THE EFFECTS OF TEACHER CONSTRUCTED FURNACE ON STUDENTS' PERFORMANCE IN HEAT TREATMENT IN TECHNICAL COLLEGES IN RIVERS STATE, NIGERIA

Ogundu, Isaac, PhD
Amadi, Stephen W. PhD
Department of Technical Education
Ignatius Ajuru University of Education, Rumuolumeni, Port Harcourt
Igrubia, Victor
Isaac Jasper Boro College of Education,Sagbama Bayelsa State

Abstract

The purpose of this research was to determine the effect of an improvised furnace on students' performance in heat treatment in technical colleges in Rivers State. The study adopted research and development incorporating quasi-experimental design. It involved the use of control group, pre-test – post test design. The population of 194 students from four technical colleges in Rivers State was used for the study. The instrument for data collection was made up of Heat Treatment Achievement Test (HTAT) developed by the researchers. The achievement test consists of 50-multiple choice items with four options of A-D. The test items were identified and selected from the content of (NABTEB) syllabus on metal work technology. Test re-test method was used to establish the reliability of the instrument; the tests yielded 0.70, 073 and 0.72, 0.74 for the first and second tests respectively. Four experts in metal work technology were involved in both face and content validity of the instrument. The results obtained from the test scores were compiled and analyzed using statistical tools such as; percentage, mean, and analysis of covariance (ANCOVA) in answering the research question and testing the hypothesis at 0.05 level of significance. Improvised furnace had positive effects on students' performance in heat treatment with a mean gain of 4.61. The difference in performance between those taught using improvised furnace and those taught using conventional teaching aids was found to be significant at 0.05 levels of significance. Based on the findings of the study, the researcher recommended that government, technical college principals and the different agencies should provide fund to procure the materials and component for designing and constructing furnace

by the teacher for teaching heat treatment in technical colleges in Rivers State. Also, constant power supply, generators, accumulators, anvil, steel vessel, pipes and electric blower should be provided and distributed by the ministry of education to the technical colleges for construction of furnace for effective teaching of in Rivers State. The industries, government, non-governmental agencies and private enterprises and communities should provide components, consumable materials necessary for teaching heat treatment and supply the materials directly to the individual technical colleges in Rivers State.

Keywords: Improvisation, Furnaces, Performance, Heat Treatment, Technology and College

Introduction

The provision of quality technical education is the responsibility of the government to meet human resources needs of the nation in technology. Quality technical education trainings are aimed at equipping the learners with useful skills and knowledge in their desired areas of study. Technical Education programmes are provided for the learners to have opportunity to acquire the knowledge and manipulative skill for effective nation building. Technical education programme is conducted in Technical Colleges and other related institutions. Nwachukwu (2006) defines technical education as that aspect of education, which leads to the acquisition of practical and applied skills as well as basic scientific knowledge. Technical Education programme is offered in Technical Colleges and other related institutions.

Technical Colleges according to Okoro (2006) are vocational training institutions in Nigeria that admit junior secondary school leavers to senior secondary schools and provide them with a full vocational course of three years duration. Technical Colleges sometimes admit students who have the First School Leaving Certificate and give them a full six years vocational training. This later case occurs in a situation where the Technical College is experiencing difficulties in attracting enough junior secondary school leavers into its vocational programmes. Technical Colleges are regarded as the principal vocational institutions in Nigeria. They give full vocational training intended to prepare students for entry into various occupations.

One of such occupations is Heat Treatment. According to Chapman (1994) heat treatment is a process that involves heating and cooling of metals in their solid states, for the purpose of changing their properties. The principal properties of steel which can be changed by heat treatment processes include hardness, brittleness, toughness, tensile strength, ductility, malleability, machinability and elasticity. Steel may be made harder, tougher, stronger or softer through various kinds of heat treatment processes.

Heat treatment is used to make tools have certain hardness, strength, toughness, brittleness or grain to do its work.

One thing common to all heat treatments, is that they are hot metal working processes. This means that they require source of heat and that source of heat is furnace. Furnace according to White House (1993) is a device used for heating and melting metals for industrial use. Examples of furnace are blast furnace, electric furnace, basic oxygen furnace, open hearth furnace. Their heating sources could be coal, charcoal, gas or electricity, it therefore follows that without a functional furnace, and technical teacher will find it difficult to develop the students' skills in heat treatment. A technical teacher is a person who has passed through some special training in the arts and science that underline the practice of some trade or profession in tertiary institutions and is employed and has willingly accepted to teach (Ogundu, 2005). Therefore, being a teacher, teaching in a workshop without functional furnace challenges the ingenuity of the teacher. The teacher's positive response to the challenge is shown by the extent of improvisation made towards effective instruction. One of such improvisations by the teacher is the teacher constructed furnace. It is patterned after the open hearth furnace. The teacher constructed furnace is a steel cylinder, lined with clay or bricks. An oven made of clay is connected to a pipe passing midway through the oven. At the end of the pipe, an electric blower is attached to it and the electric blower is connected to a source of electricity of about 800VA (see fig1).

The use of this instructional aide by the teacher may likely affect the student's performance in areas of skill development and passing of their examination. According to Okoro (2006), at the end of the approved period of study, Technical College students take various examinations, particularly, the National Technical Certificate Examination. Federal Ministry of Education (FME, 2006) reported that there is a decline in student's performance in Metal Work. The document showed that students' performances in Metal Work in Technical Colleges have been dwindling in recent time and the situation calls for immediate attention in the Technical Colleges. FME (2006) maintain that Technical Colleges are expected to produce craftsmen. In the last decade, Technical Colleges have recorded high failure rate of over 60 percent in National Business and Technical Examination Board (NABTEB). It is also on record (NABTEB, 2013) from the Chief examiner's reports that the Metal Work students who sat for the examination performed very poorly.

Ideally, Heat Treatment should be taught using the same equipment the practitioners are using in the field that is because teaching Heat Treatment involves the study of industrial technology. It therefore requires industrial facilities that include machinery or simulated industrial setting

known as workshop. This workshop must have amongst other equipment functional furnace.

For proper heat-treatment of steel, some form of furnace is necessary together with an instrument for measuring the temperature inside the furnace. Chapman (1994) states a great amount of heat-treatment, particularly on tools done in the blacksmith's fire and even today this method is still used in some places. At its best, however, this method of heating is not reliable, because the heating is not uniform, and, what is more important, the estimation of the correct temperature depends upon the skill and experience of the blacksmith. If the steel is made too hot it becomes burnt, and if the critical range is not attained the changes which are sought for in the treatment do not take place.

Furnaces are made in many shapes, sizes and varieties. Ogundu (2014) adds that the methods of heating are usually by coal, oil, gas or electricity. Furnaces may be obtained in capacities ranging from small ones with a chamber measuring about 150 mm wide x 100 mm high x 200 mm deep, suitable for small tools, to huge structures of about 10 metres long for heat-treating large bars and forgings. Furnace used for heat treatment includes Salt-bath furnace. This Salt-bath furnace is for some purposes, particularly for the treatment of tools and special steels. Chapman (1994) explains that salt-bath furnace use a bath of molten salt as the method of heating. For example, sodium cyanide fuses and becomes molten at about 600^{o}C, and in its molten state may be heated up to about 900^{o}C. If, therefore, we wish to heat certain articles to temperatures between these limits, an excellent method of doing it according to Davis (2006) is to immerse them in a bath of molten cyanide until they have reached its temperature. Whilst they are immersed in the liquid salt they are protected from the air and therefore do not oxidize and scale, and furthermore, they are being uniformly heated from all sides. The use of these furnaces involves taking certain precautions against the fumes given off, and care should be taken when quenching articles which may have a covering of molten salt because of the spitting which is liable to take place. To guard against this second risk, operators usually wear gloves and goggles.

An important auxiliary to a furnace is some method of measuring its temperature; Davies (2006) maintains the successful heat treatment of steel depends on close adherence to the correct temperature. There are many methods used for this, a simple one being to put in the furnace some substance which melts at the temperature it is desired to verify. The substances used for this are molded in the form of cones from mixtures of Kaolin, lime, feldspar, magnesia, quartz and boric acid, with their melting temperatures arranged in steps from 600^{o}C to 2000^{o}C. When a furnace temperature is required, several of these cones, covering a range of melting

temperatures within which the temperature of the furnace is judged to lie, are put in and observed. The temperature is then judged from which cones collapse, and which remain unaffected by the heat of the furnace. For example, to verify a temperature judged to be 810^{o}C, cones having melting points of 790,815 and 835^{o}C might be put in, the temperature then being estimated from their condition after sufficient time had elapsed for them to be affected. These cones are called Seger Cones or *Sentinels.* Chapman (1994) adds that for modern heat-treatment furnaces the above method of measuring temperature is not very convenient because it is lengthy in operation and does not give a continuous reading of the temperature, as is often necessary. A more scientific and reliable method of measuring furnace temperatures according to Gilchrist (1982) is by an instrument called *pyrometer.* There are various forms of pyrometers and two types in common use are: (1) The Thermo-Electric Pyrometer, (2) the Optical Pyrometer. The first type makes use of the principle that when two dissimilar wires are joined to form a complete electric circuit, and the two junctions maintained at different temperatures, an electric current flows in the circuit, the magnitude of the current depending upon the metals used, and the temperature difference of the junctions. The *hot junction,* which is placed in the furnace, is often made up of wires of platinum, and an alloy of platinum and rhodium welded together and is called a *thermocouple*. Leads from these wires are carried to a sensitive galvanometer which generally constitutes the cold junction, and which indicates the current flowing in the circuit due to the difference of temperature between the two junctions. The galvanometer is so calibrated, that instead of indicating electrical units, it reads in degrees of temperature.

Optical pyrometer compares the intensity of light being emitted from the furnace with that from some standard source. In the disappearing filament pyrometer the glow of a standard filament lamp is varied until it matches the light from the furnace and disappears when viewed through the telescope. The instrument is set up in front of the furnace and the light from the furnace is viewed through the eyepiece. The current through the lamp is varied by a resistance, and when a colour match is obtained the lamp filament disappears from sight, the lamp current required to cause this being indicated on an ammeter. This instrument may be calibrated so that it reads in degrees of temperature, instead of in units of electric current (Ashrae, 1992).

Metal is heat-treated to give it certain desired properties. White House (1993) has provided reasons and properties which may be required and the treatments necessary as follows: (1) to soften the metal – Annealing; (2) to harden it to resist wear, or to enable it to cut other metals – Hardening; (3) to remove some of the extreme brittleness caused by hardening –

Tempering; and (4) to refine the structure after it has been distorted by hammering or working when in the cold state – normalizing. Other treatments such as toughening the metal to better withstand shock, toughening soft steel so that it machines without tearing, and treating special steels to increase their strength and so on.The heat required for tempering is generally obtained by placing the article on to a piece of plate which has been heated to redness. The portion of the tool to be tempered having been previously polished with emery cloth is carefully watched, and as soon as the correct tempering colour appears it may be cooled off. Round articles such as taps may be held inside a piece of red-hot tubing so that they are uniformly heated from all sides (Chapman, 1994).

For some tools such as chisels and punches; time and heat may be saved by hardening and tempering in the same operation. Gray (2004) recommends that tool should be heated up to the hardening temperature for about half its length and then the cutting end quenched for a length of 30 to 60 mm. When it is quite certain that quenching is complete the tool should be removed from the water and the cutting edge quickly polished with emery cloth. The heat from the unquenched portion will soon travel, by conduction, to the end, and the tempering colours will show up. When the required colour appears the whole tool should be quenched. This method gives a good effect as the tool consists of the hardened and tempered cutting edge, with the metal gradually and uniformly decreasing in hardness towards the soft shank.

Statement of the Problem

Heat Treatment ought to be taught using the same equipment the practitioners are using in the field because teaching Heat Treatment involves the study of industrial technology. However, Ogundu (2005) has observed that there is lack of functional furnace in Rivers State Technical Colleges. Even where furnace is available, the high voltage electricity needed to power it is not reliable. Lack of functional furnace has possibly led to poor performance of the students in external examination such as National Business and Technical Examination. Candidates performed poorly because, according to the report from Exam Ethics project (2006), they are unable to attempt questions on Blacksmith shop equipment and other equipment for Heat Treatment. Lack of functional furnace may have contributed to the students' poor exposure to practical classes. Conventional teaching aids such as drawings, pictures and non functional furnace used in the Technical Colleges for teaching Heat Treatment are only descriptive and cannot be used to teach practical. For this reason, local construction of a furnace that can function with low voltage generator is imperative. The question then is

what is the effect of teacher constructed furnace, onstudents' performance in Heat Treatment?

Research Question

The following research question guided this study:

1) What is the effect of using teacher constructed furnace, for teaching, on students' performance in heat treatment operations?

Hypothesis

The following null hypothesis was tested at 0.05 levels of significance:

$H_{o1:}$ There is no significant difference in the mean performance of Technical College students taught heat treatment using teacher constructed furnace and those taught with conventional teaching aids

Design of the Study

This study adopted research and development (R and D) design incorporating quasi-experimental research design. Quasi- experimental design involved the use of pre-test and post-test design with experimental and control groups. This design implies that intact classes were used for the study. This design was necessary because it was not possible for the researcher to randomly sample the students and assign them to groups without disrupting the normal academic programme of the Technical Colleges involved in the study (Akaninwor, 2005 and Ali, 2006).

Population and Sample

The population of the study comprised 194 final year students of the four Technical Colleges offering Metal Work. Final year students were used here because furnace is in their scheme of work. The population for each school comprises the following: (Government Technical College, Port Harcourt 62 Students; Government Technical College,Ahoada 50 Students; Government Technical College,Tombia 48 Students, Government Technical College,Ogu 34 Students). The population of students available in each Technical College was provided by the principal of each school.

Sample and Sampling Techniques

There was no sampling as the population of 194 students was used for the study. However, selection of the Technical Colleges into the experimental and control groups was carried out using the simple random sampling techniques. Alphabet E for Experimental Group and C for Control Group where written on pieces of paper folded and tossed. Four students were asked to pick for each school. GTC Ahoada and GTC Port Harcourt formed the experimental group having a population of 112 students while

GTC Ogu and GTC Tombia constituted the control group with a population of 82 students.

Instrument for Data Collection

The instrument for data collection was the Heat Treatment Achievement Test (HTAT) developed by the researcher. Fifty test items were identified and selected from the content of Metal Work with five modules which include furnace and heat treatment contained in the National Business and Technical Examination Board (NABTEB) syllabus.

The researcher, in constructing HTAT, prepared a table of specification/test blue print to guide the development of the test items. The construction of the test blue print was guided by the guidelines in the Technical College (NABTEB) syllabus for final year students. The content determined the number of test items on a particular topic, objectives and number of tasks stipulated in the objectives of the syllabus. The final blue print containing units in Heat Treatment concepts taught and the connective learning outcomes of the test. The test blue print was further sub-divided into content dimension contained in the units taught in the study while the ability process dimension was sub-divided into knowledge, comprehension and application of knowledge. The number of test items in each of the syllabus section reflected the relative importance of the different activities and remarks highlighted in the objectives. Finally a total 50 multiple- choice test items for heat treatment was developed.

Validation of the Instrument

The researcher subjected the 200 test items for the study to both face and content validation. The test items were validated by checking the items against the NABTEB syllabus in Metal Work Technology. The test items were validated by a total of four lecturers who teach Metal WorkTechnology in tertiary institutions: Two from University of Nigeria, Nsukka, one from Rivers State University of Science and Technology Port Harcourt and one from Rivers State University of Education. They checked the content of the instrument against NABTEB syllabus in Metal work and they observed that the test instrument actually complied with the content and language of the study.

Reliability of the Instrument

The test re- test method was used to establish the reliability (the measure of stability) of the instrument items.The 200MWAT test items were administered on 24 final year students in metal work technology in Technical College, Bayelsa. The school has two arms (A&B). Class A was the experimental group and taught with the teacher constructed furnace while B

was the control group and teaching aids such as drawings, pictures and non functioning furnace were used as conventional teaching aids. At the end of the teaching exercise, the objective test was administered and the scores recorded and computed. The second test was administered after three weeks of the administration of the first test. The tests yielded a reliability index of 0.70, 0.73 and 0.72, 0.74 for the first and second tests respectively.

Method of Data Analysis

The test scores obtained from the tests were computed and tabulated into frequency tables. The research questions were analyzed by comparing the mean gain between the pre-test and post-test of each the mean gain between the experimental and control groups. The null hypotheses were tested using ANCOVA. This is because ANCOVA is a statistical tool which stabilizes the effect of independent variables such that it is not unduly affected by unknown variables (Akaninwor 2005). The use of ANCOVA also removed the initial differences between groups so that the pre-test groups can be correctly considered as equated or equivalent, by removing score differences in the pre-test group and reducing the between group score variation (Ali, 1996). The null hypotheses were rejected if the calculated value, (F- cal) exceeds the critical value (F- crit), if otherwise the null hypotheses was accepted.

Development of Teacher Constructed Furnace

The teacher constructed furnace was arrived at following these steps:

(1) The National Business and Technical Examination Board Syllabus in Metal Work were carefully analyzed to determine which aspects of the syllabus require the use of furnace in teaching. After the content areas have been identified, the specific tasks requiring the furnace were identified such as heat treatment, soldering, forging and heat treatment.

(2) The next important task was a survey of various source materials and textbooks to determine the actual furnace that could be used. In arriving at suitable furnaces, the type of components that could be available to teachers in Rivers State and the functionality of the furnace were also considered.

(3) The teacher constructed furnace is an improvised teaching material that is made up of a steel vessel hardened with carbon – molybdenum of ratio 0.20 per cent, 0.68 per cent respectively. It is lined with bricks and fired with charcoal, using an electric blower connected to a low voltage generator. The furnace was used for heat treatment and was found to be reliable.

Fig 1: Pictures of Improvised Furnace

Research Question 1

What is the effect of using teacher constructed furnace for teaching heat treatment operations on students' performance?

Table 3 Mean Scores of Students'Performance on Heat Treatment

Group	Pre-test Mean	Post-test Mean	Mean gain
Experimental	26.96	60.81	
Control	23.99	53.23	4.61

The data presented in Table 3 show that students in the experimental group had a pre-test score of 29.96, a post-test mean score of 60.81. The control groups' pre-test score was 23.99 and post test score mean of 53.23. The mean gain of was 4.61.This showed that the experimental groups performed better than the control groups in heat treatment.

Hypothesis 1

There is no significant difference in the mean performance of Technical College students taught heat treatment using teacher constructed furnace and those taught with the conventional teaching aid.

Table 7 Analysis of Covariance (ANCOVA) on Heat Treatment

Sources of variance	**Degree of freedom (df)**	**Sum of squares**	**Mean squares**	**F-cal**	**F-crict**	**Remark**
Between groups	1	1871.41	1871.41			
Within groups	191	23270.32	121.83	15.36	0.000124	S
Total	192	25141.73				

The data presented in Table 7 showed that the F-cal is greater than the F-critical value at 0.05 level of significance. This has resulted in the rejection of the null-hypothesis, which meant to show a significant difference in the performance of students taught heat treatment using teacher constructed furnace and students taught with conventional teaching aids.

Findings and Discussions

The following are the findings of this study based on the data collected through the stated research questions and hypotheses.

(1) The calculated mean gain of 4.6 meant that students taught heat treatment using teacher constructed furnace performed better than students taught conventional teaching aids

(2) The difference in performance between those taught using teacher constructed furnace and those taught using conventional teaching aids was found to be significance at 0.05 levels of significance.

Therefore, heat treatment is a process that involves heating and cooling of metals in their solid state, for the purpose of changing their properties. The principal properties of steel which can be changed by heat treatment processes include hardness, brittleness, toughness, tensile strength, ductility, malleability, machinability and elasticity. Steel may be made harder, tougher, stronger or softer through various kinds of heat treatment processes. Heat treatment is used to make tools have certain hardness, strength, toughness, brittleness and grain to do its work. The calculated mean gain of 4.6 means that students taught heat treatment using teacher constructed furnace performed better than students taught conventional teaching aids The difference in performance between those taught using teacher constructed furnace and those taught using conventional teaching aids was found to be significance at 0.05 level of significant. The closeness of the effect which is at 4.6 seems to be as a result of the complicated nature of heat treatment operations. To reduce the effect of this complication, Okala (2005) advocated for repeated practical and drill modes of learning as essential for students who engage in subjects like Metal Work, woodwork, and other practical lessons. He further stated that it is necessary for students to repeatedly perform the desired act until they reach an acceptable degree of competency. The higher performance of the experimental group may equally be linked to the findings of Mandor (2002) which indicated that the use of concrete manipulative object in teaching vocational skills could enhance performance by involving students in workshop, they can acquire process skills, making understanding of technical concepts easier and learning become less difficult.

Conclusion

The purpose of this research was to determine the effect of teacher constructed furnace on students' performance of students in heat treatment in technical colleges in Rivers State. The study revealed that there was significant difference in the mean performances of students taught using teacher constructed furnace and those taught using conventional teaching aids. The difference in performance between those taught using teacher

constructed furnace and those taught using conventional teaching aids was found to be significant at 0.05 level of significance. Therefore, for effective manipulative skill development the teacher constructed furnace is a better teaching aid when compared to the conventional teaching aid.

Recommendations

Based on the findings of the study, the following recommendations were made:

(1) Government, Technical College principals and the different agencies should provide fund to procure the materials and component for designing and developing furnace for teaching heat treatment in the Technical Colleges in Rivers State.

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