human capacity.
3. Identify bearing problems, air system leaks, steam trap leaks, and valve leaks.
4. Employ thermal imaging system to provide a thermal profile of temperatures on operating equipment
5. Eliminate unnecessary downtime, both scheduled and unscheduled.
6. Develop maintenance database about standard time to repair equipment.

7. Evaluate the vibration energy created by these electromechanical systems.
8. Utilize microprocessor-based instrument to check vibration of equipment.
9. Detect thermal anomalies of equipment by using thermography.
10. Identify physical variables (temperature, vibration, power consumption)
11. Verify grounding system integrity through periodic testing.
12. Estimate amount of time that the equipment will operate.

C. Skill improvement needs in corrective maintenance of electrical laboratory equipment

The respondents highly needed that quest to repair damaged equipment parts and refurbish tools, parts and equipment when damaged. The study also revealed that teachers highly need improvement through 10 items which include:

1. Repair damaged equipment parts.
2. Replace worn out parts which replacement.
3. Verify specific type of equipment repair.
4. Isolate beginning problem of equipment.
5. Isolate equipment after the occurrence of a failure.
6. Refurbish tools, parts and equipment when damaged
7. Rectify failure without interrupting the continuity use of the equipment.
8. Overhaul any laboratory equipment when in total stoppage situation
9. Overhaul the equipment on schedule after breakdown.
10. Eliminate the source of equipment failure without interrupting the continuity of the production process.

D. Skill improvement needs indelibility centered maintenance of electrical laboratory equipment

The respondents highly needed that quest for analyzing the potential failure modes of equipment and apply suitable safety preventions while working with electrical equipment. The study also revealed that teachers highly need improvement through 10 items which include:

1. Analyze the potential failure modes of equipment.
2. Apply suitable safety preventions while working with electrical equipment.
3. Utilize a logic diagram approach for evaluating the potential effects of equipment failure.
4. Understand the principles of grounding/protection and associated devices.
5. Conduct routine inspection of electrical connections of equipment.
6. Identify the presence of abnormal heat in electrical equipment.
7. Determine the functional importance of equipment components and their failure.
8. Effective use and carryout testing of a range of motors, solenoids, cables etc.
9. Access electrical enclosures and replace fuses, reset overloads etc.
10. Identify the conditional probability of equipment failure at specific age.

4.0 SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

The findings of the study have been organized and discussed according to the four research questions and four hypotheses. The research questions were discussed fist followed by the hypotheses as outlined below.

In research question one the finding in Table 1 indicated that the items of skill improvement need to improve the maintenance of electrical/laboratories were highly needed upon. The findings of the study also revealed that provision of opportunities for academic growth of students is one of the important responsibilities of technical and vocational teachers. Alshayea (2012) opined that some proper workshop planning by the teacher is highly needed as to meet the principles underlying the teaching of any technical trade. These include, clear objectives teaching is goal-oriented, leaner readiness, teacher should ensure that the pupil are intellectually ready for what is to be taught, previous experience; even student had some experiences before going to college, individuals differences; it is known that learners are different from one another in many capacities. These differences must be realized by the teacher and should recognize these differences and use a variety of techniques and material to teach, teaching should be systematic it should proceed form known to unknown, simple to complex concrete to abstract and general to specific. These findings are in line with Sani (2013) believe that development of sound school-based career development programmes requires a clear understanding of how individuals learn and knowledge of how to structure materials to be learned most effectively and efficiently, giving due attention to predisposition, structure and sequence. It implies that it will not be possible to effectively and efficiently train electrical installation student for vocational development without the teacher putting individual learner into consideration and knowledge of method or techniques of presenting materials to be learned.

In the four research questions posed for skill improvement needs of electrical teachers were found to be highly needed in the maintenance of electrical equipment. The findings reveal that teachers need to be adequately provided with skill improvement needs that will suit the world of work. Akanni (2006) postulated that it has become necessary for teachers to organize the use of facilities in such a way that every learner is given equal opportunity to profit from the experiences being provided. This is in line with Abdullahi, (2010) believed that skill training will be efficient in proportion as the environment in which the learner is trained is replica of the real environment in which he/she must subsequently work. This denotes that it will be deceitful to training students using obsolete or unmaintained tools while the actual job required the use of modern tools. It implies that training with electrical equipments using unmaintained tools will certainly produce graduates who will not be relevant on the job unless given a new training to meet the desire of their employers.

Principal Findings

On the basis of the data collected and analyzed, the following major findings were made:

1. Review and update when there are changes in equipment.
2. Carryout weekly routine maintenance activities for all electrical equipment
3. Evaluate the vibration energy created by these electromechanical systems.

4. Identify physical variables (temperature, vibration, power consumption)
5. Repair damaged equipment parts.
6. Refurbish tools, parts and equipment when damaged
7. Analyze the potential failure modes of equipment.
8. Apply suitable safety preventions while working with electrical equipment.

Conclusion

In conclusion from the findings of the study on re-tooling needs of electrical teachers for maintenance of electrical laboratory equipments in technical colleges, skill were highly needed by respondents in order to bring about effective and efficient learning outcome and more additional efforts are required.

Recommendations

Based on the findings of the study and their subsequent discussions and implications, the following measures are recommended:

1. Kano State science and technical school management board should encourage the training and re-training of electrical teachers on re-tooling needs of teachers of electrical subject through attendance of conference, seminars and workshop in order to possess new skills of maintaining electrical equipments.
2. North central states science and technical school management board should supply the adequate and relevant modern facilities to respective technical college electrical workshop and maintenance. This will facilitate the acquisition of practical skills that are relevant to modern industries and it will enable student to be self-employ and employ others.
3. Electrical teachers are advice to make use of recommended re-tooling in the findings of the study. This will facilitates teaching and enhance better student understanding of electrical subjects.
4. Modern electrical industrial employers should from time to time visit technical college to inform them about the new development and the required skill development that goes with it in order to keep these schools at breast with the ongoing developments.

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