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RESEARCH ARTICLE

Effect of Non-Conventional Machining Instruction for Surface Preparations on Students' Achievement and Retention by Mechanical Craft Students in Technical Colleges in Enugu State

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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 surface preparation. The effect of NMPIM and the conventional method were studied. The problem of the study was encapsulated in the dictum of John Dewey - if we teach today as we taught yesterday, we rob our children of their tomorrow and a Hebrew proverb – do not confine your children to your own learning for they were born in another time. One research question and one 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. 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. The research question was answered using Mean, 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 all the principle of surface preparation, compared with those who were taught with the conventional method. 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. 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 Instruction; Surface Preparations on Students' Achievement and Retention; Mechanical Craft Students*

1. 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. Technical and Vocational Education and Training (TVET) in Enugu State is having many challenges, some of which are low enrolment, infrastructural decay, inadequate as well as inappropriate equipment and training materials. Other of their 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 (NPE, 2013). These challenges need to be addressed to enable technical colleges to achieve their desired objectives.

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 (NPE 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 processes which involve the application of Physics, Chemistry and Metallurgy are indispensable for the training of technical college students.

Furthermore, Obanya (2004), Igwe, Puyate, Onoh and Eze (2012) and Svarovsky, Moses and Ingham (2006) as well as the National Policy on Education (NPE, 2013), recognize the need for improved productivity. 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 Technical and Vocational Education and allied Sciences would be modern technology compliant.

Situations whereby out-modeled/out-dated equipment are still being employed as training aid to the students indicate that the products of such training are still in the woods 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. In conventional machining process the ability of the cutting tool is utilized 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 utilizes 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. Such energy utilized 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. Modern equipment are many like, 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 & McGeough, 2006).

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.

Therefore, a new group of non-conventional machining techniques emerged to provide improved, convenient, and economically advantageous means for specific types of production. These were based on latest scientific and technical achievements and some new findings using laws of nature relating to light-lasers, sound-ultrasonic processes, magnetism, atomic physics-plasma, electricity -electrolysis, electronics and new powder metallurgy materials (Krar & Gill, 2003). Some of the non-conventional machining techniques include:

a. Electrochemical machining (ECM)
b. Electrochemical grinding (ECG)
c. Electrical discharge machining (EDM)
d. Wire electrical discharge (WEDM)
e. Electron-beam machining (EBM) Electron-beam (plasma) machining (EBM)
f. Water-jet machining (WJM) using Air, sand or beads eg. sand blasting.
g. Abrasive-water jet machining (AWJM)
h. Ultrasonic machining (UM) and deburring processes.
i. 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.

Surface preparation for any machining activity is accomplished prior to the operation and sometimes post operation employing the principles of wire brushing. The principles of wire brushing applied in arc welding for instance, can be said to be at micro scale. Whereas the non-conventional machining processes of Abrasive-water jet machining, Abrasive-Air, beads jet, machining, sandblasting, water-jet machining employ the same principle in a massively large scale.

For instance, the painting of buildings, various structures that take so long can be prepared employing Abrasive, air or sand blasting for surface preparations within few hours.

In order to ensure proper fusion devoid of impurities, surface preparations using wire brush is very necessary in conventional/traditional processes. This surface preparation operation in the traditional process, has been advanced into a full industrial operation for non-conventional machining techniques. This surface preparation process is achieved, manually or using a hand machining approach in traditional operations. In non-conventional machining, various cleaning media are in use. For example, sand, air, water jet, beads jets, streamer jet, etc. Sandblasting, for instance is used in a high-pressure compressor fitted with pressure hose through which the mixture of compressed air and sand are released against a large surface area for cleaning. The control is regulated by an outlet valve. The same process is applicable in Water jet machining process (WJM), Air jet machining (AJM), etc.

Similarly, for the Water Jet machining the streamer theory creates a platform for the students to understand the techniques by conjecture. However, a clearer picture holds for Abrasive Jet Machining (AJM). This technique is typical of sandblasting and finishing which is a Cathodic Protective device for technical components exposed to atmospheric corrosive attack. It is also employed for aesthetic finishing of technical components especially when they are massive beyond the application of prescribed hand tools.

A demonstrative instructional approach could be adopted because the abrasive action of the sharp sand for the washing of kitchen utensils and other domestic items speaks eloquently. By extrapolation in the case of sand blasting a volume of air is compressed under a very high pressure. This compressed air is released under pressure through an engine powered compressor and air - sand mixture impinges on the metallic surfaces to clean all unwanted spots and surfaces. This action is in line with the phenomenon of the Avalanche dynamics. This concept will drive home the instruction on Abrasive air jet machining. After the Abrasive air- sand Jet, Abrasive water Jet machining (AWJM) is then applied which cleans the entire surfaces very neatly. Thereby preparing the surfaces for the final finishing where adhesive of desired coating pigment is applied. With such elaborate surface preparation, the surface absorption capacity is tremendously enhanced and would be reliably measurable using appropriate measuring instrument.

Metal surface is covered with oxides films and loose particles which are able to prevent adequate penetration during fusion joining or bonding. The strength and durability of metallic parts is a function of surface preparation and this may be done through various methods depending upon the surface locations. Some of these methods include, blast cleaning, flame cleaning, wet (Abrasive) blast cleaning, acid pickling. All these are commercial metal cleaning methods.

For the day-to-day welding operations, wire brushing as a surface preparation technique may suffice. For non-conventional machining processes that would meet surface preparation grade of ISO 8501/ 8502 (Geneva, 2008) and commercial demand blast, flame and acid pickling cleaning are unparalleled.

Every welding or machining activity entails one surface preparation procedure or the other. Preparation of surface before joining is a critical operation in ensuring the integrity of a joint / surface (TWI, 2017). For the purpose of this study, the abrasive cleaning surface preparation technique was adopted in the form of Abrasive Jet Machining (AJM), Water Jet Machining (WJM) and Abrasive Sand or Bead Machining (ASM or ABM) with a model for demonstration. Each of these will make the surface free of oil, grease, mill scale, rust and foreign matters when viewed under magnifying lens.

Upon this background, the need arose to determine the effect of non-conventional machining principles Instruction on students' achievement and retention in respect of surface preparations in machine shops in government technical colleges in Enugu State. Surface preparation is a vital process in pre-work as well as finishing of works pieces.

Statement of the Problem

The quality of the training inculcated in the students translates to the quality of man power that would be injected to the industry. In addition, the mandate of providing entrepreneurial, technical, and vocational job-specific skills for self-reliance and for agricultural, industrial, commercial as well as economic development rests more on this level of workforce. One of the learning outcomes expected of the graduates of technical colleges is the ability to set up their own businesses and become self-employed and be able to employ others after graduation. On the part of the colleges, the National Policy on Education provides that every technical college shall establish and operate a production unit for on-the-job training of students and for commercial activities to sustain college operations (NPE, 2013).

Research findings from various researchers 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 of the challenges of TVET in Nigeria are inadequate equipment and training materials coupled with the dearth of qualified and competent teachers (NPE, 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 (NPE, 2013).

Researchers like Boboulos,(2011) posits that presently the technical/vocational institutions are still grappling with the pre-1940 and 1800 equipment and machineries for the training of the students in developing countries. These classes of equipment and machineries will not be able to stand the test of the 21st century as provided by the national policy on education.

This accounts for the need to gradually begin addressing the 21st century compliant curriculum for the students. If the mind set of these leaders of tomorrow are not tailored towards the 21st century equipment and machineries, they may still relapse in the out modeled types. The relevant authorities incharge of education sub-sector need to be reminded of the urgent need to re-engineer the technical/vocational education and training (TVET) sector. It is believed that these challenges of the Technical, 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 (NPE, 2013).

Purpose of the Study

The main purpose of this study was to determine the effect of non-conventional machining Principles of surface preparations on Students' Achievement and Retention in machine shops on year two Machining students of Government Technical colleges in Enugu State. This study specifically aims to:

"Determine the mean achievement and retention scores of year two machining students taught machining with Non-Machining Principles Instruction Model NMPIM, - principle of surface preparations and those taught same with conventional method."

Research Question

What are the mean achievement and retention scores of year two machining students taught machining with Non-Conventional Machining Principles Instruction Model NMPIM, - principle of surface preparations in the experimental and control groups?

Hypothesis

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

H_o: There is no significant difference in the mean achievement and retention scores of year two machining students taught machining with NMPIM,- principle of surface preparations and those taught same with conventional method.

2. Method

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 Process.

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

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 plans 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 posttest scores in both groups.

Area of the Study

This study was conducted amongst the Government Technical Colleges in Enugu State. Enugu State is located in the South Eastern part of Nigeria. Enugu state is bounded in the East by Ebonyi and Abia states, in the West by Anambra state, in the South by Imo state and in the North by Kogi and Benue states. Enugu state lies within latitude 6.5364 N and longitude 7.4356 E. Enugu State has 17 local government areas. The local government areas are delineated into six Education Zones. The education zones in Enugu State were: Agbani, Awgu, Enugu, Nsukka, Obollo-Afor and Udi zones.

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

Most of these colleges were without adequate equipment. However, Enugu Education Zone houses two foremost technical and vocational colleges that are fairly equipped; though with the traditional equipment. The technical colleges are Government Technical College, Enugu and Colliery Comprehensive College, Ngwo. This informed the choice of the researcher to use those two technical colleges as representatives of the rest technical colleges.

Population for the Study

The study was conducted in all the Government Technical Colleges in Enugu State totaling 30 in number. The population for the study consisted of all the year two Machining students in these institutions, numbering 121 (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 number of the year two students in these schools were, 85 for Government Technical College, Enugu and 36 for Colliery Comprehensive 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 trade-Machining. The two were purposively chosen. The two were Government Technical College, Enugu and Colliery Comprehensive Technical College, Ngwo.

Instrument for Data Collection

The instrument for data collection was the Non-conventional Machining principles instruction model (NMPIM) achievement test. It was used for data collection. The instrument was used to collect the pretest and posttest achievement and retention scores of the year two Machining students in the colleges. The instrument was developed by the researcher using a table of specifications in line with the lesson plans coverage and the educational objectives. However, prior to that, the researcher generated 50-items objective questions with options a – e covering the instructional plans.

NMPIM achievement tests were reshuffled and administered to all the subjects (experimental and control groups). The scores constituted the post test. 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.

Item Analysis

The 50-item objective questions were subjected to item-by-item analysis employing item difficulty index, item distracter index and item discrimination index.

The 50-item objective questions were administered to year two Machining students of a different technical college from the ones selected for the study. The students were made to attempt the questions within their normal academic environment. They were not timed. The time taken by the first student to finish was recorded. Similarly, the time taken by the last student was also recorded. The average of the two times was found and became the time allotted to the test by pro-rata. After scoring the test for the students; the scores were arranged in descending order of performance. The test difficulty level was equally established using

$$\frac{\text{Mean Score}}{\text{Maximum Score}}$$

The upper and lower groups of scores were determined applying

$$\left(\frac{Nu + N_L}{N} \times \frac{100}{1}\right)\% \text{ or } \frac{U + L}{N} \times \frac{100}{1}$$

Where Nu = number in upper group of wrongly scored answers.
NL = number in lower group of wrongly scored answers
N = total number in both upper and lower groups.

The items in the range of the very easy ratio and very difficult ratio were weeded off. This led the researcher to arrive at a 30–item objective questions within a moderate limit with few distracters.

Validation of the Instrument

Face Validation:
The NMPIM achievement test was subjected to face validation by five experts; one from Technology and Vocational Education, Enugu State University of Science and Technology (ESUT). A second expert was from Mechanical Technology Education, Department of Industrial Technical Education, University of Nigeria, Nsukka. Three of the experts are from Science and Computer Education (measurement and evaluation), Enugu State University of Science and Technology (ESUT). The validates suggestions, remarks and recommendations were considered by the researcher and appropriate correction(s) and adjustments effected to ensure that the instrument was improved upon to measure what it was intended to measure.

Content Validation:
The same experts were requested by the researcher to validate the instrument in respect of content validity. This was presented in line with Education objectives along cognitive levels of knowledge, comprehension, application, analysis and synthesis assigned 5%, 20%, 45%, 15% and 15% respectively. The content dimensions included, surface preparations/safety precautions and applications of non-conventional machining principles assigned 18%, 15%, 15%, 15%, 18% and 19% respectively as contained in the table of specifications. The essence was to ensure the appropriateness of the instrument in taking representative questions from each of the unit (lesson plans) as well as the NMPIM achievement test possessed the desired outcome. In this study the educational objective laid emphasis on psychomotor and affective dormains (applications).

Reliability of the Instrument
The reliability of NMPIM achievement test was established through trial-testing of the validated instrument. The instrument as validated was administered on 20-year two Machining Trade students (intact class) of Government

Technical College, Abakaliki, Ebonyi State. The choice of Ebonyi state for the trial testing of the instrument was based on proximity and contiguity. There were a number of approaches for establishing the reliability, but the researcher adopted the Kuder-Richardson Formula (K-R 20) because it yields coefficients of internal consistency. It tended to eliminate the limitations inherent in the other methods as well as providing an average of all the coefficients that could result from each of the possible ways of splitting a test (Uzoagulu, 2011). The coefficient of K-R 20 yielded 0.98. This value is high enough for the use of the instrument to gather data for the study. Similarly, the test-retest method enabled the researcher to establish the stability of the instrument. Two weeks after administering the initial test to the 20 year two students of Machining Trade at Government Technical College, Abakaliki the same test was re-administered on the same students. Both scores were distinctly recorded. Two sets of scores were correlated using the Pearson Product moment correlation coefficient(r). The correlated coefficient would determine the level of stability of the items of instrument. From the computation of the Pearson Product moment correlation coefficient (r) using the raw score method, it yielded 0.87. Therefore, 0.87 was obtained as the coefficient of stability for the items of the instrument.

Experimental Procedure

This was done under the following:

(a) Pretesting

(b) Treatment – i. Experimental group, treated with non-conventional machining principles.
ii Control group, treated with conventional machining principles.

(c) Posttesting

(d) Retention

(a) Pretesting: The pre treatment 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 notes on the Non-conventional machining Instructional model.

ii. The treatment which manipulated the Control group was the lesson note on the conventional machining principles.

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

(c) Posttesting: 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 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 instruction CMI (X)-(Posttest- P_2)	Two weeks after posttest measure of level of non-conventional compliant.

Treatment Effect = $\{P_1 \times P_2) - (P_1 (x) P_2)\}$

Training of Research Assistants

In order to avoid bias and apprehension by the students; the teachers of the year two students in charge of Machining and Welding in both institutions were trained. A two- week long training programme was carried out for the four teachers the training covered surface preparations and application of the non- conventional machining principles like the EDM, AJM, WJM, etc. The emphasis of the training was on the adaptation of the non-conventional machining processes. However, the control group had to run her normal term's scheme with the conventional machining instructions (CMI). The teachers in the course of the training were conscientized on the objectives of the study. They were also seriously cautioned against any act that may give rise to interference or extraneous variables.

The lesson notes 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.

Conduct of the Experiment

After the training, the first lesson period was in line with the normal academic calendar because the scheme was in line with the students' study. The first exercise was to administer the NMPIM to the experimental group and control group. This constituted the pretest and was recorded accordingly. The outcome was not disclosed to the students.

The treatment commenced thereafter with the NMPIM lesson plans taught the experimental group. This treatment lasted for six weeks. At the end of the six weeks the NMPIM achievement test were reshuffled and administered to all the subjects (experimental and control groups). The scores constituted the post test. Two weeks after administering the posttest, the NMPIM achievement test items were 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.

Control of Extraneous Variables

A number of extraneous variables are associated with teaching and learning processes in educational research. The researcher made concerted efforts to control and manipulate the extraneous variables such that their effects on the overall experiment were eliminated or at least minimized. These extraneous variables if not controlled may introduce bias into the study.

i. **Non-Equivalent, Non-Randomization Effect.**
   The choice of intact classes for both experimental and control groups, to a great extent eliminated bias. The classes operated in the normal setting without necessarily selecting the subjects randomly in line with intelligence, age, height etc. Such initial differences were kept constant while the Analysis of co-variance (ANCOVA) statistical tool enabled the researcher to eliminate their effects.
ii. **Hawthorne Effect**
   Hawthorne effect has to do with the subjects slated for the study getting to know that they were being used for such study. This has the tendency of introducing bias and superficial behavior. To control this effect, it was not disclosed to the students that such study was being conducted. The lessons were taught during the normal school period. Their regular class teachers were used to deliver the lessons. The normal classrooms were used such that nothing unusual took place to suggest to students they were being used for the study.
iii. **Teacher Factor**
   Involving different teachers in teaching the experimental and control groups would introduce bias. If such was done the treatment effect might not be attributed to the treatment. In order to avert this, the regular classroom teachers were trained and used to do the teaching. The researcher prepared and produced the lesson notes and the achievement and retention tests. The researcher also did all the recordings of the scores to eliminate bias.
iv. **Testing Factor**
   The NMPIM achievement test if not carefully managed and handled could be too familiar to the subjects. Considering its administration for pretest, posttest and retention tests, it calls for control to eliminate

proliferation. In effect, after each administration, the items were reshuffled. After the posttest the items were not only reshuffled but had the colour of the paper changed. After each test, the questions were retrieved from the subjects. Their performances were also not made known to them until after the experiment. These measures eliminated the effects that could introduce bias in the study.

v. **Novelty Effects**

Novelty effect is attributable to the introduction of new instructional model, new teacher, even while maintaining the class room. However, in order to control these effects, the researcher ensured that the technical colleges used were the ones offering the Machining Trade for the study. The researcher also conducted the experiment using the year two Machining students class teachers within their normal classrooms and workshops.

vi. **Subject interaction**

Only two technical colleges are offering the Machining Craft Trade in Enugu State. The researcher chose the intact class in one as experimental group and the other as control group. In order to reduce the errors that may have arisen from the exchange of ideas amongst the subjects, none of the groups knew the other. To eliminate undue interaction within each group, the normal lesson setting within their classroom at the period prescribed by the school timetable with the regular teachers to handle the lessons were arranged. As a parallel group design, it eliminates subject interactions.

Method of Data Collection

The data for the study were the pretest, posttest and retention scores from NMPIM achievement 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 CMI. 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.

Method of Data Analysis

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

Mean

The researcher computed the mean of the pretest, posttest and retention scores. $X = \sum x/n$

Higher values of mean were indications of higher performance by the subjects. Whereas lower values indicated that the subjects were not at home with the non conventional machining techniques.

Standard Deviation

The researcher computed the standard deviations of the pretest, posttest and retention scores. The lower value of the standard deviation indicates homogeneity in the performance of the subjects. Whereas, higher values of standard deviations indicated heterogeneity of the subjects' performance which is not very healthy. The formula for standard deviation

$SD = \sum(X - X)^2$ Where X = raw scores

$\overline{X}$ = mean of the score

n = number of items in the instrument

$\sum$ = summation

Hypothesis

The researcher employed the Analysis of Covariance (ANCOVA) for the hypothesis testing. If the calculated value of 'f 'is less than the f-critical (at .05 level of significance) the hypothesis was not rejected. If the f- calculated is higher than the f-critical, the hypothesis was rejected.

3. Results

Research Question

What are the mean achievement and retention scores of year two machining students taught machining with NMPIM, - principle for surface preparations compared with those taught same with conventional method?

Table 1 – Mean achievement and retention scores of Year two machining students taught machining with NMPIM – Principle for surface preparations compared with those taught same with conventional method.

Group	*N*	*Pretest Mean*	*SD*	*Posttest Mean*	*SD*	*Retention Mean*	*SD*
Experimental	85	3.04	1.3016	7.55	1.0409	7.43	1.0960
Control	36	3.33	1.1711	3.39	1.0496	3.39	1.0496

From Table 1 above, there was a progressive increase in the mean achievement scores of the experimental group from 3.04, 7.55 and 7.43 for Pretest, Posttest and Retention respectively. The mean Pretest to Posttest achievements of 3.04 and 7.55 indicates that substantial learning took place. whereas from mean posttest score of 7.55 to mean Retention score of 7.43 showed that the subjects retained very highly two weeks after the Posttest was administered.

The mean Pretest score of 3.33 for the control group compared with mean Pretest score of 3.04 for the experimental group showed that both groups were almost at par at the beginning of the experiment. However, the Posttest mean of 3.39 and retention mean of 3.39 for the control group indicated that learning did not take place. None the less, the standard deviations in Pretest, Posttest and Retention values in both experimental and control groups hover around a unit. This is an indication of relative stability in the range of scores, without extreme poor performances or extreme super performances either way.

Principle for Surface Preparations:

Null Hypothesis (H_0)

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

Pretest:

$SS_T = 140.0000$

$SS_W = 139.71$

$SS_B = 0.29$

$$\frac{\frac{0.29}{1}}{\frac{139.71}{120}} = \frac{0.29}{1.1643} \Rightarrow F_{cal} = 0.25$$

$F_{crit} = 3.92$

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

Source of variance	*D_f*	*Sum of squares*	*Mean squares*	*F_{cal}*	*F_{crit}*	*Significance*
Between groups	1	0.29	0.29			
Within groups	120	139.71	1.643	0.25	3.92	NS
Total	121	140.00				

Decision:

The F_{crit} value of 3.92 is greater than the F_{cal} value of 0.25; therefore, we do not reject the null hypothesis. This means that there is no significant difference in the mean achievement scores of year two machining students taught machining with NMPIM – Principle for surface preparations and those taught same with conventional method; Prior to the treatment of the experimental group.

Post test:

$SS_T = 140.64$

$SS_W = 43.84$

$SS_B = 96.80$

$$\frac{\frac{96.80}{1}}{\frac{43.84}{120}} = \frac{96.80}{0.3653} \Rightarrow F_{cal} = 264.9877$$

$$F_{crit} = 3.92$$

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 groups	1	96.80	96.80			
Within groups	120	43.84	0.3653	264.9877	3.92	S
Total	121	140.64				

Decision:

F_{crit} value of 3.92 is less than F_{cal} of 264.9877 therefore we reject the null hypothesis. This means that it is significant at .05 level of significance. This significant difference exists in the mean achievement scores of year two machining students taught machining with NMPIM – Principle for surface preparations and those taught same with conventional method.

Retention:

$SS_T = 140.64$

$SS_W = 33.36$

$SS_B = 107.28$

$$\frac{\frac{107.28}{1}}{\frac{33.36}{120}} = \frac{107.28}{0.278} \Rightarrow F_{cal} = 385.8993$$

$$F_{crit} = 3.92$$

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 groups	1	107.28	107.28			
Within groups	120	33.36	0.278	385.8993	3.92	S
Total	121	140.64				

Decision:

F_{crit} value of 3.92 is less than F_{cal} value of 385.8993; therefore, we reject the null hypothesis. This means that at .05 level of significance, there is significant difference in the mean retention scores of year two machining students taught machining with NMPIM – Principle for surface preparations and those taught same with conventional method.

4. Discussion of Findings

Effect of NMPIM on the Principle for Surface Preparations

The research question sought to find out the mean achievement and retention scores of year two machining students taught Machining with NMPIM – Principle for surface preparations in the experimental and control groups. Table 1 - reflected a progressive increase in the mean achievement of the experimental group from pretest scores through the posttest to retention. This is an indication that substantial learning took place. These achievements no doubt are associated with the treatment given to the experimental group. The mean scores of the control group from the pretest through the posttest to the retention remained virtually flat. It indicates that learning did not take place.

The standard deviations in both cases were around unity thus indicating homogeneity in the scores. The learning acquired through the treatment which aligns with pragmatic analogical theory is in line with (Bakkour, 2011), that retention is the second stage of memory after encoding and before retrieval. This principle which is associated with the theory of avalanche will leverage the performances of the students taught with that principle such that when opportunities offer them a massively large surface for preparations they would easily utilize the powder snow avalanches and wet snow avalanches (Mc Clung & Shaerer, 2006) which are encapsulated in sandblasting and water blasting processes. This implies that while the students who did not receive the treatment in the event of being exposed to surface preparations of tremendously large magnitude go in search of wire brushes and perhaps emery cloths, their counterparts who received the treatment would simply explore sand/water jet blasting equipment. While the former goes on wasting man-hour and resources, the later within a very short moment delivers with accuracy and utmost dispatch (Mc Clung, 2006). A set of sand blasting equipment/machine specifically modeled as a teaching aid enhanced not only the comprehension but application of AJM, WJM, BJM employing the theories of avalanche and streamer discharge.

H_0: There is no significant difference in the mean achievement and retention scores of year two machining students taught Machining with NMPIM – Principle for surface preparations compared with those taught same with conventional method.
Tables 2, 3 and 4 show the ANCOVA analysis results for the F-calculated values of Pretest, Posttest and Retention scores respectively. The F-critical for each case is 3.92. The decision rule remains that if the F-calculated (F-cal) exceeded F-critical (F-crit) value, we reject the null hypothesis. In the case of pretest, F-cal value is less than F-critical value. Therefore, we do not reject hypothesis. However, the F-calculated values for posttest and retention was each greater than the F-critical value; therefore, we reject the null hypothesis. This implies that there are significant differences in the mean achievement and retention scores of year two machining students taught Machining with NMPIM – Principle for surface preparations compared with those taught same with conventional method.
This result/finding agrees with the position of (Mc Clung & Shaerer, 2006) in respect of Abrasive/water Jet machining AJM/WJM typified by sandblasting. Principle of surface preparations provided better understanding of the non-conventional machining techniques which is currently in vogue in the machine tool industry.

5. Recommendations

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

1. Emphasis should be placed on using the non-conventional machining techniques for teaching the students Machining Craft Practice.
2. Curriculum planners should also review the present Programme of Machining and Fitting craft practice which is currently dependent on out-moded machine tools, to reflect the current 21st century equipment - the non-conventional machines.
3. The researcher advocates for systematic in-service training of teachers of Machining in the technical colleges so that they will be able to keep abreast of the realities of our time in the ever-evolving technological development because one cannot give what he/she has not.

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