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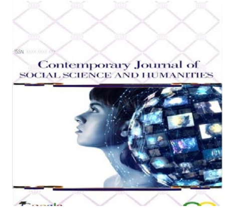

RESEARCH ARTICLE

Effect of Non – Conventional Machining Principles Instruction on Craft Students' Achievement and Retention in Machining Practice in Government Technical Colleges in Enugu State, Nigeria

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ABSTRACT

This study empirically investigated the effect of Non-Conventional Machining Principles Instruction Model (NMPIM) on students' achievement and retention in machining. The study was carried out with respect to the principles of arc length. The effect of NMPIM and the conventional method were studied. A research question and a null hypothesis guided the study. A non-equivalent pretest-posttest non randomized parallel group quasi experimental design was adopted for the study. The study was conducted in Government Technical Colleges in Enugu State, Nigeria. The population of the study was 1761-year two machining craft students. Intact classes of the only two technical colleges offering Machining Craft practice were used as subjects, with 85 and 36 students for experimental and control groups respectively. A structured instrument constructed by the researcher was validated by five experts, one from University of Nigeria, Nsukka (UNN) and four from Enugu State University of Science and Technology (ESUT). The validated instrument when subjected to item stability and internal consistency tests yielded 0.87 and 0.98, using Pearson product moment correlation coefficient formula, and Kuder Richardson (K-R 20) formulae respectively. The trial testing of the instrument by test retest was carried out in Government Technical College, Abakaliki, Ebonyi state, Nigeria. The research question was answered using Mean and Standard Deviation while the null hypothesis was analysed and tested using Analysis of Covariance (ANCOVA) at .05 level of significance. The results showed that year two machining students taught Machining with NMPIM achieved higher and retained higher in the principle learned when compared with those who were taught with the conventional method. There was no significant difference in the mean achievement and retention scores of Males over Females in the study. It was recommended that the TVET curriculum should be reviewed in line with the current technological realities with provision for 21st century equipment and training materials. The 21st century employers of labour (manufacturers) should be appointed as Technical colleges' board members so they could advice the management on the current emerging technologies and possibly donate the state-of-the-art equipment to the colleges. Therefore, NMPIM should be adopted in teaching Machining to keep the students abreast of the 21st century technology which is ever evolving.

Keywords: *Non – Conventional Machining Principles, Craft Students' Achievement, Machining Practice*

Introduction

There is an urgent need for a paradigm shift in the provision of equipment for students studying Machining Craft practice in technical colleges in Enugu State, Nigeria. Technical and Vocational Education and Training (TVET) in Enugu State, Nigeria is having many challenges, some of which are low enrolment, infrastructural decay, inadequate as well as inappropriate equipment and training materials. Other challenges include, lack of standardization and development of non-formal technical and vocational education and training as well as use of outdated curriculum, which results in a mismatch between what is taught and the needs of the labour market, Federal Republic of Nigeria (FRN, 2013). These challenges need to be addressed to enable technical colleges to achieve their desired objective.

Technical and Vocational Education and Training (TVET) is used as a comprehensive term referring to those aspects of the educational processes involving in addition to general education, the study of technologies and related sciences and the acquisition of practical, skills, attitudes, understanding and knowledge relating to occupations in various sectors of economic and social life (FRN 2013). One of the goals of TVET include: provision of trained manpower in the applied Sciences, Technology and Business particularly at craft, advanced craft and master craft levels. Following this prominent goal, the non-conventional machining principles which involve the application of Physics, Chemistry and Metallurgy are indispensable for the training of technical college students.

The National Policy on Education (FRN, 2013) provides an integrated technical education, from the upper basic level. Welding craft principles and practice cut across the various craft studies in the technical colleges; including Machining, Fitting, Fabrication, Plumbing, Automobile, Foundry and Electrical. Strategically, these institutions and their graduates have vital roles to play in producing competent manpower for the modern industries. The training scheme of these students was made available by the curriculum designing authority – National Board for Technical Education (NBTE 2007). Observations have shown that the total lack of the training equipment or poor state of the available ones hampers effective teaching and learning in the technical/vocational colleges. This researcher was irked by the use of the outdated machines, indeed machines out modelled in early 19th century for training students for the 21st century industries. It became more startling that less than 1/3 of the technical/vocational colleges presently have the out- modelled traditional machines.

The era of Information and Communication Technology (ICT) has led the developed world and even the fast-developing ones to adopt a solid introduction to the fundamentals of manufacturing. This is in line with the most up-to- date information and the concepts dealing with producing quality products. Such information and concepts are encapsulated in the training curricula of technical/vocational colleges of the countries. Unfortunately, a great number of the third world countries are still grappling with the inability to provide the pre-1940 equipment and machineries for the technical/vocational colleges operating in such environment (Boboulos, 2011). The level of decay, disrepair and dilapidation of the available ones, is pitiable. For Nigeria to realize the vision of becoming one of the 20 largest economies in the world by the year 2020, it is largely dependent on the capacity of transforming its youths into adequately skilled and competent citizens, who will be capable of competing globally (FRN 2013). Unfortunately, as at 2021 this vision is yet to be realised. The bulk of the middle level manpower needed for productive ventures in the industries and entrepreneurs for self-employment are expected to emerge from the technical and vocational colleges. However, these students are still being trained with pre-world War II equipment in the 21st century. This would hamper their global competitiveness.

However, with the need to aspire towards the attainment of the vision 2030 goal, the relevant authorities need to fast track the efforts towards equipping and providing effective training for the students in the Technical and Vocational Education and Training (TVET). For instance, presently the students are exposed to the relevant physical Sciences like Physics and Chemistry upon which the modern machineries e.g., Electrical Discharge Machines (EDM), Abrasive Jet Machines (AJM), Plasma welding machine amongst others for the TVET trainings are anchored. Procurement and practical exposure to this equipment would enhance the skills of the TVET students and usher them into the modern 21st century equipment.

Further, Imoko (2002) in Igwe, Puyate, Onoh and Eze (2012) posited that developing countries need to improve productivity throughout the economy if they are to compete successfully in this era of rapid economic and technological change. The students of TVET who should be the hub of the workforce available to the industries on graduation need to be trained with 21st century equipment. This amplifies the need for learning through an ongoing process of discovery and change in order to enhance the technological emancipation of the society (Svarovsky, Moses and Ingham, 2006). This indeed should be the hallmark of the technical institutions entrusted with the responsibility of training the students to be able to meet the manpower needs of modern production processes.

Furthermore, Obanya (2004), Igwe, Puyate, Onoh and Eze (2012), Svarovsky, Moses and Ingham(2006) and (FRN, 2013), recognized the need for improved technical productivity and economic growth. This makes it imperative for the students of TVET to be trained with modern instructional aids, training equipment and machinery. The level of competence that could be inculcated with the modern equipment would dispose them favourably on graduation for the 21st century industries. Technology has developed at an ever-increasing pace in Western and other advanced countries, yet this rate has been very slow in Nigeria, (Khan, 1989 in Iloputaife, 2000). Technology education is key to developing skills and competencies that would be in conformity with the demands of the world of work. Therefore, the curriculum should be industry-friendly. By so doing, the students of Technology and Vocational Education and allied Sciences would be modern technology compliant.

Situations whereby out-modelled/outdated equipment are still being employed as training aid to the students indicate that the products of such training are still lagging technologically as far as technological advancement is concerned. Non-conventional machining process (or non-traditional machining process) is a special type of machining process in which there is no direct contact between the tool and the workpiece (Sankaraj, 2013). In conventional machining process the ability of the cutting tool is utilised to stress the material beyond the yield point to start the material removal process. This requires that the cutting tool material be harder than the workpiece material. The non-conventional machining process in contrast utilises a very soft material as cutting tool to cut very hard workpiece. In non-conventional machining, a form of energy is used to remove unwanted material from a given workpiece (Sankaraj, 2013). Such energy utilised by non-conventional machining processes for metal removal include; Chemical, Electro-Chemical, Electro-Mechanical, Electro-Thermal, through such mechanisms as shear, erosion, chemical ablation, ionic dissolution, spark erosion, vaporization etc. (Rajput, 2007). The main reasons for using non-conventional machining processes are for High strength alloys, complex surfaces and High accuracies and surface finish. For instance, Electrical Discharge Machining (EDM) is often included in the "non-traditional" or "non-conventional" group of machining methods as well as processes such as electrochemical machining (ECM), water jet cutting (WJC), Abrasive water jet machining (AWJM), laser cutting and plasma technology (Jameson, 2001). These machining techniques came into operations industrially in 1800 (Silberberg, 2010). The non-conventional machineries fall under this category of modern equipment. They include, Spark Erosion Discharge machine (SEDM), Wire Electrical Discharge machine (WEDM), Electron-beam (Plasma) machine (EBM), Ultrasonic machine (UM), Powder Metallurgy amongst others.

Presently in machining operations in technical colleges in Enugu State in particular and Nigeria in general conventional machining techniques though obsolete and outdated, are still in use. Such techniques include, mechanical cutting operations, material removal techniques such as, chipping - off, forging, casting, stamping and engraving. Additional conventional processes include turning, milling, drilling, grinding, shaping and slotting operations (Mbachu, 2011). The "conventional" or "traditional" group of machining techniques includes-turning (lathe machine), milling, grinding, drilling and any other process whose material removal is essentially based on mechanical forces (McCathy and McGeough,2006).

In the 1940s, the needs of the defence industry, aviation and space industry, electronics and other industries necessitated machining techniques to be adopted for processing thin, fragile or special and very thin products that cannot be made using the conventional processes and that would have been rather impracticable and costly. Consequently, upon the adoption of the non-conventional machines and equipment, through reforms and innovation of the school curriculum, Nigeria can achieve perfection (Mbachu, 2011). This will become a launching pad for modern technological achievements. An appropriate instruction therefore becomes necessary to be able to make this desirable technological attainment realisable.

Some of the non-conventional machining techniques include:

a. Chemical machining (CM)
b. Electrochemical machining (ECM)
c. Electrochemical grinding (ECG)

d. Electrical discharge machining (EDM)
e. Wire electrical discharge (WEDM)
f. Laser-beam machining (LBM)
g. Electron-beam machining (EBM) Electron-beam (plasma) machining (EBM)
h. Water-jet machining (WJM) using Air, sand or beads e.g. sand blasting.
i. Abrasive-water jet machining (AWJM)
j. Ultrasonic machining (UM) and deburring processes.
k. Powder metallurgy processes (used to produce hard-alloy cutting tools made of tungsten carbide, titanium carbide, colbalt, vanadium etc. (Silberberg, 2010).

These are used in wide range of machining applications for high-alloyed rigid steels and materials and also for manufacturing complex cutting shapes – turbine propellers, tools – stamps, moulds, dies. The technique is suitable for drilling small holes and cutting into hard materials which ordinarily cannot be achieved through the conventional machining techniques. Similarly, outstanding component features like super quality surface finish, dimensional accuracy, insignificant tool wear and environmental friendliness are readily achievable with non-conventional machines.

Interestingly, the traditional/conventional machines may be so laborious to scare the females but the non-conventional machines are very convenient and less laborious to operate. For instance, the EDM has a servomechanism that guides the feeding of the electrode and subsequently the cutting.

A good number of the non-conventional machining techniques, though relatively new, employ the use of improved technology and principles of arc welding. Arc welding-fabrication process though a traditional process provides five principles that could be adapted for the non-conventional machineries. Arc welding is a fusion welding process in which the welding heat is obtained from an electric arc between the work (or base metal) and an electrode. The electric arc is produced when two conductors of an electric circuit are touched together and then separated by a small distance, such that, there is sufficient voltage in the circuit to maintain the flow of current through the gaseous medium (air). The temperature of heat produced by the electric arc is of the order of 6000^0c to 7000^0c (Khurmi & Gupta, 2012). The EDM employs one of the prime principles of arc welding which observes arc-length. The electrode in the arc welding process, depending on the device handling the torch, varies between 3mm-5mm after striking, for the production of efficient welding beads. In EDM or Spark erosion as it is popularly called, the spark gap recommended is the thickness of human hair (Krar, 2009). To maintain this very thin space without the electrode making contact with the wall of the workpiece or the pool, a servomechanism device is employed to control the operating torch. This system makes for a very high precision and accuracy of control.

The plasma arc-welding, on the other hand, employs the use of inert gas as a shielding medium. This protects the surface of the metallic workpiece from oxidation or any other reaction with the atmospheric elements. Arc length is a unique principle of arc welding which is also applicable to the Electrical Discharge Machining (EDM), though to a different degree. The following arc welding principles are employed in one way or the other in the modern non-conventional machining techniques and they include:

The principle of arc length,

Statement of the Problem

Research findings from various researchers eg. Boboulous (2011) and Bodong (2016) have indicated that technology has developed at an ever-increasing pace in Western and other advanced countries, yet this rate has been very slow in Nigeria. This is affirmed by the National Policy on Education which stated that the two greatest challenges of TVET in Nigeria are inadequate equipment and training materials coupled with the dearth of qualified and competent teachers (FRN, 2013). The use of out-dated curriculum which results in a mismatch between what is taught and the needs of the labour market has become obvious (FRN, 2013).

This accounts for the need to gradually begin replacing the conventional machines with the non-conventional machines. If the mind set of these leaders of tomorrow are not tailored towards the 21st century equipment and machineries, they may still rely on the out modelled types. The relevant authorities in charge of education sub-sector need to be reminded of the urgent need to re-engineer the technical and vocational education and training (TVET) sector. These challenges of the Technical and vocational Education and Training (TVET) if not properly addressed will give rise to the shortage of appropriately skilled labour across many industries, which is a big challenge to Nigeria's economic growth and future development (FRN, 2013).

It is time for the stakeholders in the sector to take pro-active step by providing the relevant information to make for positive improvement. The need to provide the students with appropriate modern technology-based learning machines and equipment is the thrust of this study.

Therefore, this study intends to leverage on one of the most modern (non-conventional) machining techniques to expose the year two machining students of technical colleges in Enugu State, Nigeria to the transformation and application of principle of arc length in machining processes. The problem of the study put in a question form is, "what are the effects of non-conventional machining principles on students' achievement and retention in machine shops in government technical colleges in Enugu State, Nigeria"?

Purpose of the Study

The main purpose of this study was to determine the effect of non-conventional machining principles instruction on craft Students Achievement and Retention in machining practices in Government Technical Colleges in Enugu State, Nigeria. This study specifically sought to:

Determine the mean achievement and retention scores of year two craft machining students taught machining with non-conventional machining principles instruction model (NMPIM); principle of arc length and those taught same with conventional machining principles instruction model (CMPIM).

Research Question

The following research question guided the study.

1. What are the mean achievement and retention scores of year two craft machining students taught machining with NMPIM - principle of arc length and those taught same with CMPIM

Null Hypothesis

The following null hypothesis was tested at .05 level of significance.

H_{01}: There is no significant difference in the mean achievement and retention scores of the year two craft machining students taught machining with NMPIM - principle of arc length and those taught same with CMPIM**.**

Review of Related Literature

Basic Concept in Machining
The basic concept in machining has to do with material removal. In certain machining concept especially the traditional/conventional machining, very hard cutting tools are employed for metal removal in a relatively softer material. Such very hard tools include twist drills, turning tools and milling cutters. In the non- conventional machining processes sometimes involves hard tools whereas at other times they involve very soft cutting tool apparently fragile and doing the exercise of cutting the extremely hard material. For example, copper electrode could be used in cutting tungsten, vanadium, cementite carbide, titanium, inconel, kovar which themselves are cutting tools in the traditional machining processes. Energy beams take place at the interface of the conventional and non-conventional machining processes especially the operations involving localized flames. For example, arc-welding, oxy-acetylene gas welding in the traditional machines and the plasma cutting, laser cutting, Electrical Discharge Machining (Spark erosion) and wire EDM operations. Some of the interesting features and concept of the machines both conventional and non- conventional are discussed briefly below:

Electrical Discharge Machining (EDM): Electrical discharge machining is a subtractive machining process in which material in a conductive workpiece is removed by spark erosion. There are two main classes of EDM.

1. Wire EDM in which the tool is a wire that slices cuts into the work piece.

2. Sinker EDM, in which the tool is a machined block that "sinks" into the workpiece, gradually creating a negative of the tool pattern.

A power supply applies a voltage potential between the tool and the workpiece. The tool is brought close to the work under automatic control and some method is used to maintain close spacing between the two so that arcing may occur. The electrode and the workpiece are both submerged in a dielectric fluid, which is generally light lubricating oil. A servo mechanism maintains a space of about the thickness of a human hair between the electrode and the work preventing them from contacting each other.

The spark erosive effect of electrical discharges was first noted in 1770 by English physicist Joseph Priestley (Krar and Gill, 2003). Two Russian Scientists, B.R. Lazarenko and N.I. Lazarenko, were tasked in 1943 to investigate ways of preventing the erosion of tungsten electrical contacts due to sparking. They failed in this task but found that the erosion was more precisely controlled if the electrodes were immersed in a dielectric fluid. This led them to invent an EDM machine used for working difficult-to-machine materials such as tungsten. The Lazarenkos' machine is known as an R-C- type machine, after the RC circuit used to charge the electrodes (Jameson, 2001).

Simultaneously but independently, an American team, Harold Stark, Victor Harding and Jack Beaver developed an EDM machine for removing broken drills and taps from aluminum castings. Initially constructing their machines from feeble electric-etching tools, they were not very successful. More powerful sparking units combined with automatic spark repetition and fluid replacement with an electromagnetic interrupter arrangement produced practical machines. Stark, Harding and Beavers' machines were able to produce 60 sparks per second. Later machines based on their design used vacuum tube circuits that were able to produce thousands of sparks per second, significantly increasing the speed of cutting (Jameson, 2001)

Sinker EDM also called cavity type EDM or volume EDM, consists of an electrode and workpiece submerged in an insulating liquid such as more typical oil or less frequently, other dielectric fluids (Jameson 2001). The electrode and workpiece are connected to a suitable power supply. The power supply generates an electrical potential between the two parts. As the electrode approaches the workpiece, dielectric breakdown occurs in the fluid, forming a plasma channel (Descoeudres 2006, Dibitonto, Eubank, Patel, Barrufet (2009) and a small spark jumps. These sparks usually strike one at a time (Jameson 2001) because it is very unlikely that different locations in the inter-electrode space have the identical local electrical characteristics which would enable a spark to occur simultaneously in all such locations. These sparks happen in huge numbers at seemingly random locations between the electrode and the workpiece. As the base metal eroded and the spark gap subsequently increased the electrode is lowered automatically by the machine so that the process can continue uninterrupted. Several hundred thousand sparks occur per second with the actual duty cycle carefully controlled by the set-up parameters. This phenomenon is typified in lesson plan and driven by analogical reasoning instructional approach which was employed in delivering NMPIM. Non-conventional machining techniques also include, Water Jet machining (WJM), Abrasive Jet machining (AJM).

Concept of Achievement

Achievement connotes final accomplishment of something noteworthy, after much effort and often in spite of obstacles and discouragements. Indeed, Achievement tests do not reveal inborn abilities but the skills a person acquired up to a point (Shenk, 2011). An achievement test is designed to measure a person's level of skill, accomplishment, or knowledge in a specific area.

An achievement test is a developed skill or knowledge. The most common type of achievement test is a standardized test developed to measure skills and knowledge learned in a given level, usually through planned instruction such as training or classroom instruction (Robert & Dennis, 2007). Better teaching practices are expected to increase the amount learned in a school year and therefore increase achievement scores and yield more proficient students than before (James, 2012). Achievement test, therefore is any test that measures the attainments and accomplishment of an individual after a period of training or learning (Downie, 2014).

Nworgu (2004) in Chime (2012), posited that achievement testing involves the determination of the degree of attainment of individuals on tasks, courses or programmes to which the individuals were sufficiently exposed. For instance, the role of Career and Technical Education (CTE) as a major source of skilled workers for the American economy and a vital component of American education is well established. Several recent studies show that when CTE programs combine rigorous academic standards and industry-based technical content, the result is higher academic achievement and better economic outcomes for an increasing number of high school students (Wilkin & Nwoke, 2011).

Collins English Dictionary – Hanks, and Urdang (2014), however summarised achievement test as a test designed to measure the effects that learning and teaching have on individuals.

Some examples of achievement test include.

i. A Mathematics examination covering the latest chapter in work book
ii. A skill demonstration in technical trade amongst others

Each of these tests is designed to assess how much one knows at a specific point in time about a certain topic. Achievement test are not used to determine what one is capable of; they are designed to evaluate what one knows and ones level of skill at the given moment. Hence its application in determining the performance of the students prior to the commencement of the treatment and after treatment; as well as the level of retention two weeks after the posttest.

Concept of Retention

Retention is a preservation of the after effects of experience and learning that makes recall or recognition possible. It is equally persistence of learned behavior or experience during a period when it is not being performed or practiced. Retention is the second stage of memory after encoding and before retrieval (Bakkour, 2011). Tinto (2007) introduced the importance of student integration (socially and academically) in the prediction of student's retention. Tinto (2007) suggested that retention is related to the students' ability and actions to become an involved actor in organized institutional platform.

Retention in respect of this study is classified as retention within the course. This remains the smallest unit of analysis of retention when compared with institutional, system and retention within a major discipline. The analysis is measured by course completion as well as specific determination of percentage retention relative to the performance in the achievement test. Retention is one of the most common ways students, parents, and stake holders evaluate the effectiveness of teaching/learning outcome (Mc Mahon, 2000). Positive learning outcome is measured by the learner's ability to retain what has been impacted and apply them in real life situations. This accounts for the use of the retention test, two weeks after the post treatment test was administered to measure the level of the students' ability to recollect what they were taught a fortnight before then. The retention test items were reshuffled with the colour of the paper changed in order to control testing effect.

Principle of Arc Length

Arc length also called arc gap, is the distance between the part that has to be welded and the electrode tip. The arc length depends on the arc stability, the weld current and the concentricity of the part. The task of the operator is to keep the electrode at a certain distance from the surface so that there is enough place to avoid stubbing out (longevity, 2014). Arc length in a typical arc welding process varies between 2.5 – 5mm while in the EDM process; it is the thickness of a normal human hair (i.e microns).

Concept of Plasma Arc Welding (PAW):

Plasma arc-welding is an arc welding process wherein coalescence is produced by the heat obtained from a constricted arc set up between a tungsten/ alloy tungsten electrode and the water cooled (constricting) nozzle (non transferred arc or between a tungsten/alloy tungsten electrode and the job/workpiece – transferred arc). The process employs two inert gases, one forms the arc plasma and the second shields the arc plasma. Filler metal may or may not be added (Khurmi and Gupta, 2012).

The plasma exits the orifice at high velocity (approaching the speed of sound) and a temperature approaching 28,000^{0}c (50,000 ºF) or higher. This is against about 5,500ºc of the temperature obtainable in ordinary electric arc welding. Similarly, when used for cutting, the plasma gas flow is increased so that the deeply penetrating plasma jet cuts through the material and molten material is removed as cutting dross (American welding society 2015). Generally speaking, plasma is the fourth state of matter, many places teach that there are three states of matter solid, liquid and gas, but there are actually four. The fourth is plasma. To put it very simply and succinctly, a plasma is an ionized gas, a gas into which sufficient energy is provided to free electrons from atoms or molecules and to allow both species, ions and electrons, to coexist. The funny thing about that is that as far as we know, plasmas are the most common state of matter in the universe. They are even common here on earth.

Plasma is a gas that has been energized to the point that some of the electrons break free from, but travel with their nucleus. Gases can become plasmas in several ways but all include pumping the gas with energy. A spark in a gas will create plasma. A hot gas passing through a big spark will turn the gas stream into a plasma that can be useful. Plasma torches like that are used in industry to cut metals. The biggest chunk of plasma you will see is from the sun. The sun's enormous heat, rips electrons off the hydrogen and helium molecules that make up the sun. Essentially, the sun like most stars is a great big ball of plasma (Brian 2015). This phenomenon is applied in the non-conventional machining process to provide a rare gas region around the machining region to avoid oxidation, thereby generating a perfect surface finish of the metals. The simplest form of this is the argon welding equipment which is part of the concern of this study.

Research Design

This study adopted quasi-experimental design. It is the most powerful and valid design which can be used to identify confidently the cause of any given effect (Nworgu, 1991) in Idoko (2011). In this design the researcher manipulated certain variables employing certain controlled conditions with a view to producing determined effects on other variables. In this design too, with the manipulation of one or more independent variable(s), ensuring controls of extraneous variables, the effect on the dependent variables was observed.

The specific design for this study is non-equivalent pretest-posttest non randomized parallel group design. In this design, two equated groups-one experimental and the other control were created. The subjects were not randomly assigned to the two groups. In effect, intact classes were used, one intact class as experimental, the other intact class as control group. The design is represented mathematically as hereunder:

P_1 X P_2 (Experimental group)

P_1 (X) P_2 (control group)

Where P_1 = Pre–treatment observation

X = treatment for experimental group with non-conventional machining Principles

(X) = treatment for control group with conventional machining principles.

P_2 = post treatment observation for both groups (Idoko, 2011)

After creating the two groups, both groups were pre- tested with (NMPIM) achievement test. Subsequently, the experimental group was treated with the Non-conventional Machining principles lesson plan over a period of times (six weeks).

At the same time the control group was treated with the conventional machining principles as reflected in its own lesson plans for the same period (six weeks). At the end of the treatment, both the experimental group and the control group were administered with the NMPIM achievement test. The effect of the treatment was then determined by comparing the pretest scores with the post-test scores in both groups.

This study was conducted in Government Technical Colleges in Enugu State, Nigeria. Enugu State is located in the South Eastern part of Nigeria. Enugu state is bounded in the East by Ebonyi state, in the West by Anambra state, in the South by Imo and Abia states, in the North by Kogi and Benue states. Enugu state is located within tropical rain forest of Nigeria. Enugu State has 17 local government areas. The local government areas are delineated into six Education Zones. The education zones in Enugu State are: Agbani, Awgu, Enugu, Nsukka, Obollo-Afor and Udi zones. The Government Technical College Enugu chosen for the experimental group is located within latitudes 5.917^0 and 7.167^0 North and longitudes 6.917^0 and 7.917^0 East. Colliery Comprehensive Technical College Ngwo chosen for the control group is located within latitudes 5.428^0 and 6.428^0 North and 6.454^0 and 7.454^0 East.

There are 30 Technical and Vocational Colleges spread across the various education zones of Enugu State. The technical and vocational colleges in the education zones in Enugu State were obtained from Enugu State Science, Technical and Vocational Schools Management Board (ESVTMB).

Most of these colleges are without adequate equipment. However, Enugu Education Zone houses two technical and vocational colleges that are fairly equipped; though with the traditional equipment. This class of equipment in the two colleges within Enugu Education Zone far surpasses the machines in all other technical and vocational colleges put together. The technical colleges are Government Technical College, Enugu and Colliery Comprehensive Technical College, Ngwo. Both technical colleges are accredited by National Board for Technical Education (NBTE). This informed the choice of the researcher to use those two technical colleges as representatives of the rest technical colleges.

The study was conducted in all the 30 states government owned Technical Colleges in Enugu State, Nigeria. The population for the study consisted of all the year two craft machining students in the institutions. The total population was 1761. (source: Enugu State Science, Technical and Vocational schools Management Board – ESTVMB).

Sample and Sampling Technique

The sample size for the study was 121 students from the colleges running the trade- Machining. The numbers of the year two students in these schools were, 85 for Government Technical College, Enugu and 36 for Colliery Comprehensive Technical College, Ngwo. Purposive sampling technique was adopted because the relevant elements to the study were year two machining students. Out of the 30 Government Technical Colleges in Enugu State only two were offering the machining trade. The two were purposively chosen. The two were Government Technical College, Enugu and Colliery Comprehensive Technical College, Ngwo. Out of 85 year two machining students from Government Technical college, Enugu, 83 were males while two were females. Similarly, of the 36 year two machining students from Colliery Comprehensive Technical College, Ngwo, 35 were males while one was a female. The total number of male students involved in the study was (83 + 35) = 118, while the total number of female students involved in the study was (2 + 1) = 3.

Instrument for data Collection

The instrument for data collection was the Non-conventional Machining Principles Instruction Model (NMPIM) achievement and retention tests. It was used for data collection. The instrument was used to collect the pretest and posttest achievement and retention scores of the year two craft Machining students in the colleges. The instrument was developed by the researcher using a table of specifications in line with the six lesson plans and the educational objectives – comprehension, application, analysis and synthesis. However prior to that, the researcher generated 50 - item objective questions with options A – E covering the instructional plan.

NMPIM achievement tests were reshuffled and administered to the subjects (experimental and control groups). The achievement test scores constituted the posttest. Two weeks after administering the posttest, the NMPIM achievement test was further reshuffled and printed in a different colour of paper. It was administered on experimental and control groups. The scores obtained were recorded as retention scores.

Experimental Procedure

This was done under the following:

(a) Pretesting

(b) Treatment –

i. Experimental group, treated with non-conventional machining principles instructional model package.

ii. Control group, treated with conventional machining principles instruction model package.

(c) Post-testing

(d) Retention

(a) Pretesting: The pretreatment observation was the pretest. The NMPIM achievement test was administered on both the Experimental and Control groups. Their scores were recorded but not disclosed to the students.

(b) Treatment:

i. The treatment which manipulated the experimental group was the lesson plan on the non-conventional machining Instructional model package.

ii. The treatment which manipulated the control group was the lesson plan on the conventional machining principles instructional model package.

These provided a platform for the post treatment observation which was the posttest.

(c.) Post-testing: After the six weeks treatment of both groups appropriately, The NMPIM achievement test was reshuffled and administered on both groups. Their scores were recorded but not disclosed to the students.

(d) Retention: After two weeks of the posttest, the same NMPIM achievement retention test was reshuffled and printed on a different colour of paper and administered on the students. The scores were recorded. At this point, the scores could be disclosed to the students. Each of the observations for the experimental group was compared with the corresponding observations from the control group with the overall effect deduced. Therefore, the research design is non-equivalent because the subjects were not paired and non-randomized because intact classes were used.

Experimental Design Model

Group	***Treatment***		
	Pretest	**Posttest**	**Retention Test**

Experimental	Measure of level non conventional machining compliant (pretest – P_1)	After treatment with NMPIM X Posttest –P_2)	Two weeks after posttest measure of level of non-conventional compliant.
Control	Measure of level of non conventional machining compliant (Pretest –P_1)	Treatment with Conventional machining principles instruction model CMPIM (X)- (Posttest- P_2)	Two weeks after posttest measure of level of non-conventional compliant.
	Treatment Effect = {P_1 x P_2) – (P_1 (x) P_2)}		

Training of Research Assistants:

In order to avoid bias and apprehension by the students, four teachers, two from each college, teaching year two craft machining students were trained and used as research assistants. A two- week long training programme was carried out for the four teachers. The training covered arc welding equipment and functions, arc welding principles and processes, techniques of arc striking and jobbing sparking and scratching, safety precautions against toxic substances/surface preparation, heat generation for arc welding and application of the non- conventional machining principles like the EDM, AJM, WJM, Plasma arc welding etc. The emphasis of the training was on the adaptation of the arc welding principles in the non-conventional machining processes. However, the control group had to run her normal term's scheme with the conventional machining principles instructions (CMPIM). The teachers in the course of the training were conscientised on the objectives of the study. They were also seriously cautioned against any act such as Hawthorne and teacher effects that may give rise to interference or extraneous variables.

The lesson plan were discussed extensively with the trainees. The validated instrument which was used for collecting data for the pretest and posttest was also discussed. At the end of the training each of the teachers demonstrated the extent of assimilation of the package while the researcher did the evaluation.

Method of Data Collection

The data for the study were the pretest, posttest and retention scores from NMPIM achievement and retention tests. The pretest was the score of the subjects both in the experimental and control groups. The posttest on the other hand was obtained after the treatment of Experimental group with NMPIM and Control group with CMPIM. The posttest scores were for both experimental and control groups. These data were recorded. The scores were generated thus. All the NMPIM achievement test item questions bordering on the education objective of 'Application' were assigned two marks each while every other question attracted one mark each because the main thrust of the study is on the application of the principles.

Method of Data Analysis

The data collected were tallied and analyzed using mean and standard deviation. These analyses were used to answer the research question. While the hypothesis was tested using the Analysis of Covariance (ANCOVA). The test was at .05 level of significance.

Results

Research Question

What are the mean achievement and retention scores of year two craft machining students taught machining with NMPIM, - principle of arc length and those taught same with CMPIM?

Table 1 ***Mean and Standard Deviation of the Achievement and Retention Scores – Principle of arc Length***

Group	N	Pretest		Posttest		Retention	
		Mean	SD	Mean	SD	Mean	SD
Experimental	85	3.36	1.2944	7.53	0.9075	7.22	1.0279
Control	36	3.28	1.2786	3.28	1.2786	3.28	1.2786

From table 1– above the pretest mean score for the experimental group was 3.36 while for the control group it was 3.28. These mean scores showed that before the treatment of the experimental group with NMPIM, the groups were almost at par in terms of ability. The standard deviation of 1.2944 and 1.2786 for experimental and control groups indicate homogeneity in the spread of the scores achieved by the subjects of both groups. For the posttest scores, the experimental group had a mean of 7.53 while the control group had 3.28 these scores indicate that the experimental group achieved higher scores than the control group. This is an indication that higher achievement had taken place with the subjects in the experimental group. The control group however remained consistent in the scores achieved by the subjects in the group. The standard deviation for the experimental group was 0.9075. This indicates further homogeneity which means there are little or no extreme scores. Similarly, the standard deviation of 1.2786 for the control group which was consistent with that recorded for pretest scores indicates no changes in the dispersion of the scores of the subjects in the control group.

Further, the mean retention score for the experimental group was 7.22 with a standard deviation of 1.0279. The mean retention scores of the control group was 3.28 while the standard deviation stood at 1.2786. The high mean scores of 7.22 recorded by the subjects of the experimental group relative to the posttest scores mean of 7.53 indicates that they retained virtually what they were taught. The standard deviation of 1.2786 which is slightly above a unit shows there are little or no extreme scores. The control group Pretest, Posttest and Retention mean scores (3.28, 3.28, and 3.28) respectively with their corresponding standard deviations of 1.2786, 1.2786 and 1.2786 showed that appreciable learning did not take place in respect of their performance in the NMPIM.

Null Hypothesis (Ho_1)

There is no significant difference in the mean achievement and retention scores of the year two Machining students taught Machining with NMPIM – Principle of arc length and those taught same with conventional method.

Table 2 - ANCOVA analysis of the students' achievement (pretest) scores.

Principle of Arc Length – Pretest:

Table 2 – ANCOVA Analysis of the Students' Achievement of Pretest Scores.

Source of Variance	*D_f*	*Sum of Squares*	*Mean Squares*	*F_{cal}*	*F_{crit}*	*Significance*
Between Group	1	0.66	0.66			
Within Group	120	66.5	0.56	1.18	3.92	NS
Total	121	67.31				

Decision:$F_{critical}$ of 3.92 is greater than f_{cal} of 1.18 therefore we do not reject the Null hypothesis. This means that significant differences do not exist in the mean achievement scores of the year two machining students taught machining with NMPIM – Principle of arc length and those taught same with conventional method before the commencement of the experiment.

Posttest:

Table 3 - ANCOVA Analysis of the Students' Achievement of Posttest Scores.

Source of Variance	D_f	*Sum of Squares*	*Mean Squares*	F_{cal}	F_{crit}	*Significance*
Between Group	1	71.31	71.31			
Within Group	120	4.51	0.0376	1896.5426	3.92	S
Total	121	75.82				

Decision:

F_{crit} 3.92 is less than F_{cal} of 1896.5426 therefore we reject the null hypothesis. This means that significant differences existed in the mean achievement and retention scores of year two machining students taught machining with NMPIM – Principle of arc length and those taught same with conventional method.

Retention:

Table 4– ANCOVA Analysis of the Students' Retention Scores.

Source of Variance	D_f	*Sum of Squares*	*Mean Squares*	F_{cal}	F_{crit}	*Significance*
Between Group	1	47.02	47.02			
Within Group	120	24.29	0.2024	232.3123	3.92	S
Total	121	71.31				

Decision:

F_{crit} of 3.92 is less than f_{cal} of 232.3123; therefore, we reject the null hypothesis. This means that significant differences existed in the mean retention scores of year two machining students taught machining with NMPIM – Principle of arc length and those taught same with conventional method.

Discussion of Findings:

The findings of this study were discussed in line with the, research question and hypothesis.

Effect of NMPIM on Principle of Arc Length vis – a – vis Students' Achievement and Retention:

The research question sought to find out the mean achievement and retention scores of year two machining students taught Machining with NMPIM–Principle of arc length compared with those taught same with conventional method.

The pretest scores were not significantly different in respect of the achievements of the experimental and control groups. This showed they were of equal ability. However, the experimental group achieved higher mean(s) in the posttest and retention scores.

This is an indication that higher achievement took place with the experimental group. The standard deviations for the pretest, posttest and retention scores in the experimental and control groups hovered around unity. This indicated that there were no extreme scores whereby a few students achieved the score while the poor ones thrilled behind. The groups were near balanced but for the treatment made to the experimental group. This accounts for the significant difference in the mean achievement and retention scores at .05 level of significance. It is shown in the tables 1, 2, 3,&.4. This particular finding corroborates the position of (Mc Mahon 2000) who held that retention is one of the most common ways students, parents and stakeholders evaluate the effectiveness of teaching – learning outcome. Considering, the high temperature associated with the non-conventional machining techniques, this finding aligns with the dictum of (Gentner, Holyoak and Kokinov, 2001) indicating that the central aim of the theory of analogy is to characterize the selection process with emphasis on goal relevance. In effect, of all the arc lengths involved in diverse shielded welding processes, the thickness of a normal human hair to optimize the relevance of the Electrical Discharge Machine (EDM) as a foremost non-conventional machining technique could be taught. Therefore, this instructional model is worthwhile adopting for the teaching of non-conventional machining principle of arc length because it will enhance metal removal rate.

Ho_1 – There is no significant difference in the mean achievement and retention scores of the year two craft machining students taught Machining with NMPIM – Principle of arc length and those taught same with CMPIM.

The ANCOVA analysis result for pretest, posttest and retention scores are shown in tables 2, 3 & 4 respectively. The decision rule was that whenever the calculated value of F exceeded the critical value of F, the researcher rejects the null hypothesis. Whereas when the F-calculated value is less than the F-Critical value the researcher does not reject the null hypothesis. Since the calculated value of F is less than the critical value of F, therefore we do not reject the null hypothesis. This implies that there are no significant differences in the mean achievement and retention scores of the year two machining students taught machining with NMPIM-Principle of arc length compared with those taught same with CMPIM prior to the commencement of the treatment. After the treatment the posttest and retention scores ANCOVA analysis yielded F-calculated values higher than the critical value of F. In both cases, the F-Calculated exceeded the F-critical value. Therefore, in line with the decision rule, we reject the null hypothesis. This implies that significant differences existed in the mean achievement and retention scores of year two craft machining students taught machining with NMPI- Principle of arc length and those taught with CMPIM. This agrees with the position of Khurmi and Guputa, (2012) as well as the position of Todd, Allen and Alting (2012).4

Conclusion

From the findings of this study, the following conclusions were drawn: -

The year two craft machining students taught Machining using the NMPIM obtained higher achievement than those taught same with CMPIM. The year two craft machining students taught machining with the NMPIM retained more than those taught same with CMPIM, principle of arc length. This provided better understanding of the non-conventional machining techniques which is currently in vogue in the machine tool industry.

The gender of an individual is not a barrier to intellectual achievement and retention (Kamala, 2000) because both male and female were at par in their mean achievement and retention scores. The null hypothesis was not rejected, indication that gender is immaterial in one's intellectual achievements.

Recommendation

From the findings of this study, the researcher recommended as here under:

1. It was recommended that the TVET curriculum in Enugu State, Nigeria should be reviewed in line with the current technological realities with provision for 21st century equipment and training materials.
2. The 21st century employers of labour (manufacturers) should be appointed as technical colleges' board members so they could advice the management on the current emerging technologies and possibly donate the state-of-the-art equipment to the colleges

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