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Effect Of Unconventional Machining Instructions of Coolant Dispensation on Craft Students' Achievement and Retention In Machining Practice For Sustainable Development Goals 4 And 9, in Government Technical Colleges In Enugu State, Nigeria.

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ABSTRACT

The study is a quasi experimental research involving non-equivalent pretest posttest non randomized parallel group design. All traditional/conventional machining processes use one form of coolant or the other especially a mixture of water and soluble oil. This solution is a conductor of electricity. unconventional high temperature resistant coolants on the other hand are usually dielectric oils/fluid with very high flash point. Machining materials at a very high temperature capable of melting the workpiece but insulated from melting and electrocution by a dielectric fluid is one of the emerging technological principles of processing very hard materials. Therefore, a Unconventional Machining Instructions Model (UMIM) was constructed to teach the experimental group while the traditional/conventional model was used to teach the control group. A research question on how the achievement and retention test scores of Government Technical college students treated with UMIM especially the coolant fluid (dielectric fluid) principle compare with those treated with Conventional Machining Instructions (CMI), guided this study. A null hypothesis was also used to test the mean scores at .05 level of significance. The findings of the study showed that the mean achievement and retention scores of the experimental group were 2.93, 4.89 and 4.88 for pretest, posttest and

retention test scores respectively. The mean achievement and retention test scores of the control group were 2.97, 3.06 and 3.28 for pretest, posttest and retention scores respectively. From the scores, before the take off of the experiment both classes were almost equal in ability. However, the ability level changed with the treatment of the experimental group and it became manifest in the posttest and retention scores of 4.89 and 4.88 respectively for experimental group and 3.06 and 3.28 for the control group respectively. The standard deviations of the experimental group were 0.0778, 1.0011 and 0.9338 for pretest, posttest and retention scores respectively; whereas for the control group we had 0.9996, 0.9241 and 0.8819 for pretest, posttest and retention scores respectively. Each of the standard deviation scores are within unit which indicates there were no extreme case scores. The null hypothesis tested at .05 level of significance showed that there were significant difference in the mean achievement and retention scores of the students taught machining with UMIM in respect of Principle of coolant fluid (dielectric fluid) and those taught same with Conventional method. In conclusion, the Principle of coolant fluid (dielectric fluid) provided better understanding of unconventional Machining techniques at so high temperatures devoid of melting the workpiece rather offering insulating effects; in line with emerging technologies in Machine tool industries the application of the findings of this study will boost the realization of SDGs 4 and 9. The researcher recommended increased emphasis on innovations supported by systemic reform of technical, vocational and training Education policies and practices to incorporate the emerging technologies.

Keywords: Unconventional, Conventional/traditional, Machining, dielectric fluid, emerging technology

Introduction

Cutting edge technologies are currently available in the advanced technologies of the world. There is an urgent need for Nigeria to fast track her TVET. However, several constraints pose challenges; which 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 (FRN, 2013). Interestingly, The Sustainable Development Goal 4.3 as well as means of implementation of the SDG 4b and 4c address these challenges.

The continued use of outdated traditional machining techniques are largely responsible for the setbacks being experienced in technical colleges in Enugu State in particular and Nigeria in general (Mbachu, 2011). The conventional/traditional techniques of machining involve enormous mechanical force with the attendant residual heat process (McCathy & McGeough,2006). The processes call for coolant application. The coolant applicable in the conventional machining processes are sometimes water and additives of soluble oil, which can evaporate when exposed to high temperatures.

Unconventional machining processes take place at exceedingly very high temperatures. At such very high temperatures the relatively softer cutting tools retain their integrity. Special coolants are applied to make this seemingly impossible process realizable (Mbachu, 2011). An appropriate instructional model, is required to be able to impart the innovative knowledge desirable suitable for the technological attainment.

The unconventional machining techniques involve less mechanical forces but so high residual higher temperatures. The temperatures of heat produced by some of the unconventional systems are in the region of 6000^0c to 7000^0c (Khurmi & Gupta, 2012). For instance, the EDM is an exceedingly high temperature process. In EDM or Spark erosion as it is popularly called, the spark gap recommended is the thickness of human hair (Krar, 2009). A mixture of soluble oil and water is used for cooling tools in the traditional machining processes, while the dielectric fluid provides not only cooling effect but also flushing of debris, as well as providing the insulating medium between the electrode and the workpiece in typical Electrical Discharge machining (EDM) - spark erosion process.

Arc welding process is a high temperature process; just like most of the unconventional machining processes, for example EDM, LBM, EBM, powder metallurgy and plasma welding process. These principles and processes are very vital with very large application in various industrial settings. The relevance of these principles to the society is immeasurable. 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.

Similarly, soluble oil and water solution provides cooling in traditional machining processes. Dielectric fluid which not only provides cooling effect but serves as an insulator is employed in the unconventional machining technique of EDM. Coalescence of the fussing conducting metals take place at such high temperature ranging between $6000^{o}c$ – $8000^{o}c$ for arc welding process. The EDM operates in a temperature far higher than $8000^{o}c$ about $14000^{o}c$ – $21000^{o}c$, yet no fusion takes place. Rather a fine surface finish is realized and any metal, no matter how hard, could be machined at such temperatures for non-conventional machining techniques. On the other hand, in plasma welding process which is also a unconventional machining technique, fusion takes place at a temperature far higher than that of arc welding (between $12000^{o}c$ – $14000^{o}c$). Some coolants are more environment friendly than others.

Dielectric Fluid are more suitable for use in the Advanced (untraditional) machining processes this is because of some obvious qualities and the very high temperatures involved in the processes. For instance, dielectric fluids do not evaporate readily with very high flash point (ZAP, 2001)

Dielectric fluids come in the form of synthetic or petroleum products. However, the choice of dielectric fluid is guided by a parameter/specification of operations chart in respect of viscosity, flash point, fluid strength, evaporation rate, odor and colour. Standard charts are there for making choice vide – www.edmoils.com. The dielectric fluids is inevitable for the optimal performance of unconventional machining process.

Dielectric fluid flows through the gap between the electrodes providing a flushing as well as lubricating effects. This produces sparks between the electrodes which melt and sometimes vaporize material from both the tool and the workpiece. The spark energy density is usually very high, hence the electrode's material melts and vaporizes in the localized area. The cavity produced in the workpiece is approximately the replica of the tool (John, George & Nikolaos, 2013).

Most of the Unconventional machines perform optimally in terms of Metal Removal Rate and surface finish at very high temperatures without distorting the grain structure of the workpiece material. This is one of the concerns of this study.

Achievement test was conducted, following the UMIM. Achievement connotes final accomplishment of something noteworthy, after much effort and often in spite of obstacles and discouragements. The level of assimilation of the UMIM after treatment is a measure of achievement not inherent (Shenk, 2011). An achievement test is designed to measure a person's level of skill, accomplishment, or knowledge in a specific area.

The degree of the learned activities the learner was able to manifest is an indication of Retention. Retention contributes in behavioral change usually associated with learning. Where substantial learning has taken place, substantial knowledge suppose to have been acquired.

Sustainable Development Goals 4 has 10 targets encompassing many different aspects of Education. There are seven targets which are expected outcomes and three targets which are means of achieving these targets.

For instance, Goal 4.3 has as its Outcome target – equal access to technical/vocational and higher education which should be affordable and qualitative. Goal 4.b and 4.c also provide the means of implementation with a view to encouraging scholarships particularly in least developed countries and African countries in the field of technical, vocational and training (TVET) amongst others. This goal calls for substantial increase of the supply of qualified teachers by 2030 (UNESCO, 2021) .

Sustainable Development Goal 9 is to build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation. The United Nation defined 8 targets and 12 indicators for SDG 9. The targets specify the goals while the indicators represent the metrics by which the attainment or otherwise are measured. The targets range from , Development of sustainable, resilient and inclusive infrastructures, to Promotion of sustainable industrialization and manufacturing value.

TVET programmes are being employed in the developed and fast developing technologies towards realizing these targets by 2030. Enugu State and Nigeria cannot afford to be left behind.

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 class 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 (2013). Thus to achieve the targets of SDG 9 on industrialization and manufacturing TVET at all levels must be given a boost. The ability to determine the effects of unconventional machining instructions of coolant dispensation on students' achievement and retention in machining practice for sustainable development goals [SDGs] 4 and 9 actualisation in government technical colleges in Enugu State"? Unconventional Machining Instructional Model (UMIM) - principle of coolant fluid (dielectric fluid) and those taught same with conventional method.

Scope of the Study

This study was limited to the two foremost Government technical colleges in Enugu State where Machining Craft Practice trade is being offered. They are Government Technical College (GTC), Enugu and Colliery Comprehensive Technical College (CCTC), Ngwo. The students share common environments in terms of policies and supervision. The scheme of work and content coverage in Machining craft practice and related courses of study were obtained from the Enugu State Science, Vocational and Technical Colleges Management Board (ESVTMB).

Research Question

1. How do the mean achievement and retention scores of year two machining students taught machining with UMIM - coolant fluid (dielectric fluid) compare with those taught same with conventional method?

Hypothesis

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

Ho_1 There is no significant difference in the mean achievement and retention scores of year two machining students taught machining with UMIM - principle of coolant fluid (dielectric fluid) and those taught same with conventional method.

Methodology

The UMIM 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.

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. Preparations/safety precautions and applications of unconventional 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 UMIM achievement test possessed the desired outcome. In this study the educational objective laid emphasis on psychomotor and affective dormains (applications).

The reliability of UMIM 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.

Procedure that Guided the Experiment

It took the under listed order:-

(a) Test set from the UMIM was administered as Pretest.

(b) It was followed by Treatment – Experimental group was treated with unconventional machining instructions model (UMIM). Control group was treated with conventional machining instructions (CMI).

(c) After treatment, the Posttest of the UMIM was administered on both groups.

(d) Two weeks after the Posttest, the Retention test was administered on both groups.

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 UMIM 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 UMIM lesson plans taught the experimental group. This treatment lasted for six weeks. At the end of the six weeks the UMIM 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 UMIM 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.

Method of Data Collection

The data for the study were the pretest, posttest and retention scores from UMIM 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 UMIM 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 UMIM

achievement test item questions bordering on the education objective of 'Application' were assigned two marks each while every other questions 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. $X = \frac{\sum x}{n}$

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 unconventional 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 deviation indicated heterogeneity of the subjects performance which is not very healthy. The formula for standard deviation

$SD = \sqrt{\frac{\sum(X - \bar{X})^2}{n-1}}$ Where X = raw scores

$\bar{X}$ = 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.

Results

Research Question

How do the mean achievement and retention scores of year two machining students taught with UMIM-Principle of coolant fluid (dielectric fluid) compared with those taught same with conventional method?

Table: 1

Mean achievement and retention scores of year two machining students taught with UMIM-Principle of coolant fluid (dielectric fluid) compared with those taught same with conventional method.

GROUP	N	PRETEST		POSTTEST		RETENTION	
		Mean	SD	Mean	SD	Mean	SD
Experimental	85	2.93	0.0778	4.89	1.0011	4.88	0.9338
Control	36	2.97	0.9996	3.06	0.9241	3.28	0.8819

From table 1 above the mean achievement and retention scores of the experimental group were 2.93, 4.89 and 4.88 for pretest, posttest and retention scores respectively. These are relative to the mean achievement and retention of the control group, 2.97, 3.06 and 3.28 for pretest, posttest and retention scores respectively. Before the take off of the experiment both classes were almost equal in ability. However this ability level changed with the treatment of the experimental group and it became manifest in the posttest and retention means of 4.89 and 4.88 for experimental group with posttest and retention means of 3.06 and 3.28 for control group respectively. These results suggest that the experimental group achieved better in the knowledge of the principle of coolant fluid (dielectric fluid) which means there was learning by the experimental group.

The standard deviations of the experimental group were 0.0778, 1.0011 and 0.9338 for pretest, posttest and retention scores respectively. All of them are within a unit each and indicates little or no extreme scores. On the other hand, the standard deviations for the control group were 0.9996, 0.9241 and 0.8819 for pretest, posttest and retention scores respectively. Each of the deviations is less than a unit which indicates that there were no extreme scores.

Principle of Coolant Fluid

Null Hypothesis (H_0)

There is no significant difference in the mean achievement and retention scores of year two machining students taught machining with UMIM – Principle of coolant fluid (dielectric fluid) and those taught same with conventional method.

Pretest

$SS_T = 53.49$

$SS_W = 53.07$

$SS_B = 0.42$

$$\frac{\frac{0.42}{1}}{\frac{53.07}{120}} = \frac{0.42}{0.4423} \Rightarrow F_{cal} = 0.95$$

$F_{crit} = 3.92$

Table 2 - ANCOVA analysis of the students' Achievement of Pretest scores.

Sources of variance	D_f	Sum of squares	Mean squares	F_{cal}	F_{crit}	Significance
Between groups	1	0.42	0.42			
Within groups	120	53.07	0.4423	0.95	3.92	NS
Total	121	53.49				

Decision: From the above table, F_{crit} is 3.92 which is greater than Fcal which is 0.95 at 0.05 level of significance. Therefore, we do not reject the null hypothesis. This means that significant difference do not exist in the mean achievement scores of year two machining students taught machining with UMIM – Principle of coolant fluid (dielectric fluid) and those taught same with conventional method at the commencement of the experiment.

Posttest

$SS_T = 51.972$

$SS_W = 12.46$

$SS_B = 39.51$

$$\frac{\frac{39.51}{1}}{\frac{12.46}{120}} = \frac{39.51}{0.1038} \Rightarrow F_{cal} = 380.6358$$

$F_{crit} = 3.92$

Table 3 - ANCOVA analysis of the students Achievement of Posttest scores.

Sources of variance	D_f	Sum of squares	Mean squares	F_{cal}	F_{crit}	Significance
Between groups	1	39.51	39.51			

Within groups	120	12.46	0.1038	380.6358	3.92	S
Total	121	51.97				

Decision: The F_{crit} value of 3.92 is less than the F_{cal} value of 380.6358 at .05 level of significance. Therefore, we reject the null hypothesis. This means that significant difference exists in the mean achievement scores of year two machining students taught machining with UMIM – Principle of coolant fluid (Dielectric fluid) and those taught with conventional method.

Retention

$SS_T = 53.306$

$SS_W = 8.27$

$SS_B = 45.04$

$$\frac{\frac{45.04}{1}}{\frac{8.27}{120}} = \frac{45.04}{0.0689} \Rightarrow F_{cal} = 653.7010$$

$$F_{crit} = 3.92$$

Table 4 - ANCOVA analysis of the students' Retention scores.

Sources of variance	D_f	Sum of squares	Mean squares	F_{cal}	F_{crit}	Significance
Between groups	1	45.04	45.04			
Within groups	120	8.27	0.0689	653.7010	3.92	S
Total	121	53.31				

Decision: The F_{crit} value of 3.92 is less than the F_{cal} value of 653.7010 at .05 level of significance, therefore we reject the null hypothesis. This means that there is significant difference in the mean retention scores of year two machining students taught machining with the UMIM – Principle of coolant fluid (dielectric fluid) and those taught same with conventional method.

Summary of Finding

The mean achievement and retention scores for the principle of coolant fluid (dielectric fluid) of the experimental and control group indicate that this was a familiar terrain to both groups. However, the experimental group still had an edge over the control group. This is supported by the hypothesis testing which showed that significant differences exist in the mean achievement and

retention scores of year two machining students taught machining with UMIM- Principle of coolant fluid (dielectric fluid) and those taught with conventional method.

Effect of UMIM - Principle of Coolant fluid (dielectric fluid) on both the experimental and control groups.

The research question sought to know the mean and standard deviation achievement and retention scores of year two machining students taught Machining with UMIM - Principle of Coolant Fluid (dielectric fluid) compared with those taught same with conventional method.

Table 1 shows a progressive increase in the mean achievement scores for pretest, posttest and retention scores of the experimental group which showed significant learning took place. In the contrary, the near level amplitude of mean achievement for pretest, posttest and retention scores of the control group showed significant learning did not take place in respect of the UMIM.

For the standard deviations, all hovered about a unity which indicates homogeneity and no extreme performances. Rather the scores were obtained by the entire class not a few individual achievements at the extremes. This finding agrees with the assertion of Amina, (2014), Chime, (2012), and Wilkin & Nwoke, (2011), that improved achievement in a standard test is a function of learning. The import of the plasma shielded welding technique in producing super finish surfaces devoid of oxidation, enabled the students taught with UMIM to appreciate analogically the immeasurable role of dielectric fluid in non-conventional machining operations. This accounted for their better performance and higher achievements.

H_0 – There is no significant difference in the mean achievement and retention scores of year two machining students taught Machining with UMIM – Principle of coolant fluid (dielectric fluid) and those taught same with conventional method.

Tables 2, 3, and 4 show the ANCOVA analysis results for Pretest, Posttest and Retention scores respectively. For the pretest F-cal value is less than F-critical value. Therefore, we do not reject the null hypothesis. This implies learning had not taken place. Each of the F-calculated values for the posttest and retention scores exceeded the F-critical value. Therefore in line with the decision rule, we reject the null hypothesis. This implies that significant differences exist in the mean achievement and retention scores of year two machining students taught Machining with UMIM - Principle of coolant fluid (dielectric fluid) compared with those taught same with

conventional method. This finding supports the constructivism as a learning theory as amplified by Heinz (2002) in Rauner and Maclean (2008), Herbert (2001), Paul (2007) and Schutz & Pekrun (2007)...

Conclusion

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

The year two machining students taught Machining using the UMIM obtained higher achievement than those taught same with conventional method. The year two machining students taught machining with the UMIM retained more than those taught same with conventional method. The principle of coolant fluid (dielectric fluid) provided better understanding of the unconventional machining techniques which is currently in vogue in the machine tool industry.

Recommendations

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

1. Emphasis should be placed on using the unconventional machining techniques for teaching the students Machining Craft Practice especially the craft of dielectric coolant dispensation..
2. Curriculum planners should also review the present programme of Machining craft practice which is currently dependent on out- moded machine tools, to reflect the current 21st century equipment - the unconventional machines.
3. Increased emphasis on innovations supported by systemic reform of technical, vocational and training (TVET) Education policies and practices need to be aggressively addressed with a view to pursuing the realization of the Sustainable development goals 4 and 9 by the year 2030.

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