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Effect of Inquiry-Based Teaching Technique on Students' Performance in Basic Technology in Rivers State Secondary Schools

[1]Obed O.O & [2]TOM, Chukwulenwa Christian

[1]Department of Industrial Technology Education, Rivers State University, Port-Harcourt Rivers State, Nigeria
Email: obed.obededum@yahoo.com

[2]Department of Industrial Technical Education, Ignatius Ajuru University of Education, Port Harcourt, Nigeria
Email: chukstom@gmail.com

ABSTRACT
The study investigated the effect of Inquiry-Based Teaching Technique on the performance of basic technology students in Rivers State secondary schools. Two research questions guided the study while two hypotheses were formulated for the study. Quasi-experimental design, specifically, the non-randomized control group design involving two intact classes were used. The population was 157 basic technology students of two secondary schools in Rivers State. Basic technology Performance Test instrument were developed, validated and used for data collection. Reliability of the basic technology performance test was 0.65. Arithmetic mean and standard deviation were used to analyze data collected in respect to the research questions while ANCOVA was used to test the hypotheses at 0.05% level of significance. Findings of the study revealed that inquiry-based teaching technique has significant effect on student's performance in metal-work. This is evident in the mean performance of students taught with the inquiry-based teaching technique in turning operation x = 25.12 and knurling operation x = 26.06. While students taught with conventional teaching technique had a mean performance of turning operation x = 20.54, and knurling operation x = 20.79. It implies that from the findings, that there is need for basic technology teachers to employ the use of inquiry-based teaching technique in teaching as it proved more effective in improving student's performance in basic technology. It is recommended that states and federal ministries of education including professional bodies like Nigerian Association of Teachers of Technology and examination bodies like National Business and Technical Examination Board (NABTEB) should organize workshops, seminars and conferences to train and encourage teachers on the use of this innovative technique among others.
Keywords: Inquiry-Based Teaching Approach, Secondary School, Students, Achievement, Basic Technology

INTRODUCTION

Technical and Vocational education is the foundation of nation's wealth creation, economic diversification in developing the economy of a nation. It is a type of education that is meant to produce skilled and technical manpower necessary to restore, revitalize, energize, operate and sustain the national economy and substantially reduce unemployment and also create wealth for the citizens. According to Federal Government of Nigeria (2013), technical and vocational education is a form of education

involving, in addition to general education, the study of technologies and related sciences and the acquisition of practical skills, attitudes, understanding and knowledge relating to occupations in various sectors of economic and social life which leads to industrial development. This specialized education offered in vocational institutions is saddled with training of skilled-men which led to the introduction of basic technology in the secondary schools.

Basic Technology is a subject that introduces students at the Junior Secondary schools in Nigeria to the basic rudiment of technology (Fakomogbon , Morakinyo, Omiola and Ibrahim 2012). At the inception of the 6-3-3-4 System of education, it was called "Introductory Technology" but currently in the 9-3-4 System of education it is called "Basic Technology". Basic technology deals with training that borders on acquisition of knowledge and skills in woodworks, metalwork, electrical/electronics, welding and fabrication, building, auto-mechanics etc including workshop organization and management (Miller, 2011). However, the skills in basic technology involve the application of scientific knowledge and practical skills. The goals of basic technology include:

1. Understand workshop safety rules and their application in machine shop.
2. Know the physical properties, manufacturing process and application of ferrous and nonferrous metals in common use.
3. Select and use common measuring, marking out, cutting and striking tools.
4. Understand the basic working principles of drilling machine and be able to use it for various types of screws treads rivets, and be able to rivet and cut screws by hand.
5. Understand the application of various types of screw threads and rivets, and be able to rivet and cut screws by hand.
6. Understand the ISO system of tolerances and fits their application in engineering production.
7. Produce simple engineering components on the bench.
8. Understand the essential features and working principles of the center, lathe and carry out basic operations such as turning, stepped turning facing, taper turning, knurling, chamfering and undercutting.

This goal can however be achieve only when basic technology is appropriately taught to learners. This can be possible by making teaching learning process to be student-centered as against being teachers-centered and by also viewing students as problem solvers rather than direction followers. Salami in Amadi, Ikedi and Obed (2015) observed that many teaching methods do not use students to their full capacity, and for this reason, teachers should use appropriate teaching method that is student-centered as against teacher-centered when teaching basic technology.

Hence, teacher-centered teaching methods is capable of achieving only minimum students' performance with the result that teachers contribute more and more to accomplish less and less in terms of both learning, productivity and quality of the learning experience (Okoli and Toby, 2000). Recent discoveries in psychology and neurophysiology have led to other theories of learning. One of such theories is the theory of constructivism which has resulted into emergence of a more productive and student-centered (inquiry based teaching technique). This technique focuses on student's constructed learning as opposed to teacher transmit information. In learning through inquiry-based teaching technique, learners are place in a problem situation and are surrounded by lots of appropriate and suitable materials with which to explore the environment and solve problems.

Inquiry-based teaching technique is one of the methods that involve active learner participation in learning process. According to Agboola and Oloyede (2007), it creates situations in which students take the role of a scientist. This is because ; students take the initiative to observe and question phenomena, pose explanation of what they see, device and conduct test to support or contradict their theories, analyze data, draw conclusion from experimental data, design and build models or any combination of these. The America National Scientific Foundation (2000) viewed inquiry-based learning as an approach to learning that involve the process of exploring the natural or material world, and that lead to asking questions, making discoveries, rigorously testing those discoveries in the search of new understanding. Inquiry-

Based teaching technique is the activities associated with discovery learning in which students "discover" ideas instead of learning ideas from the explanations of a teacher or textbook. In extension, inquiry-based teaching technique are more generally, as any activity in which students explore situations and try to solve problems. Erick and Reed (2002) asserted that inquiry teaching method is a project-oriented pedagogy strategy based on constructivist and social constructivist theories of learning. It is a method that elicits critical thinking skills. It is also a mental process that engages in cognitive process to understand conflicting factors in a situation (Moon, 2001; Davis, 2003).

This mental engagement results in a persons' actively constructing knowledge about a situation in-order to develop a strategy to proceed within that situation. Inquiry-based teaching technique can be regarded as teacher designed situations whereby pupils are caused to employ procedures used by research scientist to recognize problems, ask questions and apply investigative procedures, which might be in form of laboratory or practical activities. This is with a view to providing consistent description, predictions, and explanations which are compatible with shared experience of the physical world and which are capable of eliciting critical thinking in students. According to Moore (2000) critical thinking requires a lot of thinking that is more of evaluation and synthesis than analysis or application. Thus inquiry helps students to develop higher order thinking skills by prompting students to relate new knowledge to their previous knowledge: to think in both abstract and concrete terms (Hmole and Ferrari, 2008). In inquiry based method, students learn not only concepts and principles but self-direction, responsibility and social communication.

Therefore, to maximize the utilization of inquiry-based teaching, important key elements or tools need to be adopted in inquiry class. One of such elements is the concept presentation. The concept explanation or principles underlying a given problem to be solved by teachers is to enable and prompt students reflection based on newly presented information (Moon, 2001). Another inquiry tool is the wait time usage. This is waiting a few seconds after putting questions to students, thereby giving them time to think before answering the question. The effective usage of wait time by teachers promotes critical thinking in students. The bringing of real life experience by teachers to classroom learning activities also provides real situation and contextualize knowledge about new information the students are learning. Furthermore, collaborative learning which is another inquiry tool in which students explore their understanding and misunderstanding together helps them to think about what they already know, what they need to know and how they would defend and present their own ideas in reaction to an instructional situation. All this skills are necessary tools that will assist the teachers in the teaching of the skills required of modern metalwork.

However, teachers play vital roles in adapting the inquiry process to the knowledge and ability level of their students. Warner and Myers (2006), pointed out that when using inquiry-based learning, teachers are responsible in starting the process, promoting students diagnoses, transitioning between small groups and classroom discussions, intervening to clear misconceptions or develop students understanding of content materials, modeling scientific procedures and attitude and utilizing students experiences to create new contents. Based on the objectives of the lesson and the abilities of the students, teachers must decide how much guidance they will provide. Regardless of the amount of assistance that teachers provide, the fundamental goal of inquiry is student's engagement during the learning process. The degree of the students' engagement or involvement during classes also depends on the inquiry teaching technique adopted. The inquiry teaching method has been found to be the most suitable for the teaching of science oriented courses by different scholars than the traditional teaching methods (Erick and Reed, 2002: Avarado and Herr, 2003: Glenda, Hebrank, Ybara and Kenk, 2005).

From the chief examiners' report (NABTEB, 2008) showed that student's performance in metalwork in secondary schools have been dwindling in recent time and the situation calls for immediate attention in the secondary schools. In the last decade, secondary schools have recorded high failure rate of over 60% in National Business and Technical Examination Board (NABTEB). It is also on record (NABTEB, 2008) from the chief examiners reports that the metal work students who sat for the examination performed very poorly. Furthermore, NABTEB examination conducted on metal work in May/June, 2004, recorded 30%

failure in questions on sheet metal practice, 60% failure in forging and 65% failure in foundry (NABTEB, 2008). The National Business and Technical Education Board (NABTEB 2008) grade distribution from 2007-2008 May/June result revealed failure rate of 46% for the students who sat for the examination in metal work technology. The result also revealed unsatisfactory performance of the students in questions bordering on heat treatment and soldering with failure rate of 42.5 and 45.5% respectively. This is an indication of overall performance of candidates achieving below average during the examinations. It has been observed by NABTEB (2008) that the persistence poor performance emanate mainly from the inappropriate teaching methods adopted by the technical teachers. (Osagie 1997, Onuoha 1997) also stated that the poor performance of students in practical skills is traceable to the lack of inquiry-based teaching technique. Ideally, metal work technology should be taught using the same equipment the practitioners are using in the field that is because teaching metalwork technology involve the study of industrial technology. Metalwork therefore requires industrial facilities which include machinery or simulated industrial settings known as workshop.

However, what is prevailing now in Rivers State is that the metal-workshop is not standardized, forcing the teacher to use the conventional teaching aids such as drawing, pictures, explanations. The conventional teaching aids cannot be used by the teacher to teach manipulative skills effectively. Ogwo and Oranu (2006) emphasize that unless the teachers stimulates student's interest in learning, student's achievement will be minimal. Hence it is essential that technical college teachers use teaching methods which ensures student's active involvement in learning to stimulate interest and improve performance.

Performance could be perceived as a method of expressing students' scholastic standing. It could be grades for subjects, or trade courses as symbolized by a score or mark in an achievement test, expressed in numerical scale (Lavin, 2009). Atherson (2003) contended that student's performance is dependent upon several factors among which are instructional methods, learning environment and the learner. Achievement in academics can be in cognitive or psychomotor domain. The cognitive domain according to Okoro (2006) involves knowledge and the development of intellectual skills. This includes the recall or recognition of specific facts, procedural patterns and concepts that serve in the development of intellectual abilities and skills.

Thus learning in this domain could be in form of identification of metals or recall the safety rules to be observed in the workshop to more intellectual skills such as determining and selecting the best or the combination of appropriate techniques in metalwork project. Teachers with good teaching methods challenge students to work at higher intellectual level. On the other hand, psychomotor domain is concerned with the development of muscular skills coordination. Objectives from this domain emphasize motor skills, manipulation of materials or subjects or an act which requires neuromuscular coordination (Knoll, 2004). This could be a performance task as simple as using a screwdriver to fasten a screw or as using series of tools and instruments in overhauling a machine. In other to sustain gains in cognitive and psychomotor achievement, teaching method must be capable of bridging the achievement gap. The question now becomes to what extent would student's performance be sustained when taught metalwork using inquiry-based teaching technique? Would students prefer being taught metalwork with inquiry-based technique? This gap in knowledge underscores the need to examine the effect of inquiry-based teaching technique on the performance of metalwork students. Therefore, there is need to investigate the effect of inquiry-based teaching technique on the performance of metalwork students in secondary schools.

Purpose of the Study

The general purpose of the study is to determine the effect of inquiry-based teaching technique on the performance of metal work students in Rivers State secondary schools. Specifically, the study will compare the effect of:

1. Inquiry-based teaching technique on student's performance in turning operation.
2. Inquiry-based teaching technique on student's performance in knurling operation.

Research Questions

The following research questions were posed to guide the study:

1. What is the effect of Inquiry-based teaching technique on students' performance in turning operation.
2. What is the effect of Inquiry-based teaching technique on students' performance in knurling operation.

Hypothesis

The following null hypotheses were formulated to guide the study and were tested at 0.05% level of significance;

Ho_1: There is no significant difference in the effect of Inquiry-based teaching technique on students' performance in turning operation.

Ho_2: There is no significant difference in the effect of Inquiry-based teaching technique on students' performance in knurling operation.

METHODOLOGY

Design of the Study

A quasi-experimental design was used in this study. Specifically, the pre-test, post test, non-equivalent control group design was adopted for the study. According to Gall, Gall and Borg (2007) quasi-experimental design can be used when it is not possible for the researcher to randomly sample the subject and assign them to treatment groups without disrupting the academic programmes of the schools involved in the study. Gall et al (2007) stated further that in a non-equivalent control group design, it is possible to have all groups receive treatments. This design was considered suitable for the study because intact classes (non-randomized groups) were assigned to the two different techniques of teaching. This is in order to determine the effect of the Inquiry technique on students' performance in metalwork. The experimental design of the study is symbolically represented as follows:

E =Experimental group, C= Control group, O_1=Pre-test, O_2=Post-test, No = Treatment.

Area of the Study

The study was carried out in Rivers State. Rivers State is one of the States in South-South Geopolitical Zone. The study was conducted in two secondary schools in the State.

Population for the Study

The population for the study comprised 157 JSS ll basic technology students from two secondary schools in Rivers State selected for the study.

Instrument for Data Collection

One instrument was developed for this study. The Basic Technology Performance Test (BTPT) which has five parts according to the topics outlined was used for data collection. Each part of the instrument has two sections, section A elicits personal information from the students and session B carries the 40 items questions from the topic. BTPT instrument has four options A-D , the students are expected to circle the correct answer. The Basic Technology performance test that used in this study was developed by the researcher. The test consists of 40 objective questions base on curriculum content for JSS ll students. Each item has four alternative options. Every correct answer has one point while an incorrect answer has 0 point. The development entails constructed test items on the following specific metalwork topics which was covered in the study: straight turning, turning operation, and knurling operation. The relative weights of emphasis on the test items are turning operation 50%, and knurling operation 50%.

Validation of the Instrument

The research instrument that was used for the pre-test, post–test is tagged basic technology performance test which was established by strictly drawing the items in line with the test blue print to ensure (i) that questions are set from all parts of the units, (ii) that the number of questions set in each section reflect the relative importance of each section. An initial pool of 40 items was drawn up based on the table of specifications or test blue print and sent to three experts for face-validation. The experts comprised two basic technology teachers of industrial technical education department. Ignatius Ajuru University of

Education, Rivers State and a lecturer of industrial technical section of vocational teacher education department, University of Nigeria, Nsukka. The experts were requested to ascertain the suitability of the test items for the study. This validates focused on adequacy of content, logical sequence and suitability of the technical term used. The items was corrected based on the validates' criticisms and suggestion before testing.

Reliability of the Instrument

The instrument used for the study is Metalwork Performance Test. The instrument was pilot tested on 68 JSS II basic technology students of Government secondary school Elele Alimini. These subjects were not form part of the main study but are equivalent sample of the group for which the test was developed. The reliability co-efficient of basic technology Performance Test was determined using Kuder Richardson formula 20 (KR-20). This formula is used because the Performance Test is a multiple choice question. This help to establish the internal consistency of the items. The students' scores were computed which yielded a reliability index of 0.75.

Method of Data Collection

Data was collected through the use of pre-test post-test for each topic in each week. The test was administered to the students by the basic technology teachers in both groups. The test results were the data which the teachers submitted to the researcher for analysis.

Experimental Procedures

The study involved two groups of subjects. They were those taught with inquiry-based teaching technique and those taught with conventional teaching technique. The inquiry-based group was the experimental group while the conventional teaching technique was the control group.

The regular metalwork teacher were guided and provided with the teaching manual as to master the principles of inquiry-based teaching technique in two days time before the commencement of the study. Prior to the commencement of the experiment, the researcher and the teachers trained the students on how to use the teaching manual and also make provision of the manual to the students. Lesson plan for the two groups; inquiry-based teaching technique and conventional teaching technique were developed by the researcher for JSS II students. Both groups were taught metalwork for four weeks. Students who encountered difficulties in the course of the study were assisted by the class teacher.

Control of Extraneous Variables

The following measures would be employed to control some of the extraneous variables in this study;

Initial group differences: Randomization is one of the procedures used to control initial group differences in experimental studies. However, this was not allowed in this study since the process would disrupt normal school administration. In place of that , intact classes was used.

Experimental Bias: when researchers involve external subjects in the experiments, these students become sensitized that they are being used for the study. Based on that, they tend to behave mechanically and fake most of their actions. This could introduce experimental bias in the study. In order to avoid the bias in this study, the regular metalwork teacher in each school was guided and used. The researcher monitored these occasionally as to ensure that they strictly and effectively adhere to the instruction.

Teacher Variable: when different teachers get involve in experiment, the problem of teacher-variable arises since different teachers possess different standards in terms of knowledge of the content, methodology and so on. As a measure to control this variable in the present study, the researcher prepared lesson plans for inquiry-based teaching technique on metalwork topics which ensured strict compliance with the lesson plans.

Method of Data Analysis

The data for the five research questions of this study was analyzed using mean and standard deviation. The hypotheses were tested at 0.05% level of significance using analysis of covariance (ANCOVA). The pre-test was used to control the initial differences, across the groups as well as increasing the precision due to the extraneous variables reducing errors variance. The statistical package for social sciences (SPSS) was used for all data analysis in this study. With the calculated f-ratio being greater than the table

or critical f-ratio, the null hypotheses were rejected. The value of calculated f-ratio being less than the table f-ratio value, the null hypotheses was accepted. The value of f-ratio at 0.05% level of significance and above was accepted while the value of f-ratio less than 0.05% level of significance was rejected.

RESULTS

Research Question 1: *What is the effect of inquiry-based teaching technique on student's performance in Turning Operation?*

Table 1: Mean Scores of Students Taught with Inquiry-based Teaching Technique and Students Taught Using the Conventional Teaching Technique in Turning Operation

Group	School	N	Pre-test		Post test		Mean Gain	
					X	SD	X	SD
Experimental	GTCAhoada	28	16.14	2.63	35.10	2.67	18.96	
Control	GTC PH	24	15.79	2.28	25.79	2.28	10	

Table 1 shows the pre-test and post-test mean score of students' performance in Turning Operation for both treatment and control groups. Result shows that the students in the treatment group had a pre-test mean score of 16.29 with a standard deviation of 2.98 and a post-test mean score of 33.32 with a SD of 3.78. The difference between the pre-test and post-test mean for the experiment group was 17.03, while the control group had a pre-test mean score 15.50 with a standard deviation of 2.14 and a post-test mean score of 25.58 and SD of 2.04. This shows that the mean score for the treatment group is higher than the control group, indicating that those taught with the inquiry-based teaching technique performed better.

Research Question 2

What is the effect of inquiry-based teaching technique on student's performance in Knurling Operation?

Table 2: Mean Scores of Students Taught with Inquiry-based Teaching Technique and Students Taught Using the Conventional Teaching Technique in Knurling Operation

Group	School	N	Pre-test		post test		Mean-Gain	
					X	SD	X	SD
Experimental	GTC Ahoada	28	16.29	2.98	33.32	3.78	17.03	
Control	GTC PH	24	15.50	2.14	25.58	2.04	10.08	

Table 2 shows the pre-test and post-test mean score of students' performance in Knurling Operation for both treatment and control groups. Result shows that the students in the treatment group had a pre-test mean score of 16.14 with a standard deviation of 2.63 and a post-test mean score of 35.10 with a SD of

2.67. The difference between the pre-test and post-test mean for the experiment group was 18.96, while the control group had a pre-test mean score 15.79 with a standard deviation of 2.28 and a post-test mean score of 25.79 and SD of 2.28. This shows that the mean score for the treatment group is higher than the control group, indicating that those taught with the inquiry-based teaching technique performed better.

Hypothesis 1

There is no significant difference in the effect of inquiry-based teaching technique on student's performance in Turning Operation.

Table 3: The analysis of covariance (ANCOVA) between Students Taught with Inquiry-based Teaching Technique and those Taught with Conventional Teaching Technique in Turning Operation

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	907.019[a]	2	453.510	63.722	.000
Intercept	482.309	1	482.309	67.769	.000
PRE-TEST_B	133.210	1	133.210	18.717	.000
GROUP	563.667	1	563.667	79.201	.000
Error	348.731	49	7.117		
Total	47279.000	52			
Corrected Total	1255.750	51			

Significance at $\alpha \leq 0.05$

The analysis of covariance of students' performance scores presented in Table 3 showed that f-calculated for teaching methods in the two groups is 79.201 at 0.000 significant level. It therefore implies that the null hypothesis is rejected. Thus there is a significant difference in the mean scores of students taught with inquiry-based teaching technique and conventional teaching technique respectively.

Hypothesis 2

There is no significant difference in the effect of inquiry-based teaching technique on student's performance in Knurling Operation.

Table 4: The analysis of covariance (ANCOVA) Between Students Taught with Inquiry-based Teaching Technique and those Taught with Conventional Teaching Technique in Knurling Operation

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1183.871[a]	2	591.936	115.924	.000
Intercept	637.069	1	637.069	124.763	.000
PRE-TEST_C	62.431	1	62.431	12.226	.001
GROUP	1078.067	1	1078.067	211.127	.000
Error	250.206	49	5.106		
Total	50788.000	52			
Corrected Total	1434.077	51			

Significance at $\alpha \leq 0.05$

The analysis of covariance of students performance scores presented in Table 4 showed that f-calculated for teaching methods in the two groups is 211.127 at 0.000 significant level. It therefore implies that the null hypothesis is rejected. Thus, there is a significant difference in the mean scores of students taught with inquiry-based teaching technique and conventional teaching technique respectively.

DISCUSSIONS OF FINDINGS

The findings of the study are discussed in line with research questions and hypothesis.

Turning Operation

In carrying out a straight turning operation therefore, the understanding of and following of detail procedures strictly is essential for successful operation. A taper is generated by, (1) clamping the work piece securely in the head stock, (2) mounting the cutting tool securely in the tool post, (3) setting the tail stock off-center or using taper attachment or by using the compound rest adjustment, and finally, (4) skillful and careful feeding of and manipulation of the compound rest. This is to be expected because according to Bralla (1997) the ability of a beginner-machinist to successfully carry out an operation requiring high precision finishing by complex adjustment is enhanced by the use of systematic and orderly procedure of carrying out the operation which the inquiry-based teaching guide provides.

Knurling Operation

To roughen the surface of a piece of work by making a series of indentation or depressions, the hardened knurling tool is forced into the work forming a crisscross or straight pattern of either coarse, medium or fine pattern. It is one of the lathe machine operations that require extreme care and precision to accomplish. Therefore, the need for a guide for beginner learners cannot be over emphasized. This is in agreement with the conclusions of Ogwo and Oranu, (2006) and Repp and McCarthy (1986), that when there are many operational steps, then a guide is necessary to successfully carry out the operation.

CONCLUSION

Based on the findings of the study, the following conclusions are drawn. An inquiry-based teaching technique for teaching performance skills in basic technology operations has been developed and its efficacy based on syllabus for secondary schools was tested. The mean performance of the students taught with the inquiry-based teaching technique is better than those taught with conventional teaching technique. This performance is consistent in all of the two basic technology operations and this cannot be said to have occurred by chance, but rather due to the effectiveness of the inquiry-based teaching technique. Therefore, the inquiry-based teaching technique for teaching basic technology skills in basic technology has yielded better performance.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

1. In line with the responsibility vested on practicing technical teachers in secondary schools for guiding students to improve their performance in basic technology, technical teachers should subject this newly developed technique to further try-outs in order to serve as means of further assuring its performance usefulness, and eventual adoption for continual use in teaching performance skills in metal-work. Using the inquiry-based teaching technique will yield a better student performance in basic technology.
2. Standardization and harmonization of programmes being part of the responsibilities of National Board for Technical Education (NBTE), this board should consider introducing inquiry-based teaching technique as a standardized guide for the implementation of a uniform instructional strategy in basic technology in secondary schools.

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