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The Effect of Teacher Constructed Charcoal Closed Pit Furnace on Students' Academic Performance In Foundry Technology

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ABSTRACT
This study observed the effect of using Teacher constructed closed pit charcoal furnace to teach students Foundry Technology and its implication on students' academic performance. Quasi-experimental design was used. The population was not sampled because the total population was manageable. The population was made up of all NCE II students offering Foundry Technology. The total population of 140 students was used for the study as a manageable size. The instrument for data collection was the metal foundry achievement Test (MFAT) developed by the researchers. Twenty (20) test items were constructed from the content of the Metal work Technology Syllabus (TED 211) which includes furnace safety precautions, tools and equipment, sandcasting and pattern making and melting processes as contained in the National Minimum Standards of NCCE as reviewed in 2018. To ensure consistency and accuracy of the measuring instrument, the test and re-test reliability coefficient values were found to be 0.81, 0.84, 0.86 and 0.85 respectively. Face and content validation were done by five validators, two from Ramat Polytechnic, Maiduguri, and one from ATBU Bauchi and two from Modibbo Adama University of Technology, Yola. Charts, means, percentiles and T-test were statistical tools used for data analysis, answering of research questions and testing the null hypothesis at 0.05 level of significance. In the first instance of the administration of the 20 multiple choice test. The mean of the pretest was 22 while the posttest rose to 39.5 giving rise to 28% mean differential. The dependent sample t test showed that the value of the calculated t exceeds the critical value (5.0481 > 2.093), so the means were significantly and statistically different at **t (19) = 5.05, p => .05.** In set two the mean of the pre test was 20.25 while the post test rose to 65 giving rise to a mean differential of 52% comparatively. The second absolute value of the calculated t exceeds the critical value (12.1527> 2.093), the means were significantly and statistically different at **t(19) = 12.15, p => .05.** The outcome of the finding shows that there is significant improvement in students' academic performance when taught with teacher designed closed pit charcoal melting furnace. The finding of the study was found to be unanimous with previous related literatures. The study rejected the null hypothesis and made recommendation for the use of teacher designed closed pit charcoal furnace for the teaching of Foundry Technology in Colleges of Education in Nigeria.

Keywords: Students' Academic performance, Charcoal Furnace, Foundry Technology, Metalwork Technology Students

INTRODUCTION

The provision of quality technical education is the responsibility of the government and other non-governmental organization (NGSs) to meet the human needs of the nation in technology. Quality technical education and training are aimed at equipping the learners with useful knowledge, attitudes and basic skills (KAS) in their desired areas of study. Technical Education programmes are provided for the learners to have opportunity to acquire the knowledge and manipulative skills for effective nation building. Technical Education Programmes are conducted is some College of Education and other related institutions. Nwachukwu (2006) defined technical education as that aspect of education, which leads to the acquisition of practical and applied skills as well as basic scientific knowledge. Technology Education Programmes are offered in College of Education (Technical). According to Okoro (2006) College of Education (Technical) are vocational training institutions in Nigeria that admit qualified school leavers and provide them with full vocational/technical course of study of three to five years duration. The vocational training is intended to prepare students for entry into various occupations. Among the vocational courses offered in colleges of education (technical) includes and not limited to metal work technology, which involves welding and fabrication, machining, foundry and forging, which involves heat treatment. The goal of technical education as stated in the national policy of education (FGN 2008) " is to learn skills, practice it and be proficient in it". Uzoagulu (2012) posit that TVET as skill-based programme require recipients to acquire marketable skills and are able to have the right habit of practical skill. This therefore calls for the integration of non-formal instructional approach which is hoped to improve the acquisition of practical skill in addition to the theory and practical learnt in the formal classroom situation. In the same vain, Dasmani (2011) stated that the technical colleges should ensure that practical lessons are both effective and efficient to achieve the desired results of imparting the practical skills necessary for the world of work. The vocational training is intended to prepare students for entry into various occupations in foundry work (heat treatment). Among the vocational courses offered in Colleges is metal work technology which involves welding, machining, foundry and forging which involves heat treatment.

According to chapman (1994) heat treatment is the process that involves heating, pouring and cooling of metals in 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 process. Heat treatment is used to make tools with certain qualities of hardness, strength, toughness, brittleness or grain qualities to do certain works. Similarly, foundry processes is mostly concerned with selection of metals, heating the metal to its pouring temperature pouring the molten metal into mold cavities taking the shape of the pattern or tool.

The use of furnace dates back to ancient time when man started blacksmithing activities. They needed a chamber or a device for heating the metal to the desired temperature before hammering into sheet or required form, pouring into molds and left to solidify, this is how furnace comes into use by man Kilvandin (1980). Reported that over the years, man advanced in the use of furnace from blacksmithing to melting of metals of different variety with varied melting point. This made man to design and develop furnaces dates back the invention of cupola which is essentially a vertical steel shaft with a refractory lined wall either fully or partially lined. Combustion air is introduced through a window box and augmented by blast of air through nozzles called Tuyere and this brings about incredible advances in melting technology and metallurgy have resulted by expensive casting.

A close pit charcoal furnace is among the oldest and simplest furnace used in the foundry industry. It is primarily used to melt smaller amount of non-ferrous and ferrous metals. It is mostly used in small foundries and small shops productions; which this project sought to investigate. Technology Teacher in College of Education Technical/Vocational always are confronted with various degrees of problems centering around the full implementation of the school curriculum, due to lack of equipment, cost of infrastructure and qualified personnel to mention just a few. A typical problem encountered in trade related subjects especially Welding/Fabrication and Foundry Technology, are the availability of standard workshops, machine tools and state of the art machines as used in industries. Most Colleges of Education lack facilities that promote effective Teaching and learning Technology related programmes. This trend has contributed to the type of students graduating after their studies. This affect the performance of students in acquiring the bank knowledge, attitudes and skills (KAS) required for them to be self-reliant. In a study conducted by Yakubu (2013), it was reported that, there is a very high, positive and significant relationship between NCE (Technical) teachers perceived level of exposure during pre-service training and their job performance on the use of tools and equipment in teaching. This indicates that if student are poorly exposed during pre-service training, there job performance on the job is also going to be poor. That is why Arfo in Yakubu (2013) admitted that the non-performance of Technical Teachers is as a result of poor preparation from school due to the fact that the institutions are facing problems among which is the absence of basic equipment. There is therefore a wide gap (in terms) of knowledge, altitude and skills acquired in Schools and the requirements in industries. To bridge this gap, this research work investigated the problems and provides solution in a typical college of Education (Technical).

Statement of the Problem

Foundry Technology/ (TED 211), is a compulsory course as outlined in the National minimum standard (2012). The course ought to be taught using facilities and equipment as used in the industries. This is because foundry technology involves the study of metals i.e ferrous and non-ferrous, casting, pattern making, designing of tools, melting of metals and casting etc. however, it has been observed that there is lack of functional furnace workshop in some of the Colleges. Even where imported electric furnace are available, the high voltage electricity needed to power it may not be available. The lack functional foundry furnace has led to teaching student theory lessons rather than practical lessons. This may possibly lead to the poor performance of students in their practical examinations. According to the report from Exams office, School of Technical FCE (T) Potiskum, (2006) students' performance was poor in foundry technology as they were unable to answer questions on blacksmith shop skills, equipment maintenance and other foundry Technology related processes, which are practical in nature.

Furthermore, the lack of functional furnace in the school workshop may have contributed to the student's poor performance in practical lessons. If this situation is left un-checked, it may be a threat to the much desired production of skilled manpower for the technological development in Nigeria, job creation and poverty reduction. However, if the situation is reversed by teachers taking step towards improvising some of the unavailable equipment like the closed pit charcoal furnace, and using it for teaching, it is hoped that it will lead towards enhancing skill acquisition in the area of heat treatment, casting of metal products and provide jobs for poverty reduction. That is why this study was conducted to design, construct, test and use the closed pit charcoal furnace in teaching foundry technology.

METHODOLOGY

Research Design

This study used quasi-experimental research design. Quasi-experimental Research design involved the use of pre-test and post-test design with experimental and control group respectively. This design is necessary because it will not be possible for the researcher to randomly sample the students and assign them to groups without disrupting the normal academic programme of the students involved in the study (Akaninwor, 2005 and Ali, 2006).

Population of the Study

The population the study comprised 140 registered students in Metal-work Technology Department offering the course TED 211. (They formed the experimental and control group.)

Sample and Sampling Techniques

There was no sampling as the population of 140 students used for the study is manageable size, Uzoagulu (2011). However, selection of the registered students in metal work technology department offering the course formed the experimental and control group. The experimental group was made up of 35 students from group "A", and 34 from group 'D', while the control group was made up of 36 and 35 students from group "B" and "C" respectively.

Instrument for Data Collection

The instrument for data collection was the metal foundry Achievement Test (MFAT) developed by the researchers. Twenty (20) test items were constructed from the content of the Metal work Technology Syllabus (TED 211) which includes furnace safety precautions, tools and equipment, sandcasting and pattern making and melting processes as contained in the National Minimum Standards (NCCE, 2018). The researchers in constructing the MFAT, prepared a table of specifications to guide the development of the test items. The construction of the test blue print was guided by the guidelines in the NCCE minimum standards TED 211 syllabus. The content determined the number of task analysis stipulated in the objectives of the syllabus. The final blue print containing units in metal foundry concepts taught and the connective learning outcomes of the test. The test blue print was further sub-divide into content dimension contained in the unit task taught in the study while the ability process dimension was sub-divided into knowledge, skill attitude (KAS) comprehension and application domains of the knowledge. The number of test items in the syllabus section reflected the importance of the different tasks or activities.

Validation of Instrument

The researchers subjected the 20 test items for the study to both face and content validation. The test items were validated by checking the items against the syllabus in Metal-work Technology as contained in the National Minimum Standard (2018). Foundry TED 211 the test items were validated by a total of five lecturers who teach Metalwork Technology (Foundry) in Tertiary institutions. Two of the validators are from Ramat Polytechnic, Maiduguri, one from ATBU Bauchi and two from Modibbo Adama University of Technology, Yola. The validators checked the content of the instrument against NCCE syllabus in Metalwork Technology and observed that the test instrument and all their observations were compiled to come up with the final instrument.

Reliability of the Instrument

The test re-test method was used to establish the reliability (the measure of stability) of the instrument items. The 20 FMAT test items were administered on 140 students in foundry Metal work Technology in Federal College of Education (Technical) Potiskum. The class has two groups (A and B) group A was the experimental group taught using the Teacher Constructed close pit charcoal furnace while the other group B was the control group were taught using teaching aids such as drawings, pictures and non-functioning furnace were used as conventional teaching aids. At the end of the teaching exercise, the 20 items objective test was administered and the score 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 test respectively.

Experimental procedure During Construction of the Furnace

The experimental procedures conducted by the researchers are based on the following material selection. This is of importance in the design and construction work to a component that can withstand the test of time. The materials selected for the work were selected based on these considerations.

1. Cost and availability
2. Ease of manipulation
3. Ease of fabrication
4. Service life and mechanical properties

Material for the Furnace Base: the exterior part of the furnace is made of 3mm mild steel sheet for formability and welderbility. The furnace bases is made of a tractor rim (low carbon steel), to provide a rigid base. The interior of the base is braced with angle iron and rods welded together to accommodate the lining of refractory materials such as Sodium, Silicate, Bentonite and Crown clay all mixed together with moderate Water. The mixture is then lined and rammed together to avoid cracks when dried.

The cover of the furnace: The cover of the furnace is made of a steel plate rolled into a circular shape, with the inside braced with angle iron and rods for reinforcement of the mixed brown clay, rammed and set to dry.

The blower: this unit is made of casted aluminum blower, a wheel and a pressure pipe held together by nuts and bolts. The assembled mechanism provides enough air blown into the base of the furnace through an opening that is sealed to prevent leakage of pressure. The assembled furnace has the base, blower and the cover as a unit. The crucible made of granite is placed right inside the furnace and linked to an inlet pipe for the blower. At intervals of firing, it could be observed that the clay lining may fall off due to high temperatures produced by the charcoal. To remedy that, resurfacing the lining of the furnace should be done and left overnight to dry properly.

Principles of Operation and Safety Precautions

The main purpose of the close pit charcoal furnace is to melt aluminum (Al2). Before the commencement of melting, all safety equipment should be worn e.g gurgles, aprons, hand gloves and steel toed shoes. All safety precautions should be observed while firing and pouring.

DATA ANALYSIS

This section presents and analyzes data in relation to the purpose of this study. The research questions and hypothesis guides the individual sub headings of data analysis.The main purpose of this study was to determine the Effect of Teacher Constructed Closed Pit Charcoal Furnace on students' Academic Performance in Heat Treatment and Foundry in Federal College of Education (Technical) Potiskum.

The research questions were extracted from the purpose and presented in the form of a null hypothesis

There is no significant difference between the mean performance of students taught heat treatment and foundry operation using teacher constructed furnace and those taught with conventional teaching aid

The null hypothesis will be tested using *z* test. The null hypothesis will be accepted if the calculated value, (*t*-cal) exceeds the critical value (*t*-critical) if otherwise, the null hypothesis will be rejected.

This study used quasi-experimental research design. Quasi-experimental Research design which involved the use of pre-test and post-test design with experimental and control group respectively.

The instrument for data collection was the metal foundry Achievement Test (MFAT) developed by the researchers. Twenty (20) test items were constructed from the content of the Metal Work Technology Syllabus (TED 211) which includes furnace safety precautions, tools and equipment, sandcasting and pattern making and melting processes as contained in the National Minimum Standards of NCCE for the year 2018.There was no sampling as the population of 140 students (male and female) used for the study is manageable size.

DATA PRESENTATION

Two set of data were generated for group A and group B as shown in Table 1. The population consists of male and female students. A total of 140 students registered students in metalwork technology course TED 211 were not sampled. The presentation is shown as grouped in the table.

Table 1: Students' performance before and after furnace application

	Set One		Set Two	
S/no	Pre test group B and C	Post Test Group A and D	Pre Test group B and C	Post Test group A and D
1	10	50	10	75
2	5	30	15	60
3	15	35	30	85
4	15	45	35	55
5	15	30	15	55
6	20	60	10	75
7	20	40	20	60
8	20	35	15	70
9	30	55	30	75
10	16	50	30	70
11	10	15	30	70
12	40	40	15	10
13	15	50	15	75
14	20	30	10	75
15	25	45	15	60
16	40	30	25	50
17	40	25	20	60
18	45	40	15	70
19	19	45	20	70
20	20	40	30	80

Graphical representation of data is show in the Combo chart labelled figure 1 and figure 2 for easy comparison. Figure 1 represent set One comprising of pre test group B and C and post test group A and D.

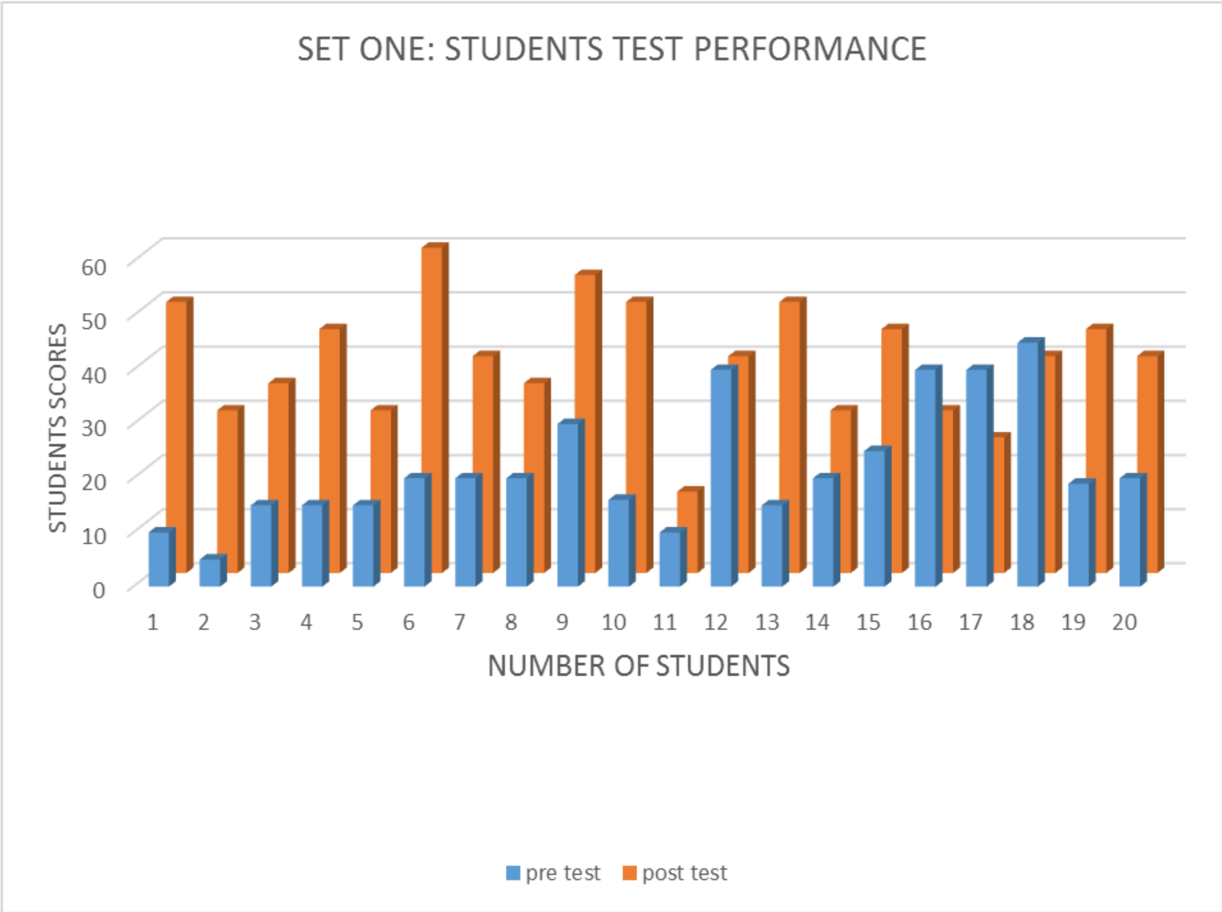

Figure 1: Graphical presentation of Pre test and post test of set one

Figure 2 represent set two comprising of pre test group B and C and post test group A and D respectively.

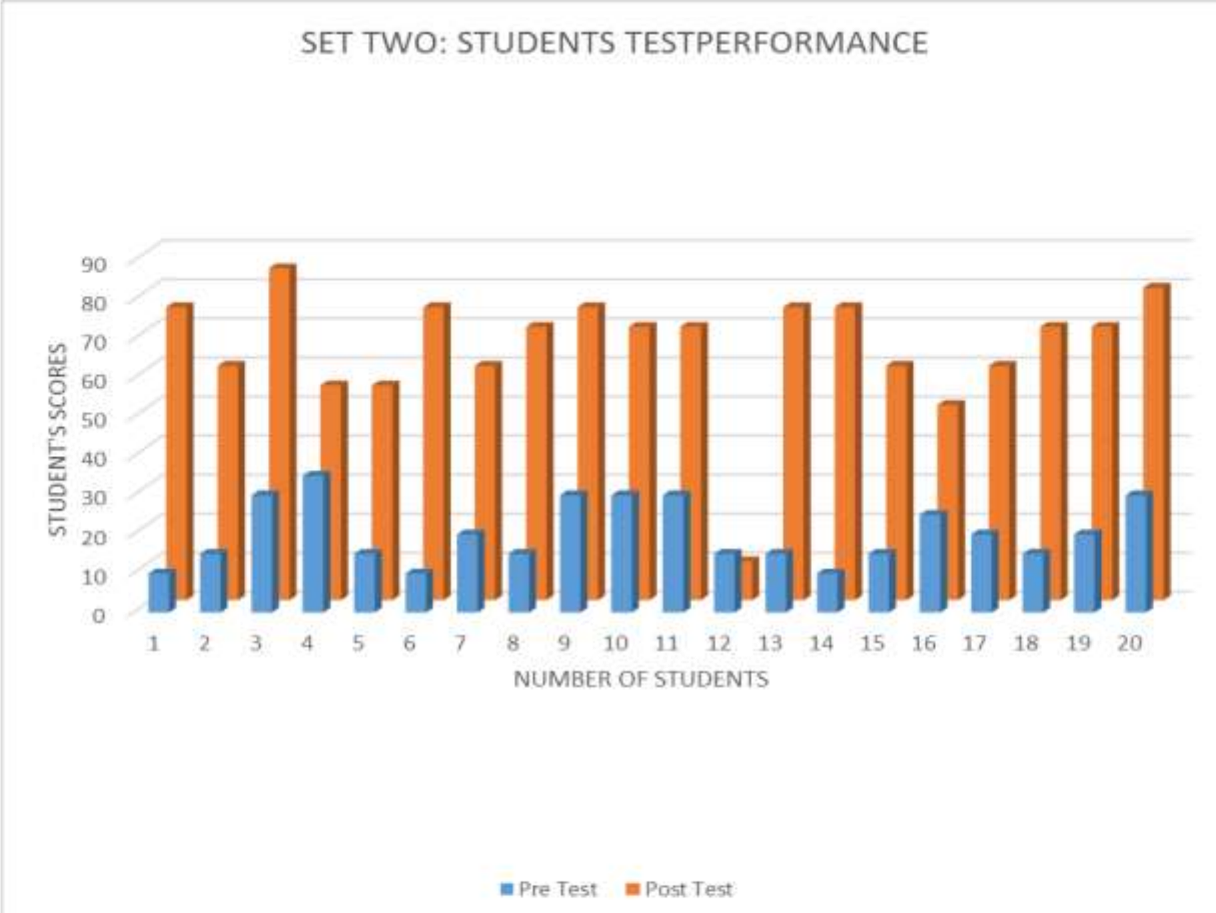

Figure 2: Graphical presentation Pre test and post test of set two

DATA ANALYSIS AND PRESENTATION OF FINDINGS

The data collected for the study was used to test the research questions and the hypothesis. The scores from the pre-test and post-test of experimental and control group will be subjected to statistical analysis. The null hypothesis "*Is there no significant difference between the mean performance of students taught heat treatment and foundry operation using teacher constructed furnace and those taught with conventional teaching aid" will be tested* using ***t***-test. The null hypothesis will be accepted if the calculated value, (***t***-cal) exceeds the critical value (***t***-critical) if otherwise, the null hypothesis will be rejected.

Set 1: The means of Group 1 and Group 2 are significantly different at $p < 0.05$.

Data Summary for Set one		
Items	Group 1	Group 2
Mean	22	39.5
Variance	120.6	114.75
Stand. Dev.	10.9818	10.7121
n	20	20
t	**-5.0481**	
d.o.f	**19**	
critical value	**2.093**	
| t | > critical value	=>	**there is sig. diff.**

Explanation 1

The means of Group 1 and Group 2 are significantly different at $p < 0.05$ as shown in table 2.
The following steps were used to obtain the result.
Step 1: Find ***t*** value and degrees of freedom
To find ***t*** value and degrees of freedom we will used following formulas:

$$t = \frac{\overline{X_D}}{\frac{S_D}{\sqrt{n}}}$$

$$d.o.f = n - 1$$

$\overline{X_D}$ = Mean of differences between pairs

S_{X_D} = Standard deviation of differences between pairs

$d.o.f$ = degrees of freedom

n = Total number of values in first(second) dataset

In this case we have:

$$\overline{X_D} \approx -17.5$$

$$S_{X_D} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(X_{Di} - \overline{X_D}\right)^2} \approx 15.5032$$

After substituting these values into the formula for *t* we have:

$$t = \frac{\overline{X_D}}{\frac{S_D}{\sqrt{n}}} = \frac{-17.5}{\frac{15.5032}{\sqrt{20}}} \approx -5.0481$$

The degrees of freedom is:

$$d.o.f = n - 1 = 19$$

Step 2: Determine critical value for ***t*** with degrees of freedom = 19 and $\alpha = 0.05$.

In this case the critical value is **2.093.**

For this analysis, the emphasis is on comparing the ***t*** values of the two groups. Here again the summary and the inferential statistics focus on the difference.

The absolute value of the calculated *t* exceeds the critical value (5.0481 > 2.093), so the means are significantly different.

Set Two: The means of Group 1 and Group 2 are significantly different at $p < 0.05$.

Data Summary for Set Two		
Items	Group 1	Group 2
Mean	20.25	65
Variance	61.1875	240
Stand. Dev.	7.8222	15.4919
n	20	20
t	**-12.1527**	
d.o.f	**19**	
critical value	**2.093**	
| t | > critical value	=>	**there is sig. diff.**

Step 1: Find ***t*** value and degrees of freedom

The following formulas were used to find **t** value and degrees of freedom.

$$t = \frac{\overline{X_D}}{\frac{S_D}{\sqrt{n}}}$$

$$d.o.f = n - 1$$

$\overline{X_D}$ = Mean of differences between pairs

S_{X_D} = Standard deviation of differences between pairs

$d.o.f$ = degrees of freedom

n = Total number of values in first(second) dataset

In this example we have:

$$\overline{X_D} \approx -44.75$$

$$S_{X_D} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(X_{Di} - \overline{X_D}\right)^2} \approx 16.4678$$

After substituting these values into the formula for t we have:

$$t = \frac{\overline{X_D}}{\frac{S_D}{\sqrt{n}}} = \frac{-44.75}{\frac{16.4678}{\sqrt{20}}} \approx -12.1527$$

The degrees of freedom is:

$$d.o.f = n - 1 = 19$$

Step 2: Determine critical value for ***t*** with degrees of freedom = 19 and **α** = 0.05.

In this computation the critical value is **2.0983**

The absolute value of the calculated *t* exceeds the critical value (12.1527> 2.093), so the means are significantly different.

Summary of data analysis

A statistical conclusion is drawn based on the findings from data analysis using ***t*** test.

Based on the statistical analysis of the two experiments, the mean differences are significant. The summary of set one with group B and C for the pre test and Group A and D for the post test and set two are respectively itemized

i. The absolute value of the calculated *t* exceeds the critical value (5.0481 > 2.093), so the means are significantly different.

ii. The absolute value of the calculated *t* exceeds the critical value (12.1527> 2.093), so the means are significantly different.

iii. Making deduction from i and ii, it can be concluded that the **t** cal is greater than the **t** critical at 0.05 significance level hence the null hypothesis "There is no significant difference between the mean performance of students taught heat treatment and foundry operation using teacher constructed furnace and those taught with conventional teaching aid "is rejected.

Summary

This section concludes this report. A summary of the research is presented, and findings of the study are discussed and interpreted. The significance of this research in the immediate context of the effect of Teacher Constructed closed Pit Charcoal Furnace on students' Academic Performance in Heat Treatment and Foundry in Federal College of Education (Technical) Potiskum is examined. Recommendations for further research end the chapter.

The scope of the following conclusions is limited to the context and historical characteristics of using constructed closed pit charcoal furnace on students' academic performance. Thus, applied to other situations, these conclusions may yield incorrect assumptions. Still, these conclusions are relevant to ways of enhancing students' academic performance in technical colleges of education.

Summary of Research

This study observed the effect of Teacher fabricated closed pit on students' academic performance specifically in Federal College of Education Technical, Potiskum. The literature review was concentrated on the design of closed pit melting furnace and its application as a teaching aid in technical colleges of Education. Different designs were reviewed with the progressive development dates historically. It was found that most designed furnaces were used primarily for blacksmithing purpose. The application of the furnace as a teaching aid was not questioned, and its benefit to teaching was taken for granted. Studies in the area of using furnaces were reduced to the types of furnaces, the fuel used, mode of heat transfer, mode of charging materials and mode of waste recovery. Long term evaluation of the use of furnaces as teaching aid was not found.

Research was undertaken in Federal College of Education (Technical), Potiskum. The intention was to observe students' performance academically when taught Foundry Technology TED 211 using teacher designed closed pit furnace. The case study showed students' level of participation with the teacher designed melting furnace. A method of data collection was developed and administered. Two research assistants in the foundry and forging unit of School of Technical were trained for the purpose of the use and administration of 20 item multiple choice instrument designed based on the syllabus content on casting.

The Students performance showed variation in the individual scores obtained. There were variations in the scores of students taught without the teacher designed closed pit melting furnace. There was a second variation in the individual scores of students taught using teacher designed melting furnace. Consequently a statistical tool T-test was used to harness the variations in scores, their meaning and implication on the use of teacher designed melting furnace for the purpose teaching Foundry technology on students' academic performance.

DISCUSSION AND INTERPRETATION OF FINDINGS

For this analysis, the emphasis is on comparing the means from two groups of pre test and post test. Here again the summary and the inferential statistics focus on the difference. From the result obtained in chapter, there is an overall improvement in the academic performance of students' taught with teacher designed closed pit furnace. This is evident from the result obtained from T-test analysis. In the first instance of the administration of the 20 multiple choice test. The mean of the pre test was 22 while the post test rose to 39.5 giving rise to 28% mean differential. In the second evidence of set one, the absolute value of the calculated t exceeds the critical value (5.0481 > 2.093) hence the means are significantly different. The dependent sample t test showed that the difference in 20 multiple choice test scores between the pre test group B and C (n = 20, M = 22, SD = 10.98) and post test A and D (n = 20, M = 39.5, SD = 10.71) were statistically significant at $t(19) = 5.05$, $p => .05$.

Hence, the absolute value of the calculated t exceeds the critical value (5.0481 > 2.093), so the means are significantly and statistically different at ***t* (19) = 5.05, *p* => .05.**

The test was repeated for the reliability of the measuring instrument. In set two the mean of the pre test was 20.25 while the post test rose to 65 giving rise to a mean differential of 52% comparatively. In the second evidence of set two, the absolute value of the calculated t exceeds the critical value (12.1527 > 2.093) hence the means are significantly different. The dependent sample t test showed that the difference in 20 multiple choice test scores between the pre test group A and C (n = 20, M = 20.25, SD = 7.8) and post test A and D (n = 20, M = 65, SD = 15.5) were statistically significant $t(19) = 12.15$, $p => .05$.

Hence the absolute value of the calculated t exceeds the critical value (12.1527> 2.093), so the means are significantly and statistically different at ***t*(19) = 12.15, *p* => .05.**

The outcome of the finding shows that there is significant improvement in students' academic performance when taught with teacher designed closed pit melting furnace.

In principle there is a relationship with the work of Rowell & Palmer, 2007on Cognitive and Constructivist Strategies for Teaching about Language and for Providing Reading and Writing Instruction. The study uncovered that Cognitive and constructivist strategies were found to be interactive and thus more powerful than the traditional lecture method of teaching college students, yet too often the traditional method prevails.

Four interactive strategies used successfully were cooperative learning, semantic feature analysis, nonsense story analysis, and fictitious writing systems. Surveys, exams, and informal discussions with

Students following the use of these strategies indicate that students found these strategies to be very effective.

In another study by Kwan & Wong, (2015) on effects of the constructivist learning environment on students' critical thinking ability, the duo reported that both cognitive strategies and goal orientations fully mediated the relationships between the constructivist learning environment and critical thinking ability. The finalized model showed an acceptable fit to the data and that 22% of the variance in critical thinking ability was explained, suggesting the usefulness of the model in predicting critical thinking ability.

Another study conducted by (Owusu, 2015) on the the impact of constructivist-based teaching method on secondary school learners' errors in algebra revealed that the study found that participants in experimental school significantly reduced their errors in algebra than those in control school. The study showed that CBTM was a more effective pedagogy that improved the errors Grade 11 learners commit in algebra than the TTM.

Conclusively, the findings of this study are unanimous with these literatures; In a study of heat treatment of metals, Ogundu (2005) and Wordu (2014) noted that students taught heat treatment using the Teacher charcoal furnace performed better than those taught with the conventional teaching aid. That the difference in performance between those taught with conventional teaching aid was very significant due to the complicated nature of heat treatment operations. Teaching and Learning becomes difficult for students when process skills are omitted in any particular task in theory lessons. Okala (2005) advocated for repeated practical and drill skills as modes of learning trade subjects of this nature. The competency of students could be improved when they repeatedly carry out practical tasks e.g preparation of sand moulding involves some tasks to perform. The higher performance of the experimental group may equally be linked to findings of Mandor (2002) where he reported that the use of concrete manipulative objects in teaching vocational skills could enhance performance by involving students in the workshops. The student gets hands-on experiences, acquire process skills and making technical concepts easier and promote effective learning. Okoli (2014) observed that college graduates would perform better given adequate workshop foundry equipment for their practical lessons. In the same vain, Ezeabikwa (2003) reported that we cannot train our potential technology teachers without functional facilities.

CONCLUSION

The study has shown that there is improvement in students' academic performance. Both male and female students improved on their scores when they were taught with teacher constructed closed pit furnace.

Statistically, the data analysis result rejected the null hypothesis "there is no significant difference between the mean performance of students taught heat treatment and foundry operation using teacher constructed furnace and those taught with conventional teaching aid" since the means were statistically significant at t (19) = 5.05, p => .05 and t(19) = 12.15, p => .05.

Significantly, the study acknowledges again the effectiveness of using teacher constructed closed pit charcoal furnace in enhancing the overall academic performance of TED 211 Foundry Technology students of Federal college of Education (Technical), Potiskum.

The findings of the study add modestly to the body of knowledge of literature on the effect of Teacher Constructed closed Pit Charcoal Furnace on students' Academic Performance in Heat Treatment and Foundry

RECOMMENDATION

The following recommendations for change and further studies are made based on the implication of the findings of the study.

i. The study recommends the use of Teacher Constructed closed Pit Charcoal Furnace for the teaching of Foundry Technology TED 211 in Technical Colleges of Education.

ii. The National Commission for Colleges of Education NCCE should include the mandatory use of Teacher Constructed closed Pit Charcoal Furnace for the teaching of Foundry Technology TED 211 in Technical Colleges of Education as a minimum requirement.

iii. Further research should focus on improving Teacher Constructed closed Pit Charcoal Furnace for the teaching of Foundry Technology in the areas of motorized blowers and heating options.

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