

Mechatronics Technical Skills Required By Teachers Of Mechanical Engineering Craft Practice For Improving The Teaching Of Students In Technical Colleges In Enugu State, Nigeria

Samson Ikenna Nwaodo¹, George Nwachukwu Ogbonna^{2*}, Victor Ikechukwu Oguejiofor³, Pauline Ijeoma Obe⁴, Joshua Onyekachi Ike⁵ & Ikechukwu Jerry Ogbonna⁶

^{1, 2*, 3, 4, 5, 6}Department of Industrial Technical Education, University of Nigeria, Nsukka.

Abstract

The purpose of the study was to identify the mechatronics technical skills required by mechanical engineering craft practice teachers in technical colleges in Enugu State, Nigeria. A survey research design was adopted for the study. Three research questions were raised to guide the study. The study was conducted in Enugu State. The population of this study was 52 mechanical engineering craft practice teachers in 41 technical colleges offering mechanical engineering craft practice in Enugu State. The entire population constituted the sample for the study, the instrument for data collection was a structured questionnaire. Three experts from the department of Industrial Technical Education, University of Nigeria, Nsukka validated the instrument and it was trial-tested. A Cronbach Alpha reliability coefficient of 0.84 was obtained indicating that the instrument was reliable to elicit information for the study. The data were analyzed using mean and standard deviation to answer the three research questions. The findings of the study revealed that the mechanical engineering craft practice teachers required technical skills in basic computer operations, data collection and interpretation of data during and after machining operations using computer numeric control machines. It was concluded that teachers of (MECP) should be retrained so that they shall impart the skills gained through retraining to their students. Based on the findings, it was recommended that Enugu State government who owns the technical colleges shall make training and retraining of (MECP) teachers a continuous capacity building programme as innovations in technology keeps emerging.

Keywords: Mechatronics technical skills, Mechanical engineering craft practice Teachers,

Introduction

Mechatronics is an interdisciplinary area of engineering that combines mechanical, electronics and computer science together in a single machine. The term mechatronics has variously been defined and interpreted by experts in the field. These definitions range from simple to complex. Harashima,

Tomizuka, and Fukada (1996) defined mechatronics as the synergistic integration of mechanical engineering, with electronics and intelligent computer control in the design and manufacturing of industrial products and processes. Auslander and Kempf (1996) defined mechatronics as the application of complex decision making to the operation of physical systems. In their view, Shetty and Kolk (1997) described mechatronics as a methodology used for the optimal design of electromechanical products. Bolton (1999), stated that mechatronics system is not just a marriage of electrical and mechanical systems and is more than just a control system; it is a complete integration of all of them. Mechatronics according to Michulzie in Shittu (2014) is the synergistic application of mechanics, electronics and computer engineering in the development of electromechanical products and systems through an integrated design approach.

All these definitions agree that mechatronics is an interdisciplinary field in which mechanical systems, electronic systems and information technology disciplines act together. Shittu further stated that mechatronics is the extension and the completion of mechanical systems with sensors and micro-computers. The system picks up changes in its environment by sensors, and reacts to their signals using the appropriate information processing, this make it different from conventional machines. Typical examples of mechatronics systems are robots, digitally controlled combustion engine, computer numeric control machines and machine tools with self adaptive tools, contact-free magnetic bearings, automated guided vehicles among others.

The study of mechatronics provides a mechanism for scholars interested in understanding and explaining the engineering design process to define, classify, organize, and integrate many aspects of product design into a coherent package. The mechatronics specialty provides an educational roadmap for engineering students studying within the traditional structure of most engineering colleges. Mechatronics is generally recognized worldwide as a vibrant area of study. The study of mechatronic systems can be divided into the following areas of specialty: physical systems modeling, sensors and actuators, signals and systems, computers and logic systems as well as software and data Actualization. These are the key elements of mechatronics.

Mechatronics is offered in mechanical engineering craft practice in technical colleges in Enugu State, Nigeria. Mechanical engineering craft practice is a 3-year vocational training course offered in a technical college for the award of National Technical Certificate (NTC) to become a craftman or 1-year post NTC vocational course leading to the award of Advanced National Technical Certificate (ANTC) to become master craftsman. The NTC and ANTC certificate are awarded by national Business and Technical Examination Board, NABTEB (Federal Republic of Nigeria, 2004). The two programmes provide the trainees the opportunity to acquire the necessary knowledge and skills required to operate industrial machine tools. A qualified mechanical engineering craft men/master-crafts men are highly skilled persons equipped with both theoretical and practical knowledge required to operate any mechanical/automated production machine-tools to reproduce any mechanical parts successfully.

Machine tool is usually used to generate cylindrical surfaces, plain surfaces, slots etc. Jain (2007), defined machine tool as a power driven device in which energy is utilized in deformation of material for shaping, sizing or processing a product to a desired accuracy by removing the excess

material in the form of chips. Machine tool in the view of Wikipedia (2008), is a powered mechanical device, typically used to fabricate metal components of machines by machining, which is the selective removal of metal. A machine tool is a machine that is capable of producing another machine (Mori, 2003). Machine tool can be referred to as power driven machine which can be used to carryout operations such as turning, drilling, milling, cutting and so on. Machine tools are of different types, and some of them like the lathe machine, milling machine, grinding machine, drilling machine, shaping machine can be used to perform many operations in the machine shop.

Operation of machine tool is one of the areas in mechanical engineering craft practice which requires effective technical skills by teachers in technical colleges. Machine operations are one of the processes used to change the shape of material. This is achieved by chips removal from the material to be machined. Operating procedure on the other hand, refers to the machine operating steps or technical skills required of the machine operator (machinist) during the operation of the machine tools. Examples of machine tool operations are turning, facing, drilling to mention but a few. Mechanical engineering craft practice teachers are expected to be competent in carrying out these operations.

The National Board for Technical Education (NABTE), the body charged with the responsibility of preparing the curriculum for technical education stated that the practical competence of the trainees on completion of any specified practical module for mechanical engineering craft practice will enable the trainees to demonstrate practical competence to the standard expected in the Industry (FRN, 2001). This statement is however faulted by Ogwo and Oranu (2006) who in their work noted that the products of technical institutions (technical colleges inclusive) are found to possess less than satisfactory levels of employability skills. Also Atsumbe, Okoro and Ogwo (2012), Kakwagh and Ikwuba (2010) expressing concern in this regard indicated that in Africa generally (Nigeria Inclusive) the skills that job seekers possess do not match the needs and demands of employers. This is because technical advancement of the present time has gone beyond the use of mechanical machines. Most industries today have gone digital.

Nigeria as a country and Enugu state in particular have been trying to switch over to digital machines in their technical colleges. Most technical colleges in Enugu State today have computer numeric control (CNC) machines. Computer Numeric Control (CNC) machine means automatic control of machine tools by a computer and computer programme (Michulzie, 2019). The author stressed that CNC is a method of operating a machine tool by a computer, through the use of discrete numerical values fed into the machine where the required input technical information is stored on a type of input media such as floppy disc, hard disc, CD Rom, DVD etc. Computer Numeric Control (CNC) machine enables an operator to communicate with machine tools through a series of numbers and symbols. Manufacturing operations here, is controlled by means of directly inserted coded numerical instructions into the machine tool.

The axial movements of CNC machine tools are guided by a computer which needs a programme and instructs several motors to move in the appropriate manner. The motors in turn cause the table to move and produce the machined parts. A CNC machine system consists of an input device like USB Flash drive, floppy disc drive, conversational programming; a control unit

which is the center piece of the machine that stores and reads the programme and tells the other components what to do. The control unit decides cutting speed, feed, depth of cut, tool selection etc. It issues command inform of numeric data to motor that position that slides and tool accordingly. It will also interpret a CNC programme and activate the series of commands in sequential order; a machine tool which helps to obtain a high degree of accuracy and repeatability in the design and make of the machine slides. The slides are usually machined to a high accuracy and coated with anti-friction materials; a driving system which comprises of the motors and screws that will finally turn the part programme into motion; a feedback system that provides the control with information about the status of the motion control system and lastly a display unit. This unit provides opportunity for the CNC machine operator to interact with the computer via human machine interface (HMI).

The human machine interface allows special verification functions (like dry run) to confirm the correctness of the CNC programme. The HMI allows certain important operator inputs to be specified separate from the programme, like tool length values. The most obvious thing that a CNC machine tool operator would have to know is the general operating characteristics of the machine. Manufacturing Industries in Nigeria now use computer numeric control (CNC) machine tools to manufacture standardized products, therefore a CNC machine tool operator requires the acquisition of combination of basic computer operation and related technical skills with machining skills to work comfortably with the machine.

Skills are function-driven capacities acquired overtime through practice and experience. Antanwu (2010) defined skill as the ability to do things well. It is the ability to bring about some end result with maximum certainty and minimum outlay of energy or of time and energy. Skill is the ability to apply knowledge and the use of know-how to complete tasks and solve problem. Osuala (2004) sees skill as ability to put into use acquired competencies, attitudes and behaviour after an exposure to theories and practices inherent in a field of study. In the opinion of Okorie (2000) skill is well established habit of performing tasks in a manner acceptable by workers in the profession. He further explained that to possess a skill is to demonstrate by acting, thinking and behaving in a specific activity in such a way that the process becomes natural to the individual through repetition or practice. Adeyemo (2010) summarized skill as a well established habit of doing something involving the acquisition of performance capabilities in the most economic way. Skill involves physical manipulative process that culminates in the achievement of ultimate goals. Skill in the context of this study is the capability which teachers of technical colleges must possess that could enable them teach mechatronics technology effectively to students. Teachers of mechanical engineering craft practice must possess the technical skills embedded in the course.

Technical skills according to Ifeanyiyeze (2010), is the ability of an individual to use special knowledge and techniques to carry out a task, that is, the capability a person has that helps him/her utilize different methods and techniques in a task to accomplish such task successfully. Technical skill in the context of this study is an organized actions, abilities and proficiency executed by technical teachers in mechanical engineering craft practice which is usually displayed in a flexible but temporal patterning. Teachers of mechanical engineering craft practice are therefore expected

to brace the challenges of acquiring technical skills in order to impart these skills to students to make them adequately competent to meet up with the demands of the present day technological innovations in the industry. Teachers cannot meet up with these challenges if they are not trained or retrained.

Teaching as a profession needs constant training and retraining of teachers in order to adapt in emerging technology. Dem (2014) stated that many educators are limited in the technological skills required for successful technological integration in career and technical education due to lack of recent training in professional field. (Mechanical engineering craft practice teachers in Enugu State inclusive). Shittu (2014) asserted that in most developing countries (Nigeria inclusive). Vocational technical teachers were up to the last millennium trained with conventional machines (mechanical). This assertion is supported by Uwaifo and Uwaifo (2009); Olateju (2017) who posit that workshop equipment used for the training of technical teachers in Nigeria are obsolete and needed replacement. This replacement is necessary owing to the fact that with conventional machine tools, the accuracy of the job to be machined depends mainly on the manual skill and expertness of the operator unlike the CNC machine tools that required possession of specific technical skills in mechanical engineering craft practice and computer technology to operate them.

Conventional machine tools are no longer used in the industry according to Chado (2007). Industries now use CNC machine tools for producing component parts for machines. Most technical colleges in Enugu State now have CNC machines but teachers have little or no skills in its operations. This new development has created skill gap. The skill gap created are: basic computer operations, data collection and interpretation of data which according to Michulzie (2019) are mechatronics technical skills.

Statement of the Problem

The need to meet the increasing industrial challenges of high repeatability and precision, as in production in high volume of automobile parts, flexibility in job change, uniformity and consistent part quality, machining of complex contours/surfaces as in turbine parts, better quality and high quantity of parts production and safe working conditions prompted the emergence of CNC machine tools such as CNC milling machine, CNC lathe machine, CNC drilling machine, CNC shaping machine etc into the production and manufacturing industries today. All CNC machine tools are computer automated that is, the work loading, spindle revolution, feed rate, cutting speed, depth of cut, coolant on/off, tool changing and part unloading are automatically controlled by computer coding.

Unfortunately, teachers of mechanical engineering craft practice in Enugu State technical colleges still rely on skills acquired through the use of conventional machines in teaching their students. This however, will not meet the objectives of the practical competency that the NBTE's curriculum specified for the trainees to possess at the time of graduation. The curriculum specified that on completion of the module for mechanical engineering craft practice, it is expected that the

trainees will demonstrate practical competencies to operate mechanical machine tools to a standard as practiced in industries.

The major problem of this study is the gap created by the out dated skills possessed by the teachers against the new development in the industry which necessitated the need for teachers of mechanical engineering craft practice in Enugu State technical colleges to acquire technical skills in basic computer operations, data collection and interpretation of data in machining operations. These are mechatronics technical skills required to operate CNC machine tools that are now available in the industries. Retraining the teachers to acquire these technical skills would enable them to work with CNC machine tools and the teachers would in turn impact the acquired mechatronics technical skills to the students.

Purpose of the Study

The purpose of this study is to identify the mechatronic technical skills required by teachers of mechanical engineering craft practice in Enugu State technical colleges. Specifically the study seeks to determine:

1. the technical skills in basic computer operations required by teachers of mechanical engineering craft practice in Enugu State technical colleges for using CNC machine tools.
2. the technical skills in data collection required by teachers of mechanical engineering craft practice in Enugu State technical colleges for using CNC machine tools.
3. the technical skills in interpretation of machining data required by teachers of mechanical engineering craft practice in Enugu State technical colleges for using CNC machine tools.

Research Questions

The following research questions were posed to guide the study:

1. What are the technical skills in basic computer operations required by teachers of mechanical engineering craft practice in Enugu State technical colleges for using computer numeric control machine tools?
2. What are the technical skills in data collection required by teachers of mechanical engineering craft practice in Enugu State technical colleges for using CNC machine tools?
3. What are the technical skills in interpretation of machining data required by teachers of mechanical engineering craft practice in Enugu State technical colleges for using computer numeric control machine tools?

METHODOLOGY

Design of the Study

The study was a survey research designed to determine the technical skills required by teachers of mechanical engineering craft practice for improving the teaching of mechatronics technology in technical colleges in Enugu State, Nigeria. This design was adopted for the study because it would enable the researcher to elicit information from the entire population. According to Ezeji in Shittu

(2014) survey research design involves the assessment of public opinion using collection of detailed descriptions of existing phenomena with the intent of using the data to justify current conditions and practices or to make better plans for improving phenomena.

Area of the Study

The study was conducted in Enugu State of Nigeria. It covered all the 41 existing technical colleges offering mechanical engineering craft practice in Enugu State. Enugu State was chosen for this study because of the existence of technical colleges that produces graduates in mechatronics technology every year. The state also has factories and organizations that employ technical college graduates at one time or the other.

Population for the Study

The population for the study comprised of all the 52 mechanical engineering craft practice teachers in all the 41 technical colleges where mecatronics technology are offered in Enugu State.

Sample and Sampling Technique

No sampling was carried out since the population was manageable.

Instrument for Data Collection

The instrument for data collection was a structured questionnaire. The items in the questionnaire were organized in accordance with the research questions formulated to guide the study. The questionnaire which contains 24 items is divided into four sections; A, B, C and D. Section A, contains items designed to obtain personal data of the respondents. Section B, contains 10 items designed to determine the technical skills in basic computer operations required by teachers. Section C, contains six items designed to determine the technical skills in data collection required by teachers while section D, contains eight items designed to determine the technical skills in interpretation of machining data required by the teachers.

The questionnaire was based on 5 points rating. The respondents were asked to rate items as:

Very Highly Required (VHR)	-	5
Highly Required (HR)	-	4
Moderately Required (MR)	-	3
Less Required (LR)	-	2
Not Required (NR)	-	1

Validation of the Instrument

The instrument was subjected to face validation by three experts from the department of Industrial Technical Education, University of Nigeria, Nsukka. They were requested to read through the instrument items and criticize, suggest corrections and adjustments that will ensure that the instrument actually measures what it is designed to measure. The suggestions of validates were integrated into the final copy of the instrument that was used for data collection.

Reliability of the Instrument

A trial test on the instrument was carried out for the purpose of establishing the internal consistency and stability of the instrument. Twenty mechanical engineering craft practice teachers from fifteen technical colleges in Ebonyi State which is outside the study area were used. The Cronbach Alpha reliability coefficient test was found to be 0.84 which was high enough for the study.

Method of Data Collection

Fifty-two copies of the questionnaire were administered on the respondents through personal contact by the researchers with the help of two briefed assistant. The respondents were given 2 days to study and respond. Repeat visits were made the third and fourth days to each of the technical colleges by the researchers and their assistants for the purpose of final collection. This method of direct contact with the respondents ensured the researchers a 94% return rate.

Method of Data Analysis

The data collected were analyzed using mean statistics to answer the research questions, and standard deviation to determine the variability or spread of the questionnaire items. Questionnaire items with the mean of 3.50 and above were considered as required while questionnaire items with the mean less than 3.50 were considered as not required. Questionnaire items with the value of standard deviation less than 1.00 were considered as relatively homogenous while questionnaire items with the value of standard deviation 1.00 and above 1.00 were considered as not homogenous.

Results

Mean responses on technical skills in basic computer operation required for using computer numerical control machine by teachers of mechanical engineering craft practice in Enugu State technical colleges

S/N	Item Statement	\bar{X}	SD	Decision
1	Ability to switch on a computer system	4.50	0.67	Required
2	Ability to use a mouse to interact with application on the computer screen	4.79	0.42	Required
3	Ability to use keyboard to interact with application on the computer screen	4.60	0.50	Required
4	Ability to navigate a computer file system	4.91	0.30	Required
5	Ability to open a file in the computer system	4.38	0.66	Required
6	Ability to save a file in the computer system	4.45	0.71	Required
7	Ability to run programmes in the computer system	4.69	0.47	Required
8	Ability to use Microsoft power point in presentation	4.40	0.67	Required

9	Ability to access data base to source for internet materials	4.79	0.42	Required
10	Ability to shutdown the computer system properly after use	4.00	0.73	Required

Table 1 shows that most respondents agreed that all the items listed as basic computer operations technical skills are required by mechanical engineering craft practice teachers in Enugu State technical colleges for using Computer Numerical Control (CNC) machine tools. Most respondents agreed that the basic computer operations technical skills required by teachers of (MECP) in Enugu State technical colleges for using computer numerical control machine tools are: ability to use keyboard to interact with applications on the computer screen, ability to save a file in the computer, ability to use internet to source for materials, ability to switch on and shutdown the computer system among others.

Items 1 – 10 were accepted based on the decision that their mean ratings were equal to or greater than $\bar{X} = 3.50$ cut off point. All the questionnaire items has standard deviation between 0.30 – 0.73 which indicated that all the questionnaire items are homogenous and are well spread.

Mean responses on technical skills required in Data collection by teachers of (MECP) in Enugu State technical college

S/N	Item Statement	\bar{X}	SD	Decision
11	Ability to use vibration analyzers on the CNC machine	4.12	0.55	Required
12	Ability to use infrared thermograph equipment for calibration	4.33	0.73	Required
13	Ability to collect machining data through serial communication	4.45	0.63	Required
14	Ability to use floppy disc drive correctly.	4.26	0.72	Required
15	Ability to initiate conversational programming	4.24	0.76	Required
16	Ability to use USB flash drive correctly.	4.71	0.46	Required

Table 2 revealed that most respondents agreed that all the items listed as technical skills in data collection are required by teachers of (MECP) for using CNC machine tools. The respondents agreed that ability to use vibration analyzers on CNC machine, ability to use infrared thermograph equipment for calibration, initiating conversational programming using floppy disc drive correctly etc are technical skills required by teachers of (MECP) in Data collection. Items 11 – 16 were accepted based on the decision that their mean rating were equal to or greater than the cutoff point of $\bar{X} = 3.50$. The Standard Deviation of the items here lie between 0.46 – 0.76. This indicated that the items are homogenous and well spread.

Table 3: Mean responses on technical skills in interpretation of machining data required by teachers of (MECP) in Enugu State technical colleges for using computer numerical control machine tools

S/N	Item Statement	\bar{X}	SD	Decision
17	Ability to interpret blocks used as command in a part programming	4.52	0.51	Required
18	Ability to interpret words used as identification letters in a part programme	4.31	0.47	Required
19	Ability to interpret tool functions in part programming	4.60	0.45	Required
20	Ability to interpret conversational programming data using keyboard	4.31	0.47	Required
21	Ability to interpret various numbers and symbols used as machine language	4.36	0.62	Required
22	Ability to interpret feed function in a part programme	4.05	0.60	Required
23	Ability to interpret spindle function in a part programme	4.17	0.67	Required
24	Ability to interpret addresses used as commands in a part programme	4.41	0.50	Required

Table 3 indicates that most respondents agreed that all the items listed under interpretation of machining data are technical skills required by teachers of mechanical engineering craft practice in Enugu State technical colleges in using computer numerical machine tools. Most respondents agreed that the technical skills required by teachers of (MECP) in Enugu State technical colleges in interpretation of machining data are: ability to interpret blocks used as commands in a part programming, ability to interpret words used as identification letters in a part programme, ability to interpret tool functions in part programming, ability to interpret conversational programming data using keyboard, ability to interpret various numbers and symbols used as machine language, ability to interpret feed function in a part programme, ability to interpret spindle function in a part programme and ability to interpret addresses used as commands in a part programme. Items 17 – 24 were accepted based on the decision that their mean ratings were equal to or greater than the cutoff point of 3.50. All questionnaire items have standard deviation between 0.45 – 0.67 which indicated that all the items are homogenous and are well spread.

Discussion of Findings

The findings of this study revealed that basic computer operation technical skills are required by (MECP) teachers in Enugu State technical colleges for using CNC machine tools. The findings revealed that technical skills in basic computer operations such as knowing how to switch on a computer system, use keyboard to interact with applications on the computer screen, save a file in

the computer, use internet to source for materials, use a mouse to interact with application on the computer and ability to shutdown a computer system properly after use are very important to make effective use of the CNC machine tools. These findings are supported by Meyrl, (2001) who listed several basic computer operation technical skills that are essential for working with any computer based machine.

Data collection technical skills refers to the level of competency of interaction existing between the operator of the CNC machine tools and the data processing unit (DPU) of the CNC machine. The findings of this study revealed that teachers of (MECP) have to know the general operating characteristics of the CNC machine tools for the teachers to make effective use of the CNC machine tools. It was also discovered from the findings that technical skills in data collection such as correct use of floppy disc drive, USB flash drive, serial communication, conversational programming devices etc are required by teachers of (MECP). These findings were supported by Macharty, (2005) who described a CNC machine operator as a person who must have a good method of data collection using floppy disk drive, USB flash drive, serial communication among others.

Technical skills required by teachers of (MECP) in interpretation of data during and after machining using computer numerical control machine tools in Enugu State technical colleges as revealed in this study include ability to interpret: tool functions in part programme, input data in accordance with machining procedures, conversational programming data using the keyboard, feed functions in a part programme, blocks used as commands in a part programme etc. These findings is in line with Harshama, (2006) who stated that a CNC machine tool operator needs to know the procedures to input data properly which must be followed to reduce the error rate. The author further stressed that faulty data input procedure could cause the entire cycle to collapse thereby lowering the efficiency of a CNC machine tool.

Recommendations

1. Enugu State government should make training and retraining of teachers in their technical colleges a continuous capacity building programme as technology is dynamic to meet up with the emerging technologies.
2. The Governemnt of Enugu State should endeavour to stock all the technical college school workshops with enough computer numerical control machine tools with their training manuals for the teachers to work with.

Conclusion

The need to retrain mechanical engineering craft practice teachers in technical colleges cannot be overemphasized if truly the technical college students at the end of their graduation are expected to demonstrate practical competence to the standard expected in the industry. The industries in Enugu State are no longer using mechanical machine tools but computer numerical machine tools in which all machine functions such as feed rate, depth of cut, coolant on/off are automatically controlled by computer coding. Mechatronics technical skills such as in basic computer operations,

data collection and interpretation in machining are required to operate this digitally controlled machine tools.

The mechatronics technical skills training given to teachers of (MECP) in Enugu State technical colleges will serve as capacity building for the teachers who are the major agents of change in imparting both the mechatronics knowledge and skills to the students. The mechatronics technical skills training programme offered to the students by their teachers will guarantee employability skill to the students, equip students with saleable skills to set up enterprise of their own and the students will also be well equipped to face future challenges.

Correspondence: Every correspondence for this research should be directed to Dr. George Nwachukwu Ogbonna of the Department of Industrial Technical Education, University of Nigeria, Nsukka.

REFERENCES

- Jain, R.K. (2007). Production technology. India Romesh Chander Khanna publishers.
- Antanwu, J.J. (2010) Empowering youths for sustainable development: An assessment of entrepreneurship skill needs of youths. International Journal of Education Research UNN 10(3), 1-10.
- Okorie, J.U. (2000). Developing Nigerian workforce. No 1 White House Street, Calabar, Nigeria. Macky Environs publisher.
- Osuala, E.C. (2004). Foundation of vocational education. Enugu; Cheston Agency ltd.
- Mori, T. (2003) Mechantronics principle. Retrieved on 4/8/19 from <http://www.engr.colostate.edu/dga/mechtronics/definition.html>.
- Ogwo, B.A. & Oranu, R.N. (2006). Modern Instructional techniques and their applications in technical/vocational education (TVE). Methodology informal and non-formal technical education. Nsukka: University of Nigeria press Ltd.
- Olateju, A.S.O. (2017). Preparing vocational technical teachers for productivity and sustainable development. Unpublished paper presented at the 30th annual conference of the Nigeria association of teachers of technology, (NATT) held in Kaduna Polytechnic, Kaduna state.
- Uwaifo, V.O. & Uwaifo, I.U. (2009). Training technology and vocational education teachers for the new 9-3-4 education system in Nigeria: Its problems and prospects. International NGO Journal, 4(4), 160 – 166.

- Ifeanyieze, F.O. (2010). Professional and technical skill improvement need of teachers of Agricultural education programme in farmer mechanization for effective teaching in colleges of education in South Eastern Nigeria. *Nigerian Vocational Association Journal* 15(1), 304 – 315.
- Dem, I.I. (2014). Skill need of automobile teachers in teaching emerging technologies in technical colleges. Unpublished M.Ed Thesis Nsukka: University of Nigeria.
- Harshama, F.J. Tomizuka, M., & Fukuda, T.L. (1996). Mechatronics – What is it, why, and how? An editorial, *IEEE/ASME Transactions on Mechatronics* 1(1), 1 – 4.
- Auslander, D.M. & Kempf, C.I. (1996). *Mechanical system interfacing*, prentice-hall, Upper Saddle River, NJ.
- Shetty, D. & Kolk, R.A. (1997). *Mechatronics system: Design*, PWS publishing company, Boston, M.A.
- Bolton, W. (1999). *Mechatronics: Electrical control system in mechanical and electrical engineering*, 2nd Ed. Addison Wesley Longman, Harlow, England.
- Wikipeda (2008). Tool and cutter grinders <http://www.wikipedia.com>.
- Shittu, A.R. (2014). Mechatronic skills needed by mechanical craft practice teachers in technical colleges in Lagos state. Unpublished M.Ed Thesis Nsukka: University of Nigeria.
- Macharty, T.C. (2005). Handbook of mechatronics data recording and logging. Retrieved on 2/8/19. From <http://www.mechatronicencyinfordata>.
- Meyrh, C.E. (2001). Computer literacy for individual development. Basic principles in computer learning. Retrieved on 04/05/19. From <http://www.computeredumthl18tkl>.
- Adeyemo, S.A. (2010). The need for skill development in science, technology and mathematics education (STME) in Nigeria. *Journal of Science Technology Education Research*, 3(5), 1 – 9.
- Atsumbe, B.N., Okoro, O.M. & Ogwo, B.A. (2012). Practical skill improvement needs of technical college mechanical engineering craft practice curriculum in Nigeria. Retrieved on 17/09/2012 from <http://www.ifrnd.org/.JEVR/VOL%203/3%284%29%20Apr%202012/3.PdF>

Chado, M.I.D. (2007). Technical and vocational education facilities and Nigeria educational reform agenda. Unpublished paper presented at the 20th annual conference of the Nigeria association of teachers of technology (NATT) held in Kaduna Polytechnics, Kaduna State.

Federal Republic of Nigeria (2001). Curriculum and modules specifications for mechanical engineering craft practice for National Technical Certificate and Advanced NTC (in full) programmes Kaduna: NBTE.

Kakwagh, A.T. & Ikwuba, V.O. (2010) Rising unemployment in developing countries: Causes and remedy. International NGO Journal, 7(2), 081 – 094.

Michulzie, P.K. (2002). Numerical control machine features and working principle, Numerical control, machine tools: Retrieved on 16/08/2019 from <http://www.numerical/infotechINChelm5tkl>.