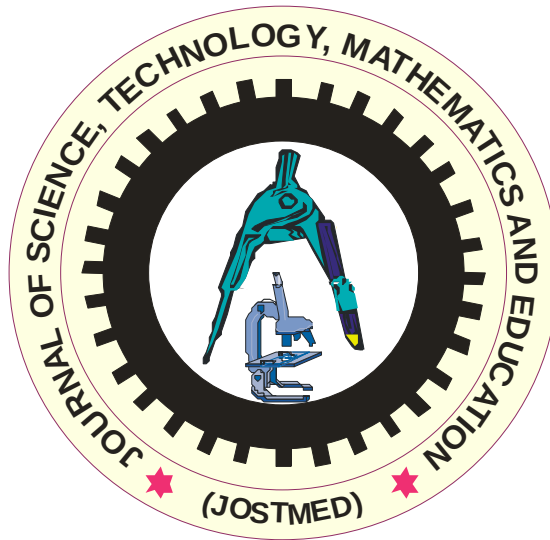


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Dr. Gambari, A. I.
Associate Professor

The Managing Editor, (JOSTMED),
Department of Science Education,
Federal University of Technology,
P. M. B. 65, Minna, Niger State, Nigeria.

E-mail: gambarii@yahoo.com; gambariisiaka@gmail.com
gambari@futminna.edu.ng ; gambari@codel.futminna.edu.ng

Website: www.gambariamosaisiaka.com

Mobile Phone: +234-816-680-7534; +234-803-689-7955; +234-805-558-6716

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CONTRIBUTORS TO THE ISSUE

1. SULE, I. O., ODEBISI-OMOKANYE, M. B., GAMBARI-AMBALI, R. O., & OKEWALE, T. A.
Department of Microbiology, Faculty of Life Sciences,
University of Ilorin, PMB 1515 Ilorin, Nigeria
E-mail: suleism@gmail.com
Phone No: +234-805-666-3764
2. OYEDUM, U. M.
Department of Microbiology, School of Life Sciences,
Federal University of Technology, Minna, Nigeria
E-mail: hemdi41@gmail.com
Phone No: +234-706-800-4509
3. ¹M. H. ALI, ²IBRAHIM YAHAYA MUHAMMAD,
²MUHAMMAD MUDASSIR USMAN &
²SUNUSI DAYYAB MUHAMMAD
¹Department of Physics, Bayero University, Kano.
²Department of Physics, Kano University of Science and Technology, Wudil.
E-mail: alim@buk.edu.ng, ibrahimyahaya29@yahoo.com, mmusman1007@gmail.com,
sunusidayyab@gmail.com
4. IKECHIAMA F. N.¹, KWAHA, B.J.² & CHAGOK, N. M. D.³
¹Department of Physics, Federal University Dutsin - Ma, Katsina State, Nigeria
^{2&3}Department of Physics, University of Jos, Plateau State, Nigeria
E-mail: fosuagwu@fudutsinma.edu.ng,
Phone No: +234-806-563-1514
5. ¹ODEBISI-OMOKANYE, M. B., ¹ZAKARIYAH, R. F.,
²JIMOH, F. A. & ¹OLUGBADE, O. F.
Department of Microbiology, Faculty of Life Sciences University of Ilorin, Kwara State.
Department of Biosciences and Biotechnology, Microbiology unit,
College of Pure and Applied Sciences, Kwara State University, Malete, Ilorin.
E-mail: Odebisimutiat@yahoo.com; odebisi.mb@unilorin.edu.ng
Phone No: +234-803-400-6111
6. NGOZI BLESSING OSSAI-UGBAH, CLN¹. & PATIENCE ONORIODE KAYOMA²
John Harris Library,
University of Benin, Benin City, Nigeria.
E-mail: ngozi.ossai-ugbah@uniben.edu, ladykayee@yahoo.com
Phone No: +234-802-361-3238
7. ABDULKARIM NASIR¹, BORI IGE¹, TIMOTHY ENITILO¹,
OLUWATOSIN SARAFA AZEEZ², ABUBAKAR MOHAMMED¹
¹Department of Mechanical Engineering,
Federal University of Technology, Minna, Nigeria
²Department of Chemical Engineering,
Federal University of Technology, Minna, Nigeria
E-mail: a.nasir@futminna.edu.ng Phone No: +234-803-318-3561
8. ADAMA, C. J., SALAUDEEN, M. T., MAMMAN, E. W. & ABDULKADIR, A.
Department of Crop Production,
Federal University of Technology, Minna, Nigeria
E-mail: cinwoj@gmail.com
Phone No: +234-806-333-0183
9. AYINDE, O. E., AYINDE, K., OMOTESHO, O. A. & MUHAMMAD-LAWAL A.
Department of Agric – Economics and Farm Management
University of Ilorin, Ilorin, Nigeria.
E- mail: opeatyinde@yahoo.com

10. TSADO, J. H¹., O. B. ADENIJI¹, TYABO, I. S¹. & KOLO, E. S².
¹Department of Agricultural Economics and Extension Technology,
Federal University of Technology Minna, Nigeria
²Niger State College of Education, Minna, Niger State, Nigeria
E-mail: jacobtsado2007@yahoo.com
Phone No: +234-806-526-8098

11. AKANBI, USMAN OLADIPO¹ & MUSA JOHN JIYA^{2*}
Department of Agricultural Economics, Faculty of Agriculture,
University of Ilorin, Ilorin, Nigeria.
Department of Agriculture and Bioresources Engineering,
School of Engineering and Engineering Technology,
Federal University of Technology, Minna, Nigeria.
E-mail: johnmusa@futminna.edu.ng
Phone No: +234-803-668-2747

12. EYITAYO A. AFOLABI¹ & J. G. M. LEE²
¹Department of Chemical Engineering,
Federal University of Technology, Minna, Nigeria.
²Newcastle University, Newcastle upon Tyne, United Kingdom.
E-mail: elizamos2001@yahoo.com
Phone No: +234-807-220-1514

13. A. B. ATTAH, A. P. ADEDIGBA & A. M. AIBINU*
Mechatronics Engineering Department
Federal University of Technology, Minna, Nigeria
E-mail: *maibinu@gmail.com, abiiodun.aibinu@futminna.edu.ng,
Phone No: +234-802-949-4164

14. ABDULKARIM NASIR¹, SALIHU A. USMAN², ABUBAKAR MOHAMMED¹,
SHUAIBU N. MUHAMMED¹, & BORI IGE¹
¹Mechanical Engineering Department, Federal University of Technology, Minna, Nigeria
²Works and Maintenance Services, Federal University of Technology, Minna, Nigeria
E-mail: a.nasir@futminna.edu.ng Phone No: +234-803-318-3561

15. GAFAR MATANMI OYEYEMI¹, EYITAYO OLUWOLE OGUNJOBI², & ADEYINKA
IDOWU FOLORUNSHO³
¹Department of Statistics, University of Ilorin, Ilorin, Nigeria
²Department of Mathematics and Statistics,
The Polytechnic Ibadan, Adeseun Ogundoyin Campus, Eruwa.
³Department of Mathematics and Statistics,
Osun State Polytechnic Iree, Nigeria
E-mail: gmoyeyemi@gmail.com

16. VICTOR O. WAZIRI¹, PATIENCE WOYE ADAMA² & AUDU ISAH³
Department of Cyber Security Science,
School of Information and Communication Technology,
Federal University of Technology, Minna, Nigeria
²Department of Computer Science and Mathematics,
Federal Polytechnic, Bida, Niger State, Nigeria
³Department of Statistics,
Federal University of Technology, Minna, Nigeria
E-mail: victor.waziru@futminna.edu.ng, Yapacie123@gmail.com,
aisah@futminna.edu.ng
Phone No: +234-806-351-8931

17. ONUORAH, M. O.,¹ AKINWANDE N. I.², FARUK ADAMU KUTA³
& ABUBAKAR, U. Y.⁴
¹Mathematics & Statistics Department, Federal Polytechnic, Nasarawa, Nigeria
^{2&4}Mathematics & Statistics Department, Federal University of Technology, Minna,
³Micro Biology Department, Federal University of Technology, Minna, Nigeria
Email: martins.onuorah@yahoo.com
Phone No: +234-803-076-4334

18. I. B. S. MOHAMMED & R. O. OLAYIWOLA
Department of Mathematics,
Federal University of Technology, Minna, Nigeria
E-mail: olayiwola.rasaq@futminna.edu.ng, babashabafu@gmail.com
Phone No: +234-805-254-8167

19. NDAMAN ISAH
Department of mathematics,
Niger State College of Education, Minna, Nigeria
Email: Isahgura@gmail.com

20. ¹VICTOR ONOMZA WAZIRI, PHD, ²USMAN ABDULQAHAR OZOVEHE, & ³AUDU ISAH
^{1&2}Department of Cyber Security Science,
School of Information and Communication Technology,
Federal University of Technology, Minna, Niger State Nigeria
³School of Physical Sciences, Department of Statistics,
Federal University of Technology, Minna, Niger State, Nigeria
E-mail: ¹victor.waziri@futminna.edu.ng ²abdulqaharusuman@gmail.com, & ³aisah@futminna.edu.ng
Phone No: +234-806-351-8931

21. DR. (MRS.) ANGELA O. DARA & LAW-Obi FIDELIA N. (MRS.)
¹Dept of Educational Psychology/Guidance and Counselling,
Alvan Ikoku Federal College of Education, Owerri, Imo State, Nigeria
²Science and Technology Unit, Dept of primary education,
Alvan Ikoku Federal College of Education, Owerri, Imo State, Nigeria
E-mail: daraangela2011@gmail.com
Phone No: +234-803-841-3888

22. OLUTOLA, ADEKUNLE T. (Ph. D.)¹, DARAMOLA, DORCAS S. (Ph.D.)² & SHEU, ADARAMAJA L. (Ph.D.)¹
¹Department of Educational Foundations, Faculty of Education,
Federal University Dutsin-Ma, Katsina State, Nigeria.
²Department of Educational Psychology/G &C, Faculty of Education,
Federal College of Education, Owerri, Imo State, Nigeria.
E-mail: aolutola@fudutsunma.edu.ng, immaculatetabitha@yahoo.com,
adaramaja4real@yahoo.com
Phone No: +234-806-029-7940, +234-809-785-0451

23. SUNMAILA OYETUNJI RAIMI, OLUFEMI AKINLOYE BOLAJI, & ABIODUN EZEKIEL ADESINA
General Studies Education, School of Education
Emmanuel Alayande College of Education
P.M.B. 1010, Oyo, Oyo State, Nigeria
E-mail: raimitunji966@yahoo.com, akinik1@yahoo.com, aeadesina2010@gmail.com
Phone No: +234-703-029-2283, +234-703-265-6077, +234-803-074-5843

24. LALEYE ADEMIOTAN MORIYIKE (Ph.D)
Department of Science Education, Faculty of Education, Adekunle Ajasin University,
Akungba-Akoko, Ondo State, Nigeria
E-mail: dammylaleye@yahoo.com Phone No: +234-806-618-6034

25. FALADE, AYOTUNDE ATANDA (Ph.D) & SAMUEL, NATHANIEL
Department of Educational Technology, University of Ilorin, Ilorin, Nigeria
Email: falade.aa@unilorin.edu.ng Phone No: +234-803-856-6249

26. ANAZA, ABDULMUMUNI ONUYI¹, ABDULLAHI, MUH'D-JIMOH A². & OHANADO, CLARA CHIBUZOR³
¹Department of Curriculum and Instruction
²Department of Primary Education
³Department of Library
Federal College of Education, Okene, Kogi State, Nigeria
E-mail: anazaao@yahoo.com, claraohanado20@gmail.com,
Phone No: +234-816-581-8332, +234-803-572-5844

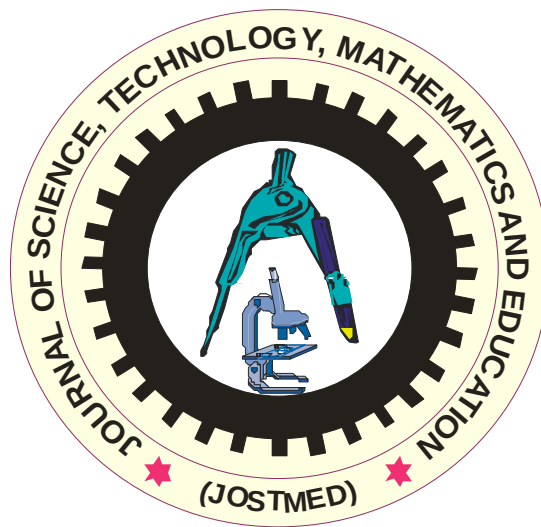
27. OLABIYI, O STEPHEN (Ph.D.)¹, JIMOH, J. A. (Ph.D.)² & OWODUNNI, A. SAMUEL (Ph.D)³
^{1&2}Department of Science and Technology Education,
Faculty of Education, University of Lagos, Akoka
³Department of Industrial and Technology Education,
Federal University of Technology Minna, Niger State
E-mail: Solabiyi@unilag.edu.ng
Phone No: +234-706-220-9015
28. MUSTAPHA, MULIKAT LADI ABDULQADIR (Ph.D) & MUHAMMED SHUAIB ABOLAKALE & ALWAJUD –ADEWUSI MARIAM B
Department of Counsellor Education,
Faculty of Education, University of Ilorin, Ilorin, Nigeria
E-mail: ladiuthman9150@gmail.com
Phone No: +234-806-214-8082
29. BABA WACHIKO¹ & AHMADU HUSSAINI²
¹Department of Primary Education Studies
²Department of Computer Science Education
Niger Sate College of Education, Minna, Nigeria
E-mail: wachikobaba35@yahoo.com
Phone No: +234-803-799-1635, +234-703-868-3373
30. BELLO, ZAKARIYAU ADEBAYO, BELLO, GANIYU (Ph.D) & PROF. ISAAC O. ABIMBOLA
¹Department of Integrated Science,
Kwara State College of Education Ilorin, Nigeria
²Department of Science Education, University of Ilorin, Nigeria
E-mail: zakbay26@gmail.com, bello.g@unilorin.edu.ng, bllganiyu@yahoo.com,
abimbola@unilorin.edu.ng
31. OLASEDIDUN, OLUTOYE KUNLE (Ph.D) & BADMUS, AYODEJI MUIDEEN (Ph.D)
Department of Curriculum and Instruction
Emmanuel Alayande College of Education, Oyo State, Nigeria
E-mail: olutoyeolasedidun@yahoo.com & badmusayomuideen@gmail.com
Phone No: +234-803-728-6108, +234-806-789-7787
32. OYENIRAN, SAHEED (Ph.D), PROF. A. Y. ABDULKAREEM & ATOLAGBE, ADEDAPO ADETIBA (Ph.D)
Department of Educational Management
University of Ilorin, Ilorin, Nigeria
E-mail: saheed.oyeniran@gmail.com, ayabdulkareem@yahoo.com,
atolagbeadedapo@gmail.com
Phone No: +234-706-886-0689, +234—803-590-3513, +234-806-077-5914

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EFFECTS OF 'DISINFECTANT A' ON THE PHYSICOCHEMICAL AND BACTERIOLOGICAL QUALITY OF SOME WELL WATER

SULE, I. O., ODEBISI-OMOKANYE, M. B.,
GAMBARI-AMBALI, R. O., & OKEWALE T.A.

Department of Microbiology, Faculty of Life Sciences,
University of Ilorin, PMB 1515 Ilorin, Nigeria

E-mail: suleism@gmail.com; Phone No: +234-805-666-3764

Abstract

Majority of the population in semi-urban and urban areas of Nigeria depend on wells as their source of water. The rate of water-borne diseases are on the increase, therefore, this study was carried out to examine the effects of 'disinfectant A' on bacteriological and physicochemical quality of some well water samples in Ilorin metropolis, Kwara, Nigeria. The disinfection of the well water was done by adding 0.5ml of the disinfectant to 100ml of each of the water sample and was allowed to stand for a contact time of 30 minutes. Both disinfected and undisinfected water samples were analyzed comparatively. The pH, chloride, total hardness, and suspended solids of the water samples prior to disinfection ranged from 6.71 - 7.49, 4.05 - 19.9mg/l, 56 - 295mg/l, and 0.001 - 0.022g/100ml respectively. Similarly, the values of the physicochemical properties of the water samples after disinfection ranged from 7.02 - 7.62, 4.76 - 25.9mg/l, 70 - 290mg/l, and 0.002 - 0.09g/100ml respectively. The total bacterial count ranged from 1.0×10^2 - 4.2×10^4 cfu/ml for the untreated water samples and $0 - 7.0 \times 10^2$ cfu/ml for the treated well water samples. The total coliform count ranged from $0 - 2.7 \times 10^3$ cfu/ml for the untreated water samples and $0 - 2.0 \times 10^2$ cfu/ml for the treated well water samples. There was no faecal coliform isolated in all the water samples. Comparatively, the addition of 'disinfectant A' to the water samples led to increase in the pH, chloride content and total hardness of the water but there was decreased in bacterial load. Therefore, the use of 'disinfectant A' should be encouraged especially in communities where pipe borne water is not available.

Keywords: bacterial counts, disinfection, physical and chemical properties, well water, reduction

Introduction

It is estimated that 8% of worldwide water use is for household purposes. These include drinking, bathing, cooking, sanitation and gardening. Drinking water is water that is of sufficiently high quality so that it can be consumed or used without risk of immediate or long term harm. Water could be classified as either surface or ground water. Surface water is water in a river, lake or fresh water wetland. Surface water is naturally replenished by precipitation and naturally lost through discharge to the oceans, evaporation, and evapotranspiration (Willey *et al.*, 2011).

Groundwater is fresh water that is located in the pore space of soil and rocks. It is water that is flowing within aquifers below the water table. Ground water is the largest single supply of fresh water available for use by humans. A well is an excavation or structure created in the ground by digging, driving, boring, or drilling to access groundwater in underground aquifers. The well water is drawn by a pump, or using containers such as buckets, that are raised mechanically or by hand. Wells can vary greatly in depth, water volume and water quality.

The quality of groundwater is changing as a result of human activities (Trevett *et al.*, 2004). Ground water is less susceptible to bacterial contamination than surface water because the soil and rocks through which groundwater flows, screens out most of the bacteria. Bacteria, however, occasionally find their way into ground water, sometimes in dangerously high concentrations (Pavlov *et al.*, 2004). Freedom from bacterial contamination alone does not mean the water is free for drinking (Adekunle *et al.*, 2007).

Many undissolved mineral and organic constituents are present in ground water in various concentrations. Most are harmless or even beneficial; though occurring infrequently, others are harmful, and a few may be highly toxic. The most common dissolved mineral substances are sodium, calcium, magnesium, potassium, chloride, bicarbonate and sulphate. Water typically is not considered desirable for drinking if the quantity of dissolved minerals exceeds 1000mg/l (WHO, 2008).

The most important quality assessment of water is the microbial quality which is determined by microbial load. Some microorganisms are known to be microbial indicators of water quality. The term "total coliforms" refers to a large group of Gram-negative, rod-shaped bacteria that share several characteristics. The group include thermotolerant coliforms and bacteria of faecal origin, as well as some bacteria that may be isolated from environmental sources. World Health Organization (WHO) Guidelines, and most national drinking water standards, take the presence of *Escherichia coli* or thermotolerant coliforms as an indication of recent faecal pollution from human or warm-blooded animals.

Worldwide, about 1.2 billion people lack access to safe drinking water, and twice that may lack adequate sanitation (WHO, 2008). As a result, the World Health Organization estimated that 3.4 million people, mostly children, die every year from water-related diseases. Well-known pathogens such as *E. coli* are easily controlled with chlorination, but can cause deadly outbreaks under conditions of inadequate or no disinfection. Even where water treatment is widely practiced, constant vigilance is required to guard against waterborne disease outbreaks (Curtis *et al.*, 2000; Craun *et al.*, 2002).

Water treatment involves two types of processes: physical removal of solids (mainly mineral and organic particulate matter) and chemical disinfection (killing/inactivating microorganisms). Treatment practices vary from system to system, but there are four generally accepted basic techniques which are coagulation, sedimentation, filtration, and disinfection (Willey *et al.*, 2011).

In households, hypochlorite is used frequently for the purification and disinfection of the water. When hypochlorite is added to water, hypochlorous acid is formed which ionizes into hydrochloric acid and oxygen (Mwambete and Manyanga, 2006). The oxygen atom is a very strong oxidizing agent. The pH of water determines how much hypochlorous acid is formed. Sodium hypochlorite is effective against bacteria, viruses and fungi. Sodium hypochlorite can easily be stored and transported, its dosage is simple, and it produces residual disinfectant.

Many people depend on well water as their source of potable water and is a common practice these days for people to disinfect water from wells to tackle microbial contaminants. Hence, this research was conducted to determine the effect of a commercial 'disinfectant A' on the bacteriological and physicochemical characteristics of well water samples.

Materials and Methods

Collection and treatment of the water samples

A total of 10 well water samples were collected according to APHA (1998). One hundred millilitre of the collected water samples was measured into each of the two 250ml capacity conical flasks. Aliquots of 0.5ml of the 'disinfectant A' was added to one of the water sample in the conical flask and left for 30 minutes contact time. Nothing was added to the well water sample in the second conical flask and termed as control. Thereafter, the undisinfected and disinfected water samples were analyzed comparatively.

Determination of physicochemical characteristics

The pH of the water sample was determined using a standardized pH meter (Fawole and Oso, 2007). The chloride content of the water was determined by titrating 100ml of the water sample with 0.1N AgNO_3 . Two millilitre of 5% Potassium Chromate was added as an indicator and the titration was done until the initial yellow colour changed to faint pink. The titre value obtained was multiplied by 3.55 in order to obtain the chloride content in mg/l (Sule *et al.*, 2014).

The total hardness was determined by placing 100ml of the water sample in a 250ml conical flask and 5 drops each of ammonia and erichrome black-T (an indicator) were added. This was then titrated with EDTA until there was a colour change from purple to light blue. The titre value of the 0.1N EDTA multiplied by 100 gives the total hardness in mg/l (De Zuane, 1997).

The suspended solid content was determined by drying a Whatman filter paper at 105°C for an hour and weighed it as W_1 . The water sample was shook and filtered with the weighed filter paper. The filter paper was left folded and dried again at the same temperature and duration. It was reweighed and recorded as W_2 . The loss in weight represents the suspended solid content in g/100ml (APHA, 1998).

Bacteriological analysis

The water samples were serially diluted up to 10^{-3} . Pour plate technique was used to determine the bacterial count using nutrient agar. The total coliform and faecal coliform

counts were determined using spread plate method while the media used were MacConkey agar and eosin methylene blue agar respectively (Fawole and Oso, 2007).

Statistical analysis

The mean value of the bacteriological and physicochemical parameters obtained were tested using students' T-test in order to determine if there is significant difference between the undisinfected and disinfected well water samples (SPSS, 2010).

Results

Physicochemical analysis of the well water samples

The pH, chloride, total hardness and suspended solid content of the undisinfected water from the wells ranged from 6.71 - 7.49, 4.05 - 19.9mg/l, 56 - 295mg/l, and 0.001-0.022g/100ml respectively while the corresponding values for the disinfected water from the wells were 7.02 - 7.62, 4.76 - 25.9mg/l, 70 - 290mg/l, and 0.002 - 0.09g/100ml respectively (Table 1).

Bacteriological analysis of the well water samples

The bacterial load of the well water samples ranged from 1.0×10^2 – 4.2×10^4 cfu/ml for the undisinfected water samples and $0 - 7.0 \times 10^2$ cfu/ml for the disinfected well water samples. The total coliform count ranged from $0 - 2.7 \times 10^3$ cfu/ml for the undisinfected water samples and $0 - 2.0 \times 10^2$ cfu/ml for the disinfected well water. The faecal coliform count was zero in both undisinfected and disinfected well water samples (Table 2).

Table 1: Physicochemical characteristics of undisinfected and disinfected well water samples

Sampling points	pH		Chloride content (mg/l)		Total hardness (mg/l)		Suspended Solids (g/100ml) $\times 10^{-3}$	
	BD	AD	BD	AD	BD	AD	BD	AD
W1	6.81 ^a ± 0.02	7.56 ^b ± 0.03	6.46 ^a ± 0.02	7.28 ^b ± 0.04	77 ^a ± 5	115 ^b ± 6	2 ^a ± 0	9 ^b ± 1
W2	6.71 ^a ± 0.03	7.02 ^b ± 0.02	19.9 ^a ± 0.03	25.9 ^b ± 0.07	295 ^a ± 9	290 ^a ± 8	9 ^a ± 2	8 ^a ± 1
W3	6.79 ^a ± 0.02	7.07 ^b ± 0.04	10.3 ^a ± 0.05	10.7 ^b ± 0.06	148 ^a ± 3	152 ^b ± 6	1 ^a ± 0	2 ^a ± 0
W4	7.20 ^a ± 0.01	7.62 ^b ± 0.02	6.25 ^a ± 0.04	6.53 ^b ± 0.04	56 ^a ± 3	70 ^b ± 4	2 ^a ± 0	2 ^a ± 0
W5	7.22 ^a ± 0.02	7.43 ^b ± 0.02	4.05 ^a ± 0.03	4.76 ^b ± 0.04	105 ^a ± 5	112 ^b ± 5	2 ^a ± 0	2 ^a ± 0
W6	7.33 ^a ± 0.02	7.40 ^b ± 0.03	9.59 ^a ± 0.02	10.9 ^b ± 0.02	155 ^a ± 5	166 ^b ± 6	22 ^a ± 2	36 ^b ± 3
W7	7.36 ^a ± 0.02	7.43 ^b ± 0.02	15.2 ^a ± 0.04	15.6 ^b ± 0.05	180 ^a ± 6	198 ^b ± 10	3 ^a ± 0	4 ^a ± 1
W8	7.27 ^a	7.31 ^b	5.43 ^a	6.04 ^b	56 ^a ± 3	70 ^b ± 5	10 ^a ± 1	18 ^b ± 2

	± 0.02	± 0.03	± 0.03	± 0.04				
W9	7.49 ^a	7.65 ^b	7.3 ^a	8.45 ^b	134 ^a ±4	150 ^b ±5	8 ^a ±1	4 ^b ±1
	± 0.04	± 0.02	± 0.03	± 0.03				
W10	7.19 ^a	7.23 ^b	4.90 ^a	5.18 ^b	76 ^a ±3	92 ^b ±5	2 ^a ±0	2 ^a ±0
	± 0.02	± 0.02	± 0.02	± 0.02				

Values are means of 3 replicate $\pm$ standard deviation

Mean values followed by different alphabets for the same parameter are significantly different at 95% confidence level using T- test statistical analysis

Key: BD= Undisinfected water (control); AD= disinfected water; W(1 - 10) = Well water samples

Table 2: Total heterotrophic counts of the undisinfected and disinfected well water samples

Sampling Sites	Bacterial count $\times 10^2$ (cfu/ml)		Total coliform $\times 10^1$ (cfu/ml)		Faecal coliform (cfu/ml)	
	BD	AD	BD	AD	BD	AD
W1	57 ^a ±4.0	6.0 ^b ±1.0	30 ^a ±3.0	0 ^b ±0.0	0 ^a ±0.0	0 ^a ±0.0
W2	1.0 ^a ±0.0	0 ^b ±0.0	21 ^a ±2.0	0 ^b ±0.0	0 ^a ±0.0	0 ^a ±0.0
W3	1.8 ^a ±0.0	0 ^b ±0.0	10 ^a ±1.0	0 ^b ±0.0	0 ^a ±0.0	0 ^a ±0.0
W4	1.0 ^a ±0.0	0 ^b ±0.0	10 ^a ±1.0	0 ^b ±0.0	0 ^a ±0.0	0 ^a ±0.0
W5	420 ^a ±10.0	2.0 ^b ±0.0	270 ^a ±10	20 ^b ±1.0	0 ^a ±0.0	0 ^a ±0.0
W6	27 ^a ±3.0	3.0 ^b ±0.0	20 ^a ±2.0	0 ^b ±0.0	0 ^a ±0.0	0 ^a ±0.0
W7	60 ^a ±4.0	2.0 ^b ±0.0	20 ^a ±2.0	0 ^b ±0.0	0 ^a ±0.0	0 ^a ±0.0
W8	27 ^a ±2.0	7.0 ^b ±1.0	0 ^a ±0.0	0 ^a ±0.0	0 ^a ±0.0	0 ^a ±0.0
W9	6.0 ^a ±1.0	1.0 ^b ±0.0	0 ^a ±0.0	0 ^a ±0.0	0 ^a ±0.0	0 ^a ±0.0
W10	6.0 ^a ±1.0	1.0 ^b ±0.0	0 ^a ±0.0	0 ^a ±0.0	0 ^a ±0.0	0 ^a ±0.0

Values are means of 3 replicate $\pm$ standard deviation

Mean values followed by different alphabets for the same parameter are significantly different at 95% confidence level using T- test statistical analysis

Key: BD= Undisinfected water (control); AD = disinfected water; W(1 - 10) = Well water samples

Discussion

This study shows that the well water samples varied in their physicochemical and bacteriological quality. This could be as a result of the location of the wells, human usage, condition of the well (covered or uncovered, ringed or unringed etc), sanitation and other environmental factors.

The pH values of the well water samples analyzed in this study were all in conformity with the WHO standard of 6.5 - 8.5 (NIS, 2007; WHO, 2008). pH plays an important role in the growth and survival of bacteria. Bacteria generally grow well at pH between 6.0 - 8.0 and more at neutral pH. With increasing pH levels, there is also a progressive decrease in the effectiveness of chlorine disinfection processes (De Zuane, 1997). In this study, it was observed that the pH of the well water samples increased on addition of the disinfectant, but still within the acceptable limit.

Generally, the higher the chlorine content, the lower the bacterial load of the water (Dada *et al.*, 1990). This explains why water from well 2 with a chloride content of 19.9mg/l had the lowest bacterial count of 1.0×10^2 cfu/ml and water from well 5 with the lowest chlorine content of 4.05mg/l has the highest bacterial count of 4.2×10^4 cfu/ml. The total hardness of water is expressed in terms of the amount of calcium and magnesium salts. Water is considered soft if it contains 0-60 mg/l of hardness, moderately hard from 61-120 mg/l, hard between 121-180 mg/l, and very hard if more than 180 mg/l (De Zuane, 1997). Very hard water is not desirable for many domestic use. In this study only water from wells 4, and 8 are considered soft before disinfection while others were hard water either before or after disinfection. Total suspended solids or turbidity is the material in water that affects the transparency or light scattering ability of the water. Generally, the higher the suspended solid content, the higher the organic matter content, and hence the higher the bacterial load (Dada *et al.*, 1990). The total viable bacterial count of the water showed that all the well water samples, with the exception of water from wells 2 and 4, are not in conformity with the WHO standard of drinking water which allowed 100cfu/ml (NIS, 2007). The physicochemical characteristics of the water from the wells may have effect on the bacterial load of the water. The addition of the disinfectant to the well water samples led to a drastic reduction in their bacterial load. Presence of coliform in water may or may not be due to faecal contamination. The WHO guideline for total coliform states that no coliform should be detected in 100ml of water samples (Osunide and Enuezie, 1999; EPA, 2002; WHO, 2008). In this study, all the water samples with the exception of water from well 5 had zero total coliform count on addition of the disinfectant. No faecal coliform i.e. *E.coli* was isolated from any of the well water samples either before or after disinfection.

Recommendations

It is recommended that good hygiene should be employed in the use of well water. Wells should not be constructed in the flood plain. Well covers should be replaced immediately upon any physical damage. It is also advisable to chlorinate the well water upon construction and when it has been opened for a long time. The quality of the well can also be improved by lining the well, fitting a pump, and ensuring that the area is kept clean and free from stagnant water and animals. The well water should not be assumed to be clean and pure by physical examination alone, bacteriological as well as physicochemical analysis of the water should also be done at least twice a year.

Conclusion

It can be concluded from this study that the 'disinfectant A' disinfectant has helped to reduce the bacterial load of the well water samples and its use is encouraged.

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COMPARATIVE STUDY OF COLIFORM CONTAMINATION OF PUBLIC WELLS AND PIPE BORNE WATER SUPPLIES IN BOSSO, MINNA, NIGER STATE

OYEDUM, U. M.

Department of Microbiology, School of Life Sciences,
Federal University of Technology, Minna, Nigeria

E-mail: hemdi41@gmail.com

Phone No: +234-706-800-4509

Abstract

This study was carried out to determine the coliform contamination of public wells and pipe borne water supplies within Bosso town. Twenty (20) water samples comprising of 10 each of wells and pipe borne samples were aseptically collected from Bosso Town and analyzed using membrane filtration technique. The results obtained showed that all the water samples from the well and pipe had coliform counts above 10cfu/100ml. The organisms isolated and identified through various biochemical tests, included species of Escherichia, Pseudomonas, Streptococcus, Staphylococcus, Salmonella, Shigella, Campylobacter, Bacillus, Proteus, Helicobacter, Klebsiella, and Yersinia. E.coli had the highest frequency of occurrence (24.4%) followed by Helicobacter pylori (13.3%), Staphylococcus aureus (10.0%), Salmonella typhi (8.9%), Shigella flexneri (6.7%), Streptococcus faecalis (5.6%), Streptococcus pyogenes (5.6%), Campylobacter jejuni (4.4%), Pseudomonas aeruginosa (4.4%), Bacillus subtilis (4.4%), Proteus mirabilis (4.4%), Klebsiella pneumonia (3.3%), Proteus vulgaris (3.3%) and Yersinia enterocolitica (1.1%). This study revealed that well water and pipe borne water samples were contaminated, with greater contamination observed with well water. This highlights the need for a continuous assessment of the quality of public water supply and intervention measures to prevent outbreak of water-borne diseases.

Keywords: Pipe borne, Well, water, organisms, water-borne disease

Introduction

Water, as one of the basic components of life is important to man, animals and plants (Ajewole, 2005). It is an essential medium required to sustain life of all living organisms, due to its unique chemical and physical properties (Obi and Okocha, 2007). According to Third World Academy of Science (TWAS), safe drinking water is a basic human requirement and it is essential for sustainable development (Omar, 2008). Also, when water is distributed to the end users, in a condition in which it is produced with required treatments, the microbial load would be reduced to a safe level (Nwachukwu *et al.*, 2000). Unfortunately, prior to the time water gets to its end users, it is usually prone to various microbial contaminations with pathogenic microorganisms, which constitute serious threat to public health (Stender *et al.*, 2001). Many people, especially in the developing world, depend on untreated surface and ground water sources for their daily water needs, and water from these sources are often contaminated (Omar, 2008).

Most water bodies contaminated with faecal coliforms clearly indicate that the water body contains other opportunistic organisms that are medically important to humans, which may cause severe illness and subsequently death. Environmental Protection Agency (EPA) (2009) reported that high pathogens in water bodies may result from inadequately treated sewage discharged from various septic tanks, and use of such water by the general populace leads to

acquisition of pathogens through various routes of transmission such as: Oral, Dermal and as Aerosol (Hailer *et al.*, 1999; APEC, 2010).

The faecal pathogens in most water supplies are diverse groups of organisms such as bacteria (e.g. *E. coli* 0157: H7, *Shigella* spp, *Campylobacter jejuni*, *Salmonella* spp and *Yersinia* spp), protozoa (for example, *Entamoeba histolytica*, *Gardia* spp and *Cryptosporidium* spp) and viruses (e.g. Noroviruses, Enteroviruses, Adenoviruses, Rotaviruses and Hepatitis A and E viruses) (Jorge *et al.*, 2008). Also, some water borne pathogenic diseases that may coincide with faecal contamination include ear infections, dysentery, typhoid fever, cholera, encephalitis, giardiasis, gastroenteritis and hepatitis (Hailer *et al.*, 1999).

Generally, the water obtained from most public water supplies, is expected to be a life-supporting medium, but studies have shown such water from various water supplies does not only improve the standard of life but can also serve as a carrier of dangerous pathogens (Oyedum, 2010). However, the role of contaminated water in the transmission of disease and the importance of water in public health cannot be overemphasized, based on the fact that it is difficult for the general public to distinguish between safe water and portable water, thereby increasing their vulnerability to illness that normally arises from the consumption of contaminated water. Therefore, it is imperative that various public water supplies are evaluated continuously to enable the detection and prevention of disease outbreaks. This study is therefore aimed at evaluating the quality of various public water supplies to Bosso and its environs, where the general populace depends on it for their daily activities and survival.

Materials and Methods

Study Area: The study was conducted between May and August 2015 in Bosso Central, Bosso Low-cost, Bosso Estate, Okada Road, El-waziri, Anguwan Tukura, Tudun Fulani, Rafin Yanshi, Federal University of Technology (FUT) Bosso Campus and Maikunkele all in Bosso Local Government Area of Niger State. All the taps and wells sampled were constructed close to buildings with soakaways, pit latrines or refuse dump sites and were frequently used by the inhabitants around the area for drinking and other domestic purposes.

Collection of Samples: Aliquots of two hundred milliliters (200 mls) each of twenty samples (made up of 10 samples of tap and 10 samples of well water) were collected aseptically in sterile sampling bottles and taken to the laboratory immediately for analysis within 3 hours (Adabara *et al.*, 2011).

Analyses of Samples: The samples were analyzed using membrane filter technique. Prior to filtration, each of the two hundred milliliters (200 mls) of water sample aseptically collected was divided to obtain two sets of 100ml of the water sample. The two sets of the hundred milliliters (100mls) were filtered simultaneously using 0.45µm pore sized membrane filter with 47mm diameter. The filter papers for each sample were then aseptically transferred onto two Petri dishes containing absorbent pads soaked previously in membrane lauryl sulphate broth using sterile forceps. These steps were subsequently repeated for each other sample of the water collected. The two Petri dishes for each sample were inverted and incubated at 30°C for 4 hours. After which, one of the Petri dishes was then transferred to an incubator at 37°C for 14 hours, to isolate the total coliform, while the second Petri dish was placed in an incubator for 44°C for 14 hours for the isolation of faecal coliform respectively. The yellow colonies appearing on the plates were counted immediately following the incubation period (Oyedum, 2010).

Identification of Isolates: Isolates from primary cultures incubated at (37°C and 44°C) were aseptically subcultured on to fresh media (such as, MacConkey agar and Nutrient agar) to obtain pure cultures using the streak plate technique. The pure isolates were identified and characterized and were stored into already prepared slant bottles. This was done using cultural characteristics and appropriate biochemical tests such as Coagulase, Catalase, Urease, Indole, Sugar fermentation, Citrate utilization, Mannitol salt and Starch hydrolysis. The isolates were identified using the schemes of Cheesbrough (2006).

Result

The result obtained showed that faecal coliform count from the wells ranged from 35.0 to 135.0 cfu/100ml while faecal coliform count from the taps ranged from 8.0 to 100.0 cfu/100ml. The result also showed that total coliform count from the wells ranged from 100.0 to 360.0 cfu/100ml while total coliform count from the taps ranged from 70.0 to 228.0 cfu/100ml (Table 1).

Ninety (90) isolates were identified and characterized from the water samples analysed. *E.coli* had the highest frequency of occurrence followed by *Helicobacter pylori*, *Staphylococcus aureus*, *Salmonella typhi*, *Shigella flexneri*, *Streptococcus faecalis*, *Streptococcus pyogenes*, *Campylobacter jejuni*, *Pseudomonas aeruginosa*, *Bacillus subtilis*, *Proteus mirabilis*, *Klebsiella pneumoniae*, *Proteus vulgaris*, and *Yersinia enterocolitica* (Table 2).

TABLE 1. Coliform count in samples of well and pipe borne water

Location of sample collected	Faecal coliform counts for well water $\times 10^2$ (cfu/100 ml)	Percentage faecal coliform count for well water (%)	Total coliform count for well water $\times 10^2$ (cfu/100ml)	Percentage total coliform count for well water (%)	Faecal coliform count for Pipe borne water $\times 10^2$ (cfu/100ml)	Percentage faecal coliform count for pipe borne water (%)	Total coliform count for pipe borne water $\times 10^2$ (cfu/100ml)	Percentage total coliform count for pipe borne water (%)
Rafin Yashi	0.60	8.8	1.60	8.1	0.35	8.8	1.30	9.3
Bosso Low cost	0.80	11.8	1.58	8.0	0.58	14.6	1.50	10.7
EL-Waziri	0.94	13.8	2.50	12.7	0.82	20.6	1.80	12.9
Anguwan Tukura	0.76	11.2	1.80	9.1	0.15	3.8	0.98	7.0
Okada Road	0.48	7.1	1.12	5.7	0.30	7.5	1.60	11.4
Maikunkele	0.52	7.6	2.30	11.7	0.10	2.5	0.90	6.4
F.U.T Minna	0.60	8.8	2.50	12.7	0.08	2.0	0.70	5.0
Tudun Fulani	0.40	5.9	1.00	5.1	0.20	5.0	1.20	8.6
Bosso Estate	0.35	5.1	1.00	8.6	0.40	10.0	1.72	12.3
Bosso Central	1.35	19.9	3.60	18.3	1.00	25.1	2.28	16.3

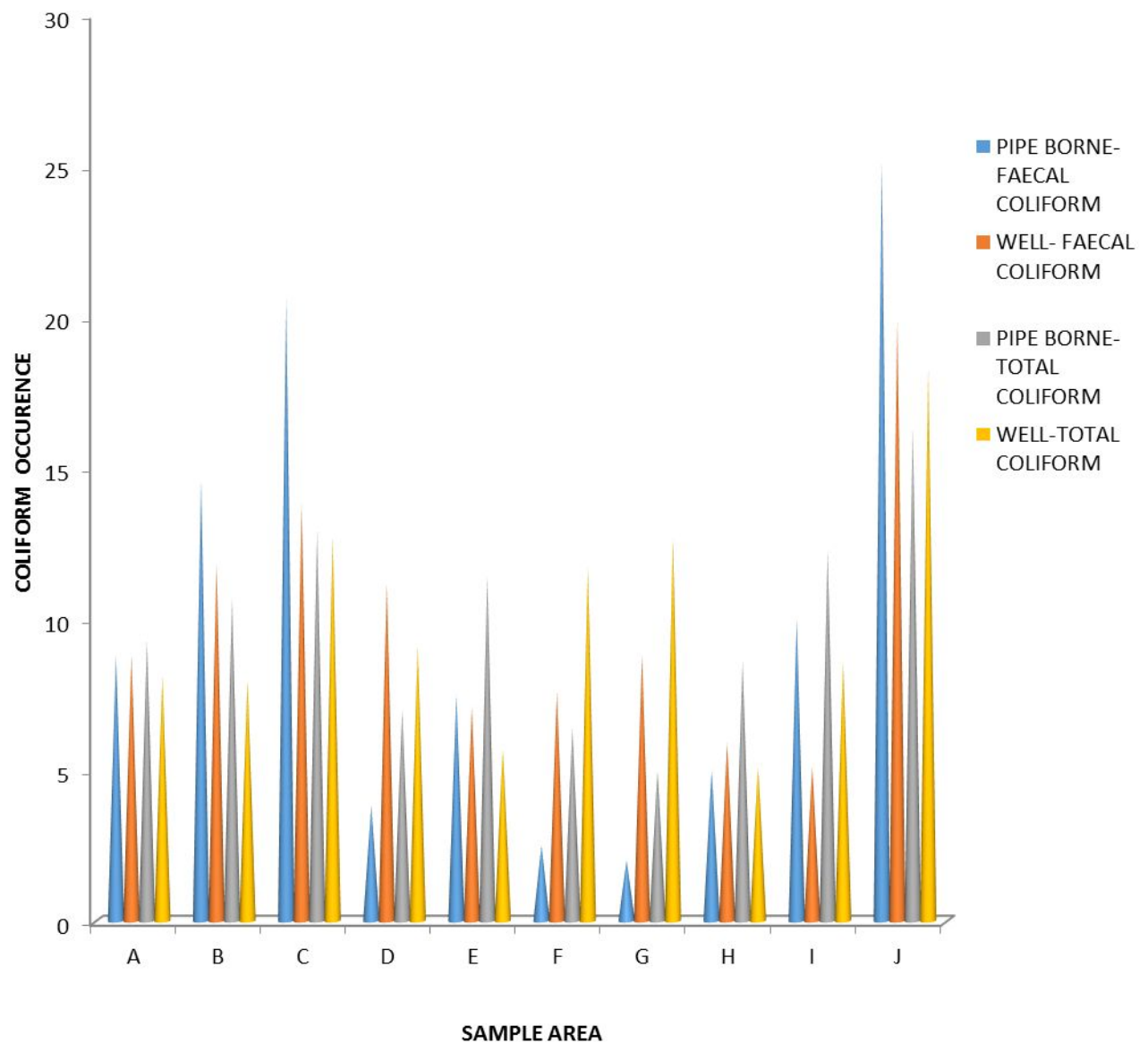


Table 2 shows a total of 90 isolates in the descending order of their frequency of occurrence as *E.coli*, *Helicobacter pylori*, *Staphylococcus aureus*, *Salmonella typhi*, *Shigella flexneri*, *Streptococcus faecalis*, *Streptococcus pyogenes*, *Campylobacter jejuni*, *Pseudomonas aeruginosa*, *Bacillus subtilis*, *Proteus mirabilis*, *Klebsiella pneumoniae*, *Proteus vulgaris*, and *Yersinia enterocolitica*.

Table 2. Frequency of occurrence of bacterial isolates

Organisms	Frequency	Percentage (%)
<i>E.coli</i>	22	24.4
<i>Helicobacter pylori</i>	12	13.3
<i>Staphylococcus aureus</i>	9	10.0
<i>Salmonella typhi</i>	8	8.9
<i>Shigella flexneri</i>	6	6.7
<i>Streptococcus faecalis</i>	5	5.6
<i>Streptococcus pyogenes</i>	5	5.6
<i>Campylobacter jejuni</i>	4	4.4
<i>Pseudomonas aeruginosa</i>	4	4.4
<i>Bacillus subtilis</i>	4	4.4
<i>Proteus mirabilis</i>	4	4.4
<i>Klebsiella pneumoniae</i>	3	3.3
<i>Proteus vulgaris</i>	3	3.3
<i>Yersinia enterocolitica</i>	1	1.1
Total	90	100

Discussion

The results shown in Table 1 revealed that the public water analysed within the study areas were contaminated. All the well water samples had coliform counts above the World Health Organization (WHO) recommended standard, of not more than 10 coliform organisms / 100ml of water (WHO, 2003). This result could be attributed to the fact that, well water which is one of underground sources of water is commonly used, due to the fact that wells are easily constructed and affordable and based on this, little or no attention is given to the adequate construction of wells. For this reason, most of these wells sampled in the study area lacked adequate concrete lining and were inadequately elevated, thereby collecting the runoff of surface water that contained coliforms. This result agrees with the findings of Bala (2006), Oyedum (2010) who reported that most of the wells sampled were not lined with concrete and were lowly elevated. However, the entire pipe borne water sampled had coliform counts above 10 coliform organisms /100ml of water. The pipe borne water contamination observed in this study maybe due to the fact that most water distributors pay less attention in flushing the head pumps and pipes of these pipe borne- water adequately to prevent the accumulation of microorganisms. Also, in most cases the head pumps and the pipes are not protected from formites regularly. Based on these, they are thus said to serve as habitats for various coliforms which give rise to the development of biofilms and this constantly contaminates the water that flows out, for the populace to use. This result is similar with the result of Okoko and Idise, (2014) who reported that the presence of biofilms in the various tap water could be attributed to defective joints on the pipes, rusted pipes crossing over the sewage or low/ high pressure in sewage pipes.

Furthermore the heavy coliform contamination of these well water sampled could be attributed to the fact that most of these wells were observed to lack proper covers/lids. Unfortunately, due to the fact that these wells sampled were inappropriately protected, most of these wells were exposed to animal droppings, dead animals, nasal droplets, rain splash, seepage splash, sewage, formites and wind heavily contaminated with coliforms. This result

is similar with the result of Adabara *et al.* (2011). In addition, most of the wells sampled lacked sterile and permanent water fetchers to draw water from these wells, due to this practice, these wells are faced with heavy microbial contamination. This result is similar to that of Bala (2006), who reported that well due to inadequate coverings could be polluted by dirt on different tins or buckets that are lowered into the wells. On the other hand, the high microbial contamination observed in the various taps is an indication that the pipes due to improper handling during their production and their lack of adequate maintenance, prior to their usage in the supply of water, serve as habitat to various contaminants in the environment and base on this, they are said to enhance the contamination level of the water that passes through them. According to the report of WHO (2003), the level of contaminations in various water supplies, is regarded as a risk factor, which enhances the outbreak of diseases like cholera or typhoid. In addition, the contamination of these tap water is also based on the fact that, the source of the water that is channeled through the pipes, are heavily contaminated with coliforms and in most cases such pipe borne water lack adequate chlorination (chlorine residual of 1mg/l or greater for at least 30minutes) (Ibrahim *et al.*, 2013) to eradicate these coliforms before the water is supplied.

The area with the highest percentage of faecal coliform contamination is Bosso central (Figure 1). This result could be attributed to the fact that various unhygienic life styles such as localize and mechanize farming with human faeces, construction of soakaways, septic tanks and pit latrines and irregular defecation are highly practiced around the locations of the wells and taps in this area. The farming and construction activities lead to violation of the pipelines and this in turn could lead to the penetration of various microorganisms including coliforms into the various pipelines within this area. This result agrees with the findings of Bala (2006); Mashi (2013) who reported that damage on the pipelines in the environment where they are laid permit the contamination of the tap water by sewage that easily seeps into the broken pipes. Consequently such contaminated water in turn, lead to the cause and spread of waterborne infections, such as typhoid fever, amoebic dysentery, bacillary dysentery, cholera, poliomyelitis and hepatitis as reported by Geldreich (2005), Okoko and Idise (2014).

Organisms isolated from the water samples in this study were species of *Escherichia*, *Helicobacter*, *Staphylococcus*, *Salmonella*, *Shigella*, *Streptococcus*, *Campylobacter*, *Pseudomonas*, *Bacillus*, *Proteus*, *Yersinia* e.t.c. This findings agree with result of Benka-Coker and Olimani (1995); Edema *et al.*(2006) and Ukpong (2008) whose works revealed that these organisms are basically regarded as water resident organisms. *E.coli* had the highest frequency of occurrence (24.4%) followed in descending order by *Helicobacter pylori* (13.3%), *Staphylococcus aureus* (10.0%), *Salmonella typhi* (8.9 %), *Shigella flexneri*(6.7%), *Streptococcus faecalis* (5.6%), *Streptococcus pyogenes* (5.6%), *Campylobacter jenuni* (4.4%), *Pseudomonas aeruginosa* (4.4%), *Bacillus subtilis* (4.4%), *Proteus mirabilis*(4.4%), *Klebsiella pneumonia* (3.3%), *Proteus vulgaris* (3.3%), and *Yersinia enterocolitica* (1.1%). *E. coli* with the highest frequency in this study indicates that the water from these various sources were faecally contaminated recently because *E.coli* is an indicator of recent faecal contamination. The result obtained from this study also agrees with the findings of Bala (2006), who isolated various organisms from the water samples from various areas in Jimeta, Yola, Adamawa State with *E.coli* having the highest frequency of occurrence.

Conclusion

In conclusion, the indication of contamination in both well and tap water is basically due to inadequate attention given to the various water sources and their constructions, to enable them serve as portable water supplies, which is essential to a human life. It is therefore

recommended that environmental health workers should help in carrying out efficient surveillance on the various water sources on regular basis to help detect lapses on the pipelines or boreholes and immediately give suggestions on how to solve the problem to avoid outbreak of waterborne disease. In addition, the Pipeline and Wells should be adequately constructed and fortified to avoid damage. Effective and sufficient chlorination treatment should be carried out on various water bodies before they are channeled to various pipelines for usage.

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ON PARTICULAR SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS WITH CONSTANT COEFFICIENTS: A REVIEW

¹M. H. ALI., ²IBRAHIM YAHAYA MUHAMMAD., ²MUHAMMAD MUDASSIR USMAN
& ²SUNUSI DAYYAB MUHAMMAD

¹Department of Physics, Bayero University, Kano.

² Department of Physics, Kano University of Science and Technology, Wudil.

E-mail: alim@buk.edu.ng, Ibrahimyahaya29@yahoo.com, mmusman1007@gmail.com,
sunusidayyab@gmail.com

Abstract

The particular solution of ordinary differential equations with constant coefficients is normally obtained using the method of undetermined coefficients where it is applicable. This method sometimes appears unnecessarily lengthy when inhomogeneous function contains product of trigonometric functions and polynomials. Strength and weakness of three alternatives to it are investigated using six examples. The result shows that the three methods performed better than the method of undetermined coefficients in all cases except when the inhomogeneous function is only exponential. Also the method in (Jia & Sogabe, 2013) excel in cases of higher order differential equations and lack of guessing in its procedure.

Keywords: Ordinary differential equation, Inhomogeneous equation

Introduction

The ubiquitousness of ordinary differential equations with constant coefficient in natural sciences cannot be over emphasized. The inhomogeneous differential equations with constant coefficient do exist also in many applications. The particular solution to the inhomogeneous part has two popular methods; the variation of parameters and the method of undetermined coefficients.

The method of undetermined coefficients is simpler compared to the general method of variation of parameters for lack of integration. However, besides its limitation to work with few functions, in some cases it turns out to be lengthy especially when the inhomogeneous function contains product of the appropriate functions. This leads to the evolution of additional alternatives, (De Leon, 2010; Gupta, 1998; Jia & Sogabe, 2013; Leon, 2015; Oliveira, 2012; Ortigueira, 2014).

Having more than one alternative means that each will have cases where it is better compared to the rest. In this work six examples are considered to investigate the strength and weakness of the three alternatives to the method of undetermined coefficients.

Procedure

The general procedure of obtaining solutions by four methods, are first presented as follow;

A. Method of Undetermined Coefficients: Rules of Thumb (Boyce & DiPrima, 1992) for ordinary differential equation of the form

$$ay'' + by' + cy = g(t), \quad (1)$$

Where a, b and c are constants

- (i) If an exponential function appears in $g(t)$, the guessing of the particular solution $Y(t)$ is an exponential function of the same exponent.
- (ii) If a polynomial appears in $g(t)$, the guessing of $Y(t)$ is a generic polynomial of the same degree.
- (iii) If $g(t)$ contains either cosine or sine functions, the guessing of $Y(t)$ have to contain both cosine and sine of the same frequency.

- (iv) If $g(t)$ is a sum of several appropriate functions, separate it into n part and solve them individually (Superposition Methods).
- (v) If $g(t)$ is a product of the normal functions, the starting choice for $Y(t)$ is chosen based on:
 - (a) $Y(t)$ is a product of the corresponding choices of all the parts of $g(t)$.
 - (b) There are as many coefficients as the number of distinct terms in $Y(t)$.
 - (c) Each distinct term must have its own coefficient, not shared with any other term.
 - i. Before finalizing the choice of $Y(t)$, compare it against the homogeneous solution $y(t)$. If there is any shared term between the two, the present choice of $Y(t)$ needs to be multiplied by t. Repeat until there is no shared term.

B. The Method of Gupta (Gupta, 1998)

The guessing for the particular solution is in general $Y(t) = u(t)e^{\alpha t}$ where u is a polynomial and α is a constant. The exponential term represents both the sine, cosine and the ordinary exponential functions. The polynomial $u(t)$ is obtained after substituting the guessed solution into the given inhomogeneous differential equation.

C. The De Oliveira Method (Oliveira, 2012)

The propose particular solution

$$Y(t) = Q(t)e^{\gamma t + i\delta} \quad (2)$$

Satisfying the differential equation

$$\frac{p^n(\gamma)}{n!} Q^n + \dots + \frac{p'(\gamma)}{1!} Q' + \frac{p(\gamma)}{0!} Q = R \quad (3)$$

Moreover

- a) If $\gamma \in \mathbb{R}$, then we can suppose that Q is real. In such case, the real function $x(t) = Q(t)e^{\gamma t}$ is a solution of the initial equation.
- b) If $\gamma \notin \mathbb{R}$, then $z(t) = Q(t)e^{\gamma t + i\delta}$ is a complex solution. If $\gamma = \alpha + \beta i$, where $\alpha, \beta \in \mathbb{R}$, then the function $x(t) = \text{Re}[z(t)]$ and $y(t) = \text{Im}[z(t)]$ satisfy $P\left(\frac{d}{dt}\right)x = R(t)e^{\alpha t} \cos(\beta t + \delta)$, and $P\left(\frac{d}{dt}\right)y = R(t)e^{\alpha t} \sin(\beta t + \delta)$. (4)
- c) If $p(\gamma) \neq 0$, then we have $\text{degree}(Q) = \text{degree}(R)$.
- d) If γ is a root of multiplicity k of the characteristic polynomial. Then we can choose a polynomial $Q(t) = t^k Q_1(t)$, with $\text{degree}(Q_1) = \text{degree}(R)$

D. The Jia and Sogabe Method (Jia & Sogabe, 2013)

This is similar to the Gupta's guess; $Y(t) = u(t)e^{\alpha t}$ but the $u(t)$ is directly calculated as follows;

- (a) if α is not the root of the characteristic equation of the homogeneous differential equation then

$$u(t) = \sum_{i=0}^m d_i g^{(i)}(t) \quad (5)$$

Where $d_0 = 1$ and $d_i = -\frac{k!}{p^{(k)}(\alpha)} \sum_{j=0}^{i-1} \frac{p^{(i-j)}(\alpha)}{(i-j)!} d_j$, for $i=1, 2, 3, \dots, m$ also $g(t) = \frac{f(t)}{p^{(k)}(\alpha)}$

- (b) if α is the root of the characteristic equation with multiplicity k, then

$$u^{(k)}(t) = \sum_{i=0}^m d_i g^{(i)}(t) \quad (6)$$

Where $d_0 = 1$ and $d_i = -\frac{k!}{p^{(k)}(\alpha)} \sum_{j=0}^{i-1} \frac{p^{(i+k-j)}(\alpha)}{(i+k-j)!} d_j$, for $i=1, 2, 3, \dots, m$ also $g(t) = \frac{f(t)}{p^{(k)}(\alpha)}$

Each of the above four methods is used to solve the following six examples in order to assess the amount of the activities needed to arrive at a solution of the given example.

Example 1: Consider

$$y'' + y = t \sin t \quad (7)$$

The homogeneous solution is given as

$$y_h = c_1 \sin t + c_2 \cos t \quad (8)$$

Method of Undetermined Coefficient for Example 1

For the particular solution using the method of undetermined coefficient we guess

$$Y(t) = t(At + B) \sin t + t(Ct + D) \cos t \quad (9)$$

Since $\sin t$ is a solution to the homogeneous equation. This leads to the following derivatives;

$$Y'(t) = (At^2 + B) \cos t + (2At + B) \sin t - (Ct^2 + Dt) \sin t + (2Ct + D) \cos t \quad (10)$$

$$Y''(t) = (2At + B) \cos t - (At^2 + B) \sin t + (At + B) \cos t + (2A) \sin t - (Ct^2 + Dt) \cos - (2Ct + D) \sin - (2C) \cos - (2Ct + D) \sin \quad (11)$$

Substituting (11) and (9) results into (7) gives

$$A = -\frac{1}{4}, B = 0, C = 0, \text{ and } D = -\frac{1}{4}$$

This yield a particular solution

$$Y(t) = -\frac{1}{4} t^2 \cos t + \frac{t}{4} \sin t \quad (12)$$

Method of Gupta for Example 1

Based on this method we guess $Y(t)$ to be

$$Y(t) = u(t) e^{\alpha t} \quad (13)$$

Where $u(t)$ is a polynomial and differentiating $Y(t)$ we get

$$Y' = u' e^{\alpha t} + \alpha u e^{\alpha t} \quad (14)$$

$$Y'' = u'' e^{\alpha t} + 2\alpha u' e^{\alpha t} + \alpha^2 u e^{\alpha t} \quad (15)$$

Substituting (13) and (15) in (7) gives

$$(u'' + 2\alpha u' + \alpha^2 u + u) e^{\alpha t} = t e^{it} \quad (16)$$

Setting $\alpha = i$, and let $v = u'$ (16) becomes

$$v' + 2iv = t \quad (17)$$

Then we guess $v = At + B$, (17) finally gives

$$A = -\frac{i}{4} \text{ and } B = \frac{1}{4}$$

Therefore, $u(t) = \left(-\frac{i}{4} + \frac{1}{4}t\right)$ and choosing the imaginary part of our initial guessing of $Y(t)$ gives

$$Y(t) = -\frac{1}{4} t^2 \cos t + \frac{1}{4} t^2 \sin t \quad (18)$$

Method of De Oliveira for Example 1

This is similar to Gupta method in that, the sine function is replaced with exponential as

$$y'' + y = t e^{it} \quad (19)$$

The characteristic polynomial is $p(\lambda) = \lambda^2 + 1$, $p'(\lambda) = 2\lambda$ and $p''(\lambda) = 2$. Inserting $p(\lambda)$ and its derivatives in the following equation

$$\left[\frac{p^{(n)}(\lambda)}{n!} q^{(n)} + \dots + \frac{p''(\lambda)}{2!} q'' + \frac{p'(\lambda)}{1!} q' + p(\lambda) q \right] e^{\lambda t} = f(t) \quad (20)$$

Gives

$$[q'' + 2\lambda q' + (\lambda^2 + 1)q] e^{\lambda t} = t e^{it} \quad (21)$$

with $\lambda = i$, (21) becomes

$$q'' + 2iq' = t \quad (22)$$

We guess $q = At^2 + Bt$, since $\sin t$ is solution to the homogeneous case. Differentiation of q gives $q' = 2At + B$ and $q'' = 2A$. Substituting q'' and q' in (22), solving for A and B gives

$$A = -\frac{1}{4} \text{ and } B = \frac{1}{4}$$

Then $q = -\frac{i}{4} t^2 + \frac{1}{4} t$ We have $y = q e^{\lambda t}$

$$Y(t) = \left(-\frac{i}{4} t^2 + \frac{1}{4} t\right) (\cos t + i \sin t) \quad (23)$$

The particular solution is the imaginary part of y

$$Y(t) = -\frac{1}{4}t^2 \cos t + \frac{1}{4}t \sin t \quad (24)$$

Method of Jia and Sogabe for Example 1

Changing the right hand side of (7) to complex form gives

$$y'' + y = te^{it} \quad (25)$$

Set $p(\lambda) = \lambda^2 + 1$, $f(t) = t$, $\alpha = i$. Since $p(\alpha) = 0$ and $p' \neq 0$, we have $k = 1$

$$\text{Set } g(t) = f(t) \cdot \frac{k!}{p^{(k)}(\alpha)} = -\frac{1}{2}it$$

$$\text{Set } d_0 = 1 \text{ and } d_i = -\frac{k!}{p^{(k)}(\alpha)} \sum_{j=0}^{i-1} \frac{p^{(i+k-j)}(\alpha)}{(i+k-j)!} d_j$$

By using d_i , we get

$$d_1 = -\frac{1}{p'(\alpha)} \cdot \frac{p''(\alpha)}{2!} d_0 = -\frac{1}{2}i \quad (26)$$

Then set

$$\begin{aligned} u^{(k)}(t) &= \sum_{i=0}^m d_i g^{(i)}(t) \\ u'(t) &= \sum_{i=0}^1 d_i g^{(i)}(t) = -\frac{1}{2}it + \frac{1}{4} \end{aligned} \quad (27)$$

Hence

$$u(t) = -\frac{1}{2}it^2 + \frac{1}{4}t \quad (28)$$

Finally, we obtain the particular solution from the imaginary part of

$$y = u(t)e^{\alpha t} = \left(-\frac{1}{4}t^2 + \frac{1}{4}t\right)(\cos t + i \sin t) \quad (29)$$

We have

$$y_p = -\frac{1}{4}t^2 \cos t + \frac{1}{4}t \sin t \quad (30)$$

Example 2: Consider

$$y'' - 5y' + 6y = 2e^{3t} \quad (31)$$

The homogeneous solution is given as

$$y_h = c_1 \sin t + c_2 \cos t \quad (32)$$

Method of Undetermined Coefficient for Example 2

Our first choice is $Y(t) = Ce^{3t}$. But this is one of the solutions of the homogenous case. Therefore $Y(t) = Cte^{3t}$, $Y'(t) = 3Cte^{3t} + Ce^{3t}$ and $Y''(t) = 9Cte^{3t} + 3Ce^{3t} + 3Ce^{3t}$ putting $Y(t)$ and its derivatives in (29) gives

$$9Ce^{3t} + 6Ce^{3t} - 15Cte^{3t} - 5Ce^{3t} + 6Cte^{3t} = 2e^{3t} \quad (33)$$

and $C = 2$ thus

$$Y(t) = 2te^{3t} \quad (34)$$

Method of Gupta for Example 2

$$\text{Given } y'' - 5y' + 6y = 2e^{3t} \quad (35)$$

Let $Y(t) = Ue^{\alpha t}$, $Y'(t) = U'e^{\alpha t} + U\alpha e^{\alpha t}$ and $Y''(t) = U''e^{\alpha t} + 2U'\alpha e^{\alpha t} + U\alpha^2 e^{\alpha t}$

Substituting $Y(t)$ and its derivatives in (35) gives

$$U''e^{\alpha t} + 2U'\alpha e^{\alpha t} + U\alpha^2 e^{\alpha t} - 5U'e^{\alpha t} - 5U\alpha e^{\alpha t} + 6Ue^{\alpha t} = 2e^{3t} \quad (36)$$

This shows that $\alpha = 0$ Therefore (36) becomes

$$U'' - 5U' + 6U = 2e^{3t} \quad (37)$$

Guessing $U = Ae^{3t}$. Multiply the guessing by t for the same argument gives

$$U = Ate^{3t}, U' = 3Ate^{3t} + Ae^{3t} \text{ and } U'' = 9Ate^{3t} + 6Ae^{3t}$$

Putting U and its derivatives in (37) gives

$$9Ate^{3t} + 6Ae^{3t} - 15Ate^{3t} - 5Ae^{3t} + 6Ate^{3t} = 2e^{3t} \quad (38)$$

Leading to $A = 2$. Therefore $U = 2te^{3t}$, $Y(t) = Ue^{\alpha t}$

$$Y(t) = 2te^{3t} \quad (39)$$

Method of De Oliveira for Example 2

$$y'' - 5y' + 6y = 2e^{3t} \quad (40)$$

Let $Y(t) = qe^{\alpha t}$. Considering the left hand side of (40), $\alpha = 0$

$$\text{Using } \frac{p'' q''}{2!} + \frac{p' q'}{1!} + p q = Q_t \quad (41)$$

Where Q_t is real, $p(\alpha) = \alpha^2 - 5\alpha + 6 = 6$, $p'(\alpha) = 2\alpha - 5 = -5$ and $p''(\alpha) = 2$

Substituting $p(\alpha)$ and its derivatives in (41) gives

$$q'' - 5q' + q = 2e^{3t} \quad (42)$$

This is similar to (Gupta, 1998), therefore multiply the guessing by t gives $q = Ate^{3t}$, $q' = 3Ate^{3t} + Ae^{3t}$, $q'' = 9Ate^{3t} + 6Ae^{3t}$ putting these into (42) yields

$$9Ate^{3t} + 6Ae^{3t} - 15Ate^{3t} - 5Ae^{3t} + Ate^{3t} = 2e^{3t} \quad (43)$$

Which leads to $A = 2$. Therefore, the solution becomes

$$Y(t) = 2te^{3t} \quad (44)$$

Method of Jia and Sogabe for Example 2

$$y'' - 5y' + 6y = 2e^{3t} \quad (45)$$

This also shows that $\alpha = 3$ and $p(\alpha) = \alpha^2 - 5\alpha + 6$, $p(\alpha) = 0$ implying α is the root of the characteristics equation of the homogeneous part of the given differential equation.

The derivative becomes

$$p'(\alpha) = 2\alpha - 5, p'(\alpha) = 1 \text{ so } k = 1 \text{ and } p''(\alpha) = 2$$

$$\text{Then } (t) = \frac{f(t)k!}{p^k(\alpha)}, g(t) = \frac{f(t)}{p'(\alpha)}, g(t) = 2 \text{ and } g'(t) = 0.$$

$$\text{Our } U^k(t) = \sum_{j=0}^m d_j g^j(t).$$

And its derivative

$$U'(t) = g(t)d_0. \text{ Also } d_0 = 1 \text{ and } d_i = -\frac{k!}{p'(\alpha)} \sum_{j=0}^m \frac{p^{(i+k+j)}(\alpha)}{(i+k+j)} d_j \text{ then } d_1 = \frac{1}{2}$$

Therefore $U'(t) = 2$, integrating gives $U = 2t$ which leads to the final solution as

$$Y(t) = 2te^{3t} \quad (46)$$

Example 3: Consider

$$y'' - 2y' + y = x^2 \quad (47)$$

The homogenous solution is given as

$$y_h = Ae^x + Be^{-x} \quad (48)$$

Method of Undetermined Coefficient for Example 3

$$\text{Let } Y(t) = Cx^2 + Dx + E, \text{ then } Y'(t) = 2Cx + D \text{ and } Y''(t) = 2C$$

Inserting $Y(t)$ and its derivatives in (47) gives

$$2C - 2(2Cx + D) + (Cx^2 + Dx + E) = x^2 \quad (49)$$

Solving the above equation gives $C = 1$, $D = 4$ and $E = 6$ which gives results the solution as

$$Y(t) = x^2 + 4x + 6 \quad (50)$$

Method of Gupta for Example 3

$$y'' - 2y' + y = x^2 \quad (51)$$

$$\text{Let } Y(t) = ue^{\alpha x}, Y'(t) = u'e^{\alpha x} + u\alpha e^{\alpha x} \text{ and } Y''(t) = u''e^{\alpha x} + 2u'\alpha e^{\alpha x} + u\alpha^2 e^{\alpha x}.$$

Substituting $Y(t)$ and its derivatives in (51) gives

$$u''e^{\alpha x} + 2u'\alpha e^{\alpha x} + u\alpha^2 e^{\alpha x} - 2(u'e^{\alpha x} + u\alpha e^{\alpha x}) + ue^{\alpha x} = x^2 \quad (52)$$

Then (53) becomes

$$u'' - 2u' + u = x^2 \quad (53)$$

Let $u = Ax^2 + Bx + C$, then $u' = 2Ax + B$ and $u'' = 2A$ putting u and its derivatives in (53) gives

$$2A - 4Ax - 2B + Ax^2 + Bx + C = x^2 \quad (54)$$

Solving the above equation gives, $A = 1$, $B = 4$ and $C = 6$, $u = x^2 + 4x + 6$ and $Y(t) = ue^{\alpha x}$

$$Y(t) = x^2 + 4x + 6 \quad (55)$$

Method of De Oliveira for Example 3

$$y'' - 2y' + y = x^2 \quad (56)$$

The characteristics equation is $p(\lambda) = \lambda^2 - 2\lambda + 1$. Then $p'(\lambda) = 2\lambda - 2$ and $p''(\lambda) = 2$

$$\frac{p''(\lambda)}{2!} + \frac{p'(\lambda)}{1!} + p(\lambda) = x^2, \frac{2q''}{2!} - \frac{2q'}{1!} + q = x^2 \text{ and } q'' - 2q' + q = x^2 \quad (57)$$

Let $q = Ax^2 + Bx + C$ then $q' = 2Ax + B$ and $q'' = 2A$ putting these in (57) gives

$$2A - 2(2Ax + B) + (Ax^2 + Bx + C) = x^2 \quad (58)$$

Which lead to $A = 1, B = 4, C = 6$ and $y = ue^{xx}$

$$Y(t) = x^2 + 4x + 6 \quad (59)$$

Method of Jia and Sogabe for Example 3

$$y'' - 2y' + y = x^2 \quad (60)$$

Here $f(x) = x^2, \lambda = 0$ we have $d_0 = 1$ and $d_i = \frac{-1}{p(\lambda)} \sum_{j=0}^{i-1} \frac{p^{(i-j)}(\lambda)}{(i-j)!} d_j$

The characteristics equation is $p(\lambda) = \lambda^2 - 2\lambda + 1$. Then $p'(\lambda) = 2\lambda - 2$ and $p''(\lambda) = 2$

Let $Y(t) = u(x)e^{xx}$

$$d_1 = \frac{-1}{p(\lambda)} \left(\frac{p'(\lambda)}{1!} \right) d_0 \text{ therefore } d_1 = \left(\frac{-1}{1} \right) \left(\frac{-2}{1!} \right) (1) = 2 \quad (61)$$

$$d_2 = \frac{-1}{p(\lambda)} \left(\left(\frac{p''(\lambda)}{2!} \right) d_0 + \left(\frac{p'(\lambda)}{1!} \right) d_1 \right) \text{ therefore } d_2 = \left(\frac{-1}{1} \right) \left(\left(\frac{2}{2!} \right) (1) + \left(\frac{-2}{1!} \right) (2) \right) = 3$$

$$g(x) = \frac{f(x)}{p(\lambda)} \text{ by substituting back } g(x) = \frac{x^2}{1} = x^2 \quad (62)$$

$$u(x) = \sum_{i=0}^m d_i g^i(x) \text{ then } u(x) = d_0 g(x) + d_1 g'(x) + d_2 g''(x) \quad (63)$$

$$u(x) = x^2 + 4x + 6 \quad (64)$$

Therefore

$$Y(t) = x^2 + 4x + 6 \quad (65)$$

Example 4: Consider

$$y'' + 4y = \cos 2t \quad (66)$$

The homogenous solution is

$$y_h = A \cos 2t + B \sin 2t \quad (67)$$

Method of Undetermined Coefficient for Example 4

$$Y(t) = tC \cos 2t + Dt \sin 2t \quad (68)$$

$$Y'(t) = C \cos 2t - 2Ct \sin 2t + D \sin 2t + 2D \cos 2t \quad (69)$$

$$Y''(t) = -4C \sin 2t - 4Ct \cos 2t + 4D \cos 2t - 4D \sin 2t \quad (70)$$

Inserting (71) and (69) in (67) gives

$$-4C \sin 2t - 4Ct \cos 2t + 4D \cos 2t - 4D \sin 2t - 4C \sin 2t + 4D \cos 2t = \cos 2t \quad (71)$$

Solving the above equation we have $D = \frac{1}{4}, C = 0$ therefore

$$Y(t) = \frac{t}{4} \sin 2t \quad (72)$$

Method of Gupta for Example 4

$$y'' + 4y = \cos 2t = e^{2it} \quad (73)$$

Let $Y(t) = ue^{xx}, Y'(t) = u'e^{xx} + u \propto e^{xx}$ and $y'' = u''e^{xx} + 2u' \propto e^{xx} + u \propto^2 e^{xx}$

Substituting $Y(t)$ and its derivatives in (74) gives

$$u'' + 4u' = 1 \quad (74)$$

Let $v = u'$, $v' = u''$, $v = At + B$ and $v' = A$.

Putting these in (75) gives $A + 4i(At + B) = 1$ therefore $B = -\frac{i}{4}$ and $A = 0$.

Then $v = -\frac{it}{4}$, $Y(t) = ue^{\alpha t}$, $Y(t) = -\frac{it}{4}(\cos 2t + i \sin 2t)$

$$Y(t) = \frac{t}{4} \sin 2t \quad (76)$$

Method of De Oliveira for Example 4

$$y'' + 4y = \cos 2t = e^{2it} \quad (77)$$

The characteristics equation is $p(\lambda) = \lambda^2 + 4$. $p'(\lambda) = 2\lambda$ and $p''(\lambda) = 2$

Therefore $\frac{p''q''}{2!} + \frac{p'q'}{1!} + pq = 1$, $\frac{2q''}{2!} + \frac{4iq'}{1!} = 1$ and

$$q'' + 4iq' = 1 \quad (78)$$

The Same case with (Gupta) method

Let $v = q'$ and $v' = q''$. Therefore we have $v' + 4iv = 1$, $v = At + B$ and $v' = A$

Substituting these in (78) gives $A + 4i(At + B) = 1$. Which yield $B = -\frac{i}{4}$ and $A = 0$

Then $v = -\frac{it}{4}$ and $Y(t) = ue^{\alpha t} = -\frac{i}{4}(\cos 2t + i \sin 2t)$

$$Y(t) = \frac{t}{4} \sin 2t \quad (79)$$

Method of Jia and Sogabe for Example 4

$$y'' + 4y = \cos 2t = e^{2it} \quad (80)$$

In this case $\lambda = 2i$, $p(\lambda) = \lambda^2 + 4$, $p'(\lambda) = 2\lambda$, $p''(\lambda) = 2$ and $k = 1$. Then $d_o = 1$

$u^{(k)}(t) = \sum_{i=0}^m d_i g^i(t)$ and $u'(t) = d_o g(t) = -\frac{i}{4}$. Then $Y(t) = ue^{2it} = -\frac{it}{4}(\cos 2t + i \sin 2t)$

$$Y(t) = \frac{t}{4} \sin 2t \quad (81)$$

Example 5: Consider

$$y'''' - 5y''' + 3y' + 9y = te^{3t} \quad (82)$$

The homogeneous solution is given as

$$y_h = c_1 e^{3t} + c_2 t e^{3t} + c_3 e^{-t} \quad (83)$$

Method of Undetermined Coefficient for Example 5

For the particular solution using the method of undetermined coefficient we guess

$$Y(t) = (At^3 + Bt^2)e^{3t} \quad (84)$$

Differentiation of $Y(t)$ gives

$$Y'(t) = (3At^2 + 2Bt)e^{3t} + 3(At^3 + Bt^2)e^{3t} \quad (85)$$

$$Y''(t) = (6At + 2B)e^{3t} + 6(3At^2 + 2Bt)e^{3t} + 9(At^3 + Bt^2)e^{3t} \quad (86)$$

$$\text{And } Y'''(t) = 6Ae^{3t} + 9(6At + 2B)e^{3t} + 27(3At^2 + 2Bt)e^{3t} + 27(At^3 + Bt^2)e^{3t} \quad (87)$$

Substituting (87), (86) and (85) in (82) gives

$$6Ae^{3t} + 4(6At + 2B)e^{3t} = te^{3t} \quad (88)$$

Solving (88) gives $A = \frac{1}{24}$ and $B = -\frac{1}{32}$

The particular solution is

$$Y(t) = (\frac{1}{24}t^3 - \frac{1}{32}t^2)e^{3t} \quad (89)$$

Method of Gupta for Example 5

$$y'''' - 5y''' + 3y' + 9y = te^{3t} \quad (90)$$

We let $Y(t) = ue^{\alpha t}$ where u is a polynomial. Differentiation of $Y(t)$ gives

$$Y'(t) = u'e^{\alpha t} + \alpha ue^{\alpha t} \quad (91)$$

$$Y''(t) = u''e^{\alpha t} + 2\alpha u'e^{\alpha t} + \alpha^2 ue^{\alpha t} \quad (92)$$

And

$$Y'''(t) = u'''e^{\alpha t} + 3\alpha u''e^{\alpha t} + 3\alpha^2 u'e^{\alpha t} + \alpha^3 u e^{\alpha t} \quad (93)$$

Substituting $Y(t)$ and its derivatives in (90) gives

$$(u''' + 3\alpha u'' + 3\alpha^2 u' + \alpha^3 u)e^{3t} - 5(u'' + 2\alpha u' + \alpha^2 u)e^{3t} + 3(u' + \alpha u)e^{3t} + 9ue^{3t} = te^{3t} \quad (94)$$

With $\alpha = 3$, (94) becomes

$$u''' + 4u'' = t \quad (95)$$

Let $u = At^3 + Bt^2$, derivatives of u gives $u' = 3At^2 + 2Bt$, $u'' = 6At + 2B$, and $u''' = 6A$
Substituting u''' and u'' in (95) gives $6A + 4(6At + 2B) = t$ yielding $A = \frac{1}{24}$ and $B = -\frac{1}{32}$

Then the particular solution is

$$Y(t) = ue^{3t} = \left(\frac{1}{24}t^3 - \frac{1}{32}t^2\right)e^{3t} \quad (96)$$

Method of De Oliveira for Example 5

$$y''' - 5y'' + 3y' + 9y = te^{3t} \quad (97)$$

The characteristic polynomial is

$$p(\lambda) = \lambda^3 - 5\lambda^2 + 3\lambda + 9, \quad p'(\lambda) = 3\lambda^2 - 10\lambda + 3, \quad p''(\lambda) = 6\lambda - 10 \text{ and } p'''(\lambda) = 6$$

Inserting $p(\lambda)$ and its derivatives in the following equation

$$\left[\frac{p^{(n)}(\lambda)}{n!} q^{(n)} + \dots + \frac{p''(\lambda)}{2!} q'' + \frac{p'(\lambda)}{1!} q' + p(\lambda)q \right] e^{\lambda t} = f(t)$$

Gives

$$[q''' + (3\lambda - 5)q'' + (3\lambda^2 - 10\lambda + 3)q' + (\lambda^3 - 5\lambda^2 + 3\lambda + 9)q]e^{\lambda t} = te^{3t} \quad (98)$$

Clearly we can see that $\lambda = 3$, the above equation becomes

$$q''' + 4q'' = t \quad (99)$$

Let $q = At^3 + Bt^2$, differentiation of q gives $q' = 3At^2 + 2Bt$, $q'' = 6At + 2B$ and $q''' = 6A$

Substituting q''' and q'' in (99) gives $6A + 4(6At + 2B) = t$ Solving this equation gives

$$A = \frac{1}{24} \text{ and } B = -\frac{1}{32}$$

Then the particular solution is

$$Y(t) = qe^{3t} = \left(\frac{1}{24}t^3 - \frac{1}{32}t^2\right)e^{3t} \quad (100)$$

Method of Jia and Sogabe for Example 5

$$y''' - 5y'' + 3y' + 9y = te^{3t} \quad (101)$$

Set $p(\lambda) = \lambda^3 - 5\lambda^2 + 3\lambda + 9$, $f(t) = t$, $\alpha = 3$. Since $p(\alpha) = p'(\alpha) = 0$ and $p'' \neq 0$, we have $k = 2$

$$\text{Set } g(t) = f(t) \cdot \frac{k!}{p^{(k)}(\alpha)} = \frac{1}{4}t \quad (102)$$

$$\text{Set } d_0 = 1 \text{ and } d_i = -\frac{k!}{p^{(k)}(\alpha)} \sum_{j=0}^{i-1} \frac{p^{(i+k-j)}(\alpha)}{(i+k-j)!} d_j$$

$$\text{By using } d_i, \text{ we get } d_1 = -\frac{2!}{p''(3)} \cdot \frac{p'''(3)}{3!} d_0 = -\frac{1}{4} \quad (103)$$

$$\text{Then set } u^{(k)}(t) = \sum_{i=0}^m d_i g^{(i)}(t), \quad u''(t) = \sum_{i=0}^1 d_i g^{(i)}(t) = \frac{1}{4}t - \frac{1}{16} \quad (104)$$

Hence $u(t) = \frac{1}{24}t^3 - \frac{1}{32}t^2$. Finally, we obtain the particular solution from

$$Y(t) = u(t)e^{3t} = \left(\frac{1}{24}t^3 - \frac{1}{32}t^2\right)e^{3t} \quad (105)$$

Example 6: Consider

$$y'' - 2y' + 2y = te^t \sin 3t \quad (106)$$

The homogenous solution is given as

$$y_h = Ae^t \sin t + Be^t \cos t \quad (107)$$

Method of Undetermined Coefficient for Example 6

$$\text{Guessing } Y(t) = (At + B)e^{t(1+3i)} \quad (108)$$

$$Y'(t) = Ae^{t(1+3i)} + (At + B)(1 + 3i)e^{t(1+3i)} \quad (109)$$

$$\text{and } Y''(t) = 2(1 + 3i)Ae^{t(1+3i)} + (At + B)(1 + 3i)(1 + 3i)e^{t(1+3i)} \quad (110)$$

Inserting (110), (109) and (108) in (106) gives

$$2(1 + 3i)Ae^{t(1+3i)} + (At + B)(1 + 3i)(1 + 3i)e^{t(1+3i)} - 2Ae^{t(1+3i)} - 2(At + B)(1 + 3i)e^{t(1+3i)} + 2(At + B)e^{t(1+3i)} = te^{t(1+3i)} \quad (111)$$

Solving (111) gives $6iA - 8(At + B) = t$, $A = -\frac{1}{8}$ and $B = -\frac{3i}{32}$

$$Y(t) = \left(-\frac{t}{8} - \frac{3i}{32}\right)e^{t(1+3i)} = \left(-\frac{t}{8} - \frac{3i}{32}\right)e^t(\cos 3t + i \sin 3t) \quad (112)$$

The particular solution is

$$Y(t) = -\frac{t}{8}e^t \cos 3t + \frac{3}{32}e^t \sin 3t \quad (113)$$

Method of Gupta for Example 6

$$y'' - 2y' + 2y = te^t \sin 3t = te^{t(1+3i)} \quad (114)$$

We have $\alpha = (1 + 3i)$. Let $Y(t) = Ue^{\alpha t}$, $Y'(t) = U'e^{\alpha t} + U\alpha e^{\alpha t}$ and

$$Y''(t) = U''e^{\alpha t} + 2U'\alpha e^{\alpha t} + U\alpha^2 e^{\alpha t}$$

Substituting $Y(t)$ and its derivatives in (114) gives

$$U''e^{\alpha t} + 2U'\alpha e^{\alpha t} + U\alpha^2 e^{\alpha t} - 2U'e^{\alpha t} - 2U\alpha e^{\alpha t} + 2Ue^{\alpha t} = te^{t(1+3i)} \quad (115)$$

$$U'' + 6iU' - 8U = t \quad (116)$$

Guessing $U = At + B$, $U' = A$ and $U'' = 0$. (116) becomes $0 + 6it - 8At - 8B = t$ which yield $A = -\frac{1}{8}$ and $B = -\frac{3i}{32}$. Therefore $U = -\frac{t}{8} - \frac{3i}{32}$ and

$$Y(t) = \left(-\frac{t}{8} - \frac{3i}{32}\right)e^t(\cos 3t + i \sin 3t) \quad (117)$$

The particular solution is

$$Y(t) = -\frac{te^t \cos 3t}{8} + \frac{3e^t \sin 3t}{32} \quad (118)$$

Method of De Oliveira for Example 6

$$y'' - 2y' + 2y = te^t \sin 3t \quad (119)$$

Let $Y(t) = qe^{\alpha t}$ then $Y(t) = qe^{t(1+3i)}$ And since $\alpha = (1 + 3i)$

The characteristic equation is $p(\alpha) = \alpha^2 - 2\alpha + 2 = -8$, $p'(\alpha) = 2\alpha - 2 = 6i$ and $p''(\alpha) = 2$

Let $\frac{p''(\alpha)q''}{2!} + \frac{p'(\alpha)q'}{1!} + pq = Q(t)$

$$q'' + 6iq' - 8q = t \quad (120)$$

Guessing $q = At + B$, $q' = A$ and $q'' = 0$. putting these in (120) gives $0 + 6iA - 8At - 8B = t$ which yield $A = -\frac{1}{8}$ and $B = -\frac{3i}{32}$

Hence $q = -\frac{t}{8} - \frac{3i}{32}$ and $Y(t) = \left(-\frac{t}{8} - \frac{3i}{32}\right)e^{t(1+3i)}$

$$Y(t) = \left(-\frac{t}{8} - \frac{3i}{32}\right)(e^t \cos 3t + i \sin 3t) \quad (121)$$

The particular solution is

$$Y(t) = -\frac{t}{8}e^t \cos 3t + \frac{3}{32}e^t \sin 3t \quad (122)$$

Method of Jia and Sogabe for Example 6

$$y'' - 2y' + 2y = te^t \sin 3t = te^{t(1+3i)} \quad (123)$$

The characteristic equation is $p(\alpha) = \alpha^2 - 2\alpha + 2$, but $\alpha = (1 + 3i)$ therefore, $p(\alpha) = -8$

$p'(\alpha) = 2\alpha - 2 = 2(1 + 3i) - 2$, $p'(\alpha) = 6i$ and $p''(\alpha) = 2$

$g(t) = \frac{f(t)k!}{p^k(\alpha)}$. Since α is not root of the equation therefore k will disappear and

$f(t) = \text{real} = t$

$$g(t) = \frac{f(t)}{p(\alpha)} = -\frac{t}{8}, \quad g'(t) = -\frac{1}{8} \quad \text{and} \quad U^K(t) = \sum_{i=0}^m d_i g^i(t)$$

Where $t = 0, 1, 2, 3, \dots, m$, $U(t) = d_0 g(t) + d_1 g'(t)$ and $d_0 = 1$

$$d_1 = -\frac{k!}{p^k(\alpha)} \sum_{j=0}^m \frac{p^{(t+j+k)}}{(t+j+k)}$$

$$d_1 = -\frac{1}{p(\alpha)} p'(\alpha) = \frac{3i}{4} \quad (124)$$

$$U(t) = -\frac{t}{8} - \frac{3t}{32} \quad (125)$$

$$Y(t) = \left(-\frac{t}{8} - \frac{3t}{32}\right) e^t (\cos 3t + i \sin 3t) \quad (126)$$

The particular solution is

$$Y(t) = -\frac{t}{8} e^t \cos 3t + \frac{3}{32} e^t \sin 3t \quad (127)$$

Results and Discussion

Table 1: Rating of the method performances

Examples	Method Of Undetermined Coefficient	Gupta Method (Hinton, 1994)	De Oleviera Method (Oliveira, 2012)	Jia And Sogabe Method (Jia & Sogabe, 2013)
1) $y'' + y = t \sin t$	Lengthy	moderate	moderate	faster
2) $y'' - 5y' + 6y = 2e^{3t}$	Faster	moderate	moderate	moderate
4) $y'' + 4y = \cos 2t$	Lengthy	moderate	moderate	faster
5) $y''' - 5y'' + 3y' + 9y = te^{3t}$	Lengthy	moderate	Moderate	faster
6) $y'' - 2y' + 2y = te^t \sin 3t$	Lengthy	moderate	moderate	faster

Conclusion

In this paper we investigated the strengths and weaknesses of four methods of obtaining the particular solution of non-homogeneous ordinary differential equation. We have realized that the method of undetermined coefficient is the best often when the inhomogeneous function is only exponential function. (Jia & Sogabe, 2013) method is found to be simpler in most cases and the best when the degree of differential equation is more than two.

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PLANER INVERTED – F ANTENNA DESIGN FOR MEDICAL IMPLANT APPLICATION AT ISM 900 MHZ

IKECHIAMA, F. N.¹, KWAHA, B. J.² & CHAGOK, N. M. D.³

¹Department of Physics, Federal University Dutsin – Ma, Katsina State, Nigeria

^{2&3}Department of Physics, University of Jos, Plateau State, Nigeria

E-mail: fosuagwu@fudutsinma.edu.ng, Phone No: +234-806-563-1514

Abstract

Radio – linked medical implant are recently attracting significant research interest. A key component of implantable medical devices which plays a major role in their compactness and general performance efficiency is the antenna. Hence, innovation in wireless body area network for telemetry applications is creating a demand for higher bandwidth and resilient implant links, and this in turn is driving the development of implantable antennas. The design of Planer Inverted – F Antenna (PIFA) based on transmission line model was made for medical implants operating at ISM 900MHz. The designed antenna was simulated using High Frequency Structural Simulator. This antenna which resonated at 902MHz frequency had a return loss of -7.61dB , impedance bandwidth of 2.2% , a radiator size of $34\text{mm} \times 17\text{mm}$ and radiation efficiency of 1.44% . The simulated result of electric field distribution E (0.12dB) is far below the reference level set for the general public by ICNIRP. The performance characteristics of the proposed PIFA reveal that it can be used as implantable antenna for medical implants. However, effective miniaturization technique need to be employed in the design to improve the radiation efficiency of the designed antenna.

Keywords: PIFA, Medical implant, Return loss, Radiation efficiency, Specific Absorption Rate (SAR).

Introduction

Advances in technology have enhanced the use of implantable medical devices operating in radio frequency range in diverse medical applications. Medical body area network (MBAN) – a network of body implanted electronic medical devices – has tremendously improved health care, therapy and diagnosis. Integrated communication from different in–body implants and on– body sensors can facilitate hearing for the deaf, sight for the blind and mobility for the lame. (Higgins, 2005).

Active medical implants are electronic devices that are surgically implanted inside the body. They have been developed to treat a wide range of ailments (Anders, 2004) such as

- i. heart pacemakers which makes the heart beat in orderly manner
- ii. brain pacemakers for the treatment of Parkinson's disease
- iii. Nerve signal recorders for use with robotic prosthesis
- iv. Implantable drug pumps
- v. Cochlea implants and so on

All these communicate with the outside world by radio. Radio communication makes the system usable at longer ranges. This telecommunication which enabled telemetry offers the following benefits:

- a. The data of the patient can be read ahead of time before he/she enters the doctor's office thereby reducing the checkup time.
- b. Patients who require very frequent checks may not necessarily be confirmed to the hospital where home care unit is available which can be made to communicate with medical implants and sends regular reports to the doctor (health care provider) in the

- hospital via internet or telephone system. This can help to decongest the hospital and also gives more comfort to the patient who will be at the comfort of his/her own home.
- c. Since patients may not need to get to hospital regularly the cost of health care is reduced.
 - d. Moreover when anything goes wrong either with the state of health of the patient or with the implant, the doctor receives the information immediately giving him/her enough time to proffer solution before the patient gets to the hospital.
 - e. Implantable devices can also facilitate the physical and mental burden to patients since their employment is able to reduce the number of visits of doctors to diagnose patients.
 - f. These devices can communicate without a wire piercing the skin thereby reducing the risk of infection in medical diagnosis (Tamotsu et al., 2007).

The antenna enables bidirectional wireless communication between the Implantable Medical Device (IMD), the exterior monitoring and control equipment (Asimina and Konstantina, 2013). In medical implant applications, it is of paramount importance to minimize antenna size and retain sufficient impedance bandwidth to cover the required operating frequency with a minimal loss in both body tissue and antenna structure. The antenna that meets this requirement is the Planer Inverted-F Antenna (PIFA). It is a self-resonating antenna with purely resistive impedance at the frequency of operation, hence, does not require conjugal circuit between the antenna and the load reducing both cost and losses. Therefore, this paper considers the design of PIFA for radio-linked medical implant that will satisfy the above requirements.

Antenna Performance Parameters

The performance of the implantable antennas and the entire system are quantified using sets of technical requirements such as the voltage standing wave ratio (VSWR), return loss, gain, quality factor, bandwidth, antenna efficiency and so on. These performance parameters are discussed briefly as follows:

Voltage Standing Wave Ratio (VSWR)

Input matching can be described either by return loss or VSWR. VSWR is a value describing the ratio of the maximum value to minimum value of the electric field intensity of a standing wave. It is basically a measure of the impedance mismatch between the transmitter and the antenna. The VSWR is given as

$$VSWR = \frac{1+|\Gamma|}{1-|\Gamma|} = \frac{|E_{max}|}{|E_{min}|} \quad 1 \leq VSWR < \infty \quad (1)$$

where Γ refers to the voltage reflection coefficient i.e. the ratio of the reflected wave to the forward wave expressed in volts (Makarov, 2002). When $VSWR = 1$, no standing wave appears and all power is transmitted. If VSWR is large, the Γ is close to one and the antenna does not transmit any power. Since the antenna is a one-point component, Γ is proportional to the S_{11} or return loss.

Return Loss (S_{11} parameter)

The return loss or reflection loss measures the effectiveness of the power delivery from the transmission line to the antenna (Edling, 2012). Hence it is a parameter that indicates how well the matching between the transmitter and antenna has taken place. A graph of S_{11} of an antenna versus frequency is known as the return loss curve. For optimum working, such a graph must show a dip at the operating frequency and have a minimum dB value at this frequency (Makarov, 2002).

$$\text{Return loss} = -20 \log |\Gamma| \text{ (dB)} \quad (2)$$

Bandwidth (BW)

The bandwidth of an antenna is defined as the range of useable frequencies within which the performance of the antenna with respect to some characteristics conforms to a specified standard (Balanis, 1997).

The impedance bandwidth of a narrowband antenna is defined as the percentage of the frequency difference over the center frequency (f_0) given mathematically as (Edling, 2012)

$$BW_{\text{narrowband}} (\%) = \left[\frac{f_2 - f_1}{f_0} \right] \times 100 \quad (3)$$

where f_0 is the center (resonant) frequency, f_1 and f_2 is the frequency when the center frequency has dropped 3 dB from the maximum value.

Due to the mismatch of the antenna, a limitation criterion is usually set to define a specific bandwidth. This criterion is not fixed since every antenna does not require the same capability. However, for most of the mobile communication antennas, the limit is ruled by return loss (S_{11}) parameter (Saisset and Travers, 2009). The limit is either $S_{11 \text{ max}} = -10\text{dB}$ or $S_{11 \text{ max}} = -6\text{dB}$ at the borders of the frequency band which correspond to a power reflection of 10% and 25% respectively (Gustrau and Manteuffel, 2006).

Quality factor (Q-factor)

Q-factor is a parameter that describes how much power that transform as losses in the system. A high Q factor indicates a lower rate of energy loss relative to the stored energy as (Edling, 2012)

$$Q = 2\pi f_0 \frac{\text{Energy stored}}{\text{Power loss}} = \frac{f_0}{f_2 - f_1} = \frac{f_0}{\text{Bandwidth}} \quad (4)$$

It is used to describe antenna as a resonator and quantifies the potential bandwidth of an antenna. Higher value implies a sharp resonance and narrow bandwidth (Ikram, 2010).

Gain

Antenna gain is a parameter which is closely related to the directivity of the antenna. The gain is the amount of power that can be achieved in one direction at the expense of the power lost in the others (Ulaby, 1999).

Radiation Efficiency

The efficiency of a handset antenna is the ratio of the total power radiated by the antenna to the forward power available at its terminals. This parameter takes into account the amount of losses at the terminal of the antenna and within the structure of the antenna. The losses include; reflections because of mismatch between the transmitter and the antenna and I^2R losses (conduction and dielectric) (Balanis, 1997).

Specific Absorption Rate (SAR)

SAR is an index that qualifies the rate of energy absorption in biological tissue expressed in W/kg. SAR measures the amount of heat generated in the tissue surrounding the implant antenna. It is generally taken as an average value over some portion covered by the antenna power. It is defined as

$$SAR = \frac{\sigma}{2\rho} |E|^2 \quad (5)$$

where σ is conductivity of the tissue (S/m), ρ is density of tissue (kg/m) and E is electric field intensity (V/m).

Safety levels are established for SAR parameter and threshold are also established for other em quantities such as power density, electric and magnetic field intensities which are easily measured outside the body. International bodies responsible for setting these safety levels

include; International Commission on Non ionizing Radiation Protection (ICNIRP), Federal Communication Commission (FCC) and International Electrical and Electronic Engineers (IEEE). Table 1 shows the reference threshold set by ICNIRP for 900MHz and 1800MHz for general public.

Table 1: ICNIRP reference levels for general public exposure to e.m field

Frequency	Limit for electric field (V/m)		limit for power density W/m ²	
	Public	Occupation	Public	Occupational
900MHz	41.25	90.00	4.5	22.50
1800	58.30	127.28	9.0	45.00

Source: Osuagwu and Emmanuel (2013)

PIFA Design Considerations

PIFA consists of five main components which are; ground plane, patch (radiator) short plate, feed pin and dielectric substrate as shown in figure 1.

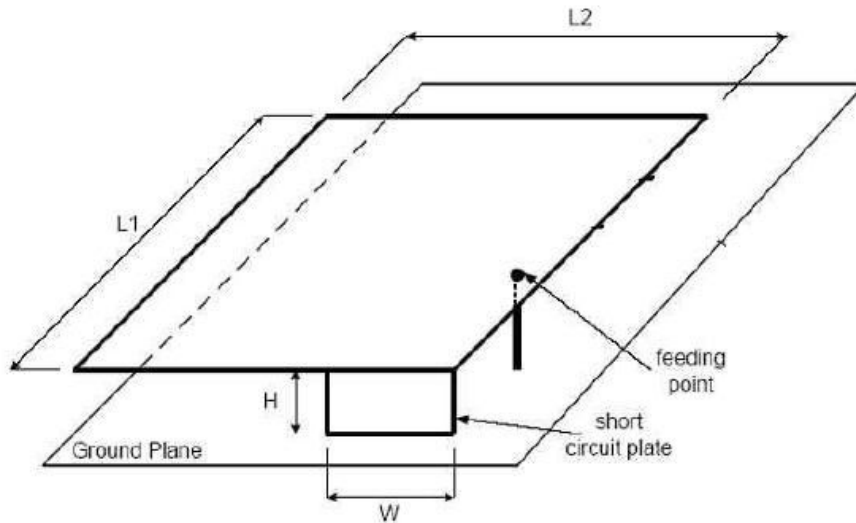


Fig. 1: Features of PIFA

In PIFA, a plate forms the shorting pin as shown in Fig.1. Here L_1 is the patch length and L_2 is patch width. The feed is at a distance of D from the shorting pin and height h from the ground. The patch is on a dielectric with permittivity ϵ_r . PIFA resonant frequency is dependent on the width (W) of the short-circuit plate. If $W = L_2$, the entire width of the patch is equal to that of the shorting pin and the resonant will have a maximum radiation efficiency (Shaheen et al, 2013).

By transmission line model, when the width of the short circuit plate W is equal to the width of the planar element L_2 , this corresponds to the case of short circuit microstrip antenna (MSA) which is a quarter-wavelength antenna. That is

$$W = L_2 \Rightarrow L_1 = \frac{\lambda}{4} \quad (6)$$

The effective length of the MSA is $L_1 + H$, where H is the height of the short circuit plate. The resonance condition then is expressed as

$$L_1 + H = \frac{\lambda_g}{4} \quad (7)$$

where $\lambda_g = c/f$ is the wavelength (Huynh, 2000). Hence resonant frequency (f) associated with $W = L_2$ is

$$f_1 = \frac{c}{4(L_1 + H)} \quad (8)$$

where c is the speed of light.

For $W = 0$, a short-circuit plate with a width of zero can be physically represented by a thin short-circuit pin. The effective length of the circuit is $L_1 + L_2 + H$. For this case, the resonant condition is expressed as (Huynh, 2000)

$$L_1 + L_2 + H = \frac{\lambda_g}{4} \Rightarrow \frac{c}{4(L_1 + L_2 + H)} \quad (9)$$

Therefore the resonant frequency that is part of the linear combination associated with the case of $0 < W < L_2$ is given as (Yves – Thierry et al., 2009)

$$F_2 = \frac{c}{4(L_1 + L_2 + H - W)} \quad (10)$$

Equation (10) holds for air dielectric with $\epsilon_r = 1$. When a dielectric material other than air is employed, the resonance frequency is given as

$$f_r = \frac{c}{4\sqrt{\epsilon_{eff}}(L_1 + L_2 + H - W)} \quad (11)$$

where ϵ_{eff} is the effective permittivity of the substrate material between the radiating patch and the ground plane (Yves – Thierry et al., 2009). The approximate value of ϵ_{eff} is given as

(Yves – Thierry et al., 2009)

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} \quad (12)$$

For fixed radiating patch lengths, the resonant frequency increases as W decreases. Optimum performance is achieved when the ratio of L_1 and L_2 is 2:1 (Yves – Thierry et al., 2009) i.e. $L_1 = 2L_2$. When $H = W$ and $L_1 = 2L_2$, equation (11) reduces to

$$f_r = \frac{c}{4\sqrt{\epsilon_{eff}}(3L_2)} \Rightarrow f_r = \frac{c}{12(L_2)\sqrt{\epsilon_{eff}}} \quad (13)$$

$$\therefore L_2 = \frac{c}{12f_r\sqrt{\epsilon_{eff}}} \quad (14)$$

As with any other electrically small antenna, practical design of PIFA needs to have some finite ground plane. For optimum design of small patch antenna, it is required that the ground plane should be greater than the patch dimensions by approximately six times the substrate thickness (h) all around the fringe. Hence, the ground plane dimensions is given as (Rajat et al., 2013)

$$L_{gp} = 6h + l \quad (15)$$

$$W_{gp} = 6h + w \quad (16)$$

Where l and w are the patch length and width respectively.

The fundamental step taken in designing a new PIFA is to calculate the patch dimensions that will make the antenna resonate at the right frequency. The value of each of the parameters is calculated thus:

Width of patch for PIFA (L_2) is calculated using equation (14)

For PIFA at 900 MHz,

Substituting the values of $c = 3 \times 10^8 \text{ m/s}$, $\epsilon_r = 4.4$ (for FR4 substrate with permittivity of 4.4) and $f = 9 \times 10^8 \text{ MHz}$ into equation 14 yields

$$L_2 = \frac{3 \times 10^8}{12 \times 9 \times 10^8 \sqrt{\frac{4.4+1}{2}}} = 1.69 \times 10^{-2} \text{ m} = 17 \text{ mm}$$

$$L_1 = 2L_2 = 2 \times 17 = 34 \text{ mm}$$

Since low profile antenna is needed, height of patch H is chosen to be equal to 2mm

$$H = W \text{ (Width of the short plate)}$$

$$\therefore H = W = 2\text{mm}$$

Length L_g and W_g of ground plane are derived from equation (15) and (16) respectively for

$$\begin{aligned} h &= 2 \\ L_g &= (6 \times 2) + 34 = 46\text{mm} \\ W_g &= (6 \times 2) + 17 = 29\text{mm} \end{aligned}$$

The shorting plate is positioned at the corner of the planer element (width of patch) for maximum reduction in antenna size.

Calculations of Performance Limits [Bandwidth (BW), Gain (G) and Efficiency (η)]

For all electrically small antennas, the impedance bandwidth (BW) is related to the quality factor (Q) and maximum allowable voltage standing wave ratio (S). For good performance, VSWR (S) should be less than or equal to 2 (i.e. $S \leq 2$) (Saisset and Travers, 2009). For this design, VSWR (S) = 2 is chosen. For perfect lossless material, the quality factor (Q) is given as

$$Q = \frac{1}{(ka)^2} + \frac{1}{ka} \quad (17)$$

$$k = \frac{2\pi}{\lambda} = \frac{2\pi f}{c}$$

where k is the wave number, a is the radius of imaginary plane enclosing the antenna and c is the speed of light (Bancroft, 2003).

The entire ground plane of an electrically small antenna is included in the size of the antenna. Therefore, a is equal to half the length of the ground plane (L_g) i.e. $a = \frac{L_g}{2}$.

$$\text{For } f = 900\text{MHz}, k = \frac{2\pi \times 9 \times 10^8}{3 \times 10^8} = 6\pi$$

Impedance bandwidth (BW) is obtained using equation (18) given as

$$BW = \frac{S-1}{Q\sqrt{S}} \quad (18)$$

where S and Q are the voltage standing wave ratio and quality factor of the antenna respectively (Bancroft, 2003).

Upper limit of Gain (G) and efficiency (η) are calculated using equations (19) and (20) respectively which are (Skirver et al, 2001)

$$G = (ka)^2 + 2ka \quad (19)$$

$$\eta = \frac{1}{1+Q\tan\delta} \quad (20)$$

Performance Limits for PIFA with FR4 substrate are calculated as follows

$$\text{At } f_0 = 900\text{MHz}, L_g = 50\text{mm}, a = 25\text{mm}, k = 6\pi, \delta = 0.02$$

From equation (17), quality factor Q is

$$\therefore Q = \frac{1}{(6\pi \times 0.025)^2} + \frac{1}{6\pi \times 0.025} = 11.674$$

This implies that from equation (18), the impedance bandwidth is

$$BW = \frac{2-1}{11.674\sqrt{2}} = 0.061 = 6.1\%$$

The gain G and radiation efficiency η are obtained from equations (19) and (20) respectively as

$$G = (6\pi \times 0.025)^2 + 2 \times 6\pi \times 0.025 = 1.17\text{dB}$$

$$\eta = \frac{1}{1+11.674\tan(0.02)} = 0.9959 = 99.6\% \quad (\text{where } \delta = 0.02 \text{ for FR4 substrate})$$

Result and Discussion

High frequency Structural Simulator (HFSS), computational electromagnetic based commercial software, was used to simulate the designed antenna and the result is as shown below.

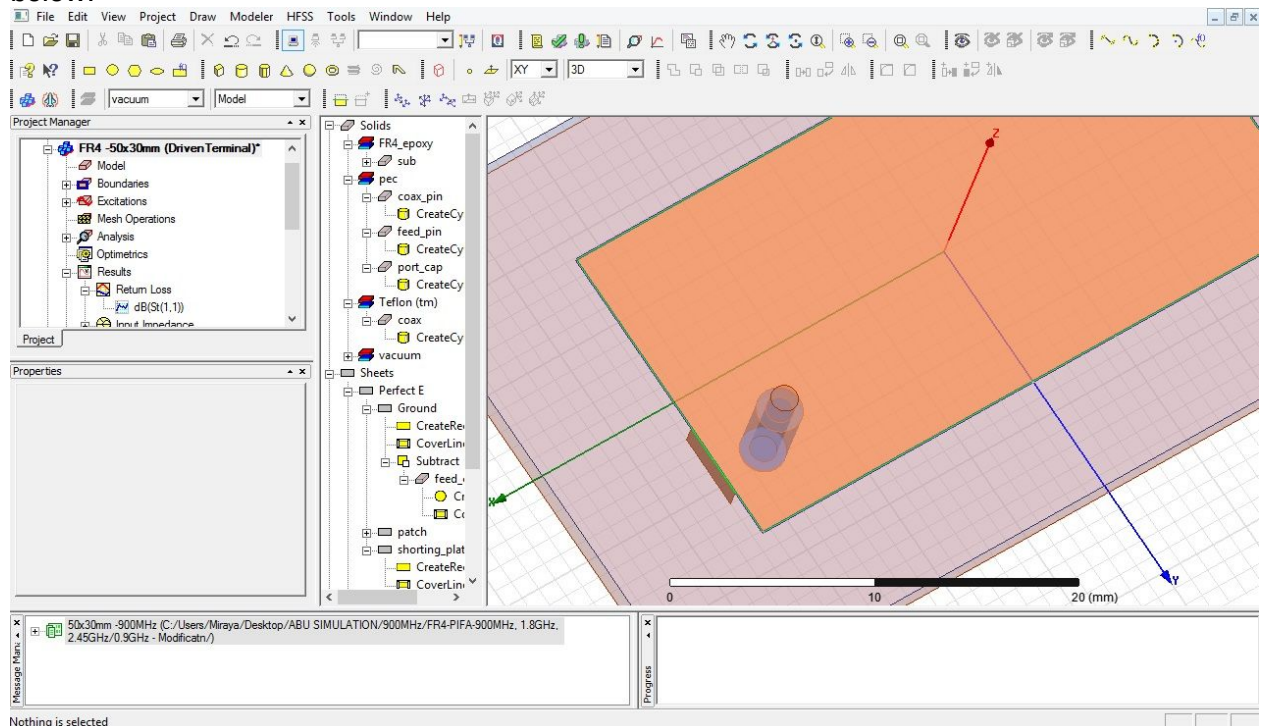


Fig. 2: Simulated structure of PIFA

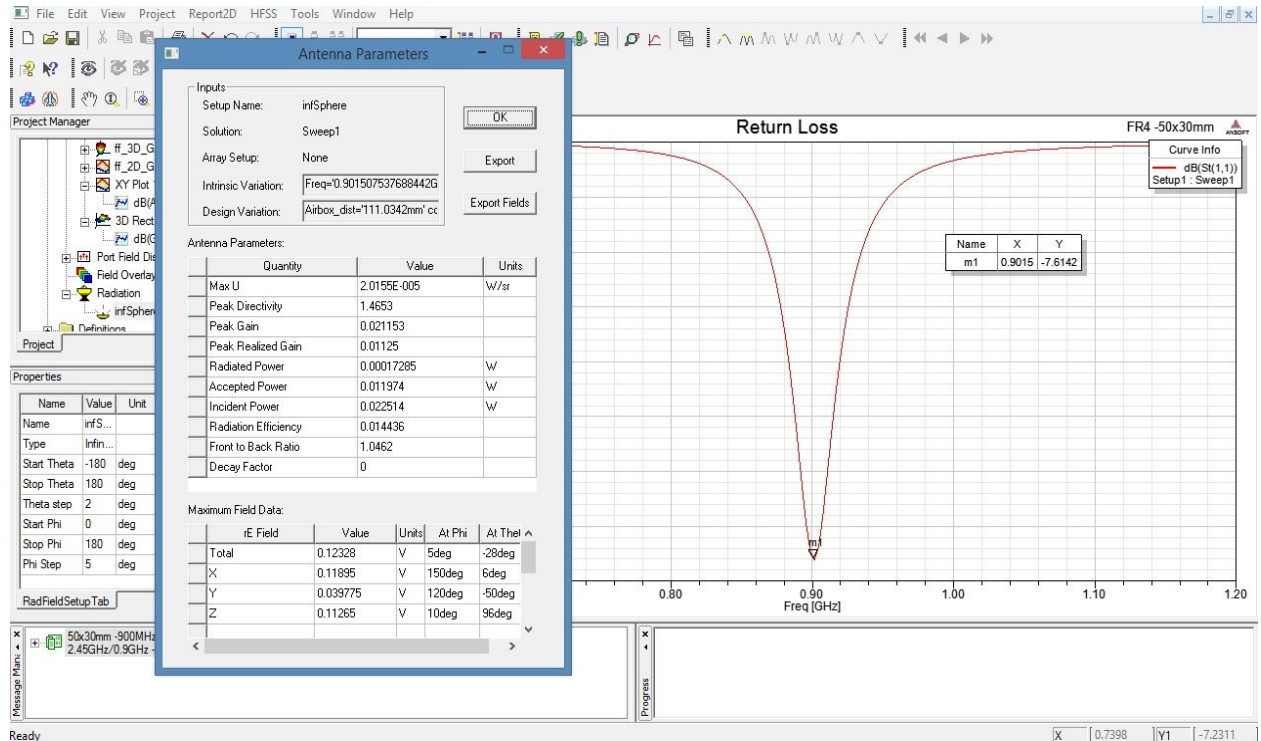


Fig. 3: Simulated Antenna Performance Parameters

Figures 2 and 3 show the structure and parameters of simulated PIFA respectively. The results read from figure 3 are clearly presented in table 2. The dimensions of the antenna radiator (patch) are 34mm by 17mm while the entire antenna dimension is 50mm x 30mm x

2mm making the designed antenna small enough to be embedded inside the body. Table 2 reveals that the resonance frequency of the designed antenna is within the desired range of ISM 900MHz band i.e. 902 – 928MHz. The return loss of -7.61dB obtained implies that the reflection loss of the antenna is less than 25%.

On the other hand, the results of calculated values of bandwidth, efficiency and gain based on theory of fundamental limit of electrically small antennas and simulated ones (table 3) show that the designed antenna has good impedance bandwidth and gain but low radiation efficiency. The calculated gain, radiation efficiency and impedance bandwidth of the antenna give the upper limits required for effective small antenna performance and as antennas become smaller, the limits on bandwidth and efficiency become difficult to attain because of their direct relationship with the size of the antenna.

Table 2: Designed parameters and simulated results of PIFA at 900MHz

Parameters (mm)							Results					
L_g	W_g	L_1	L_2	H	W	D_s	F_R (MHz)	S_{11} (dB)	BW (MHz)	G (dB)	H	E (dB)
50	30	34	17	2	2	5	902	- 7.61	20	1.41	1.44	0.12

Table 3: Calculated and Simulated Values of three main performance characteristics of PIFA (Bandwidth (BW), gain (G) and radiation efficiency (η))

Antenna	F_r (MHz)	Calculated values			Simulated values		
		BW (%)	Gain(dB)	η (%)	BW (%)	Gain(dB)	η (%)
PIFA	900	6.1	1.17	99.6	2.22	1.41	1.44

Low bandwidth and radiation efficiency recorded may be due to the small ground plane size and height of the substrate. Increase in substrate height results in the introduction of surface waves which extract power from the total available power for direct radiation. Moreover, this does not encourage miniaturization which is a critical factor in the application under consideration. More so, thick substrate with low permittivity have been known to provide better efficiency and larger bandwidth but provides loose bound fields for radiation into space. Again the application of interest are used within the human body, hence there is need to minimize undesirable radiation. The SAR of the antenna is very good as indicated by the value of the electric field which is 0.12dB.

Conclusion

Planer Inverted – F Antenna was designed based on transmission line model. The designed antenna was simulated with computational electromagnetic based commercial software known as High Frequency Structural Simulator. The simulated results show that the designed antenna has good return loss (-7.61dB), impedance bandwidth (2.22%), electric field (0.12dB) and gain (1.41dB) however, the radiation efficiency is low (1.44%). The size of the antenna is smaller than most conventional PIFA at the same frequency and cost. Hence, the designed PIFA is a good candidate for implantable medical devices. Nevertheless, the paper recommends that more effective miniaturization technique be employed in the design to improve the radiation efficiency, without making the antenna large and complex.

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MICROBIOLOGICAL AND PHYSIOCHEMICAL ASSESSMENT OF STREET
VENDED FRIED SOYABEAN CHEESE SOLD WITHIN
ILORIN METROPOLIS, NIGERIA.

¹ODEBISI-OMOKANYE, M. B., ¹ZAKARIYAH, R. F., ²JIMOH, F. A.
& ¹OLUGBADE, O. F.

Department of Microbiology, Faculty of Life Sciences University of Ilorin, Kwara State.
Department of Biosciences and Biotechnology, Microbiology unit, College of Pure and
Applied Sciences, Kwara State University, Malete, Ilorin.

E-mail: Odebisimutiat@yahoo.com; odebisi.mb@unilorin.edu.ng

Phone No: +234-803-400-6111

Abstract

*The microbiological and physicochemical quality of street vended fried soyabean cheese products from five different locations was assessed. Standard pour plate technique was used to examine the microbial load of the soyabean cheese. The pH ranged from 6.48 ± 0.241 – 6.58 ± 0.192 , Moisture content ranged from $13.94\% \pm 0.152$ – $14.22\% \pm 0.179$. The viable bacterial counts ranged from 7.0 to 61×10^5 cfu/g, while the fungal load ranged from 1 to 40×10^3 cfu/g. Eight bacteria species were isolated and identified as *Bacillus subtilis*, *Escherichia coli*, *Micrococcus* sp., *Proteus vulgaris*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Enterobacter aerogenes* and *Klebsiella pneumoniae*. Similarly, four fungal species were isolated and identified as *Mucor racemosus*, *Aspergillus fumigatus*, *Saccharomyces cerevisiae*, and *Rhizopus stolonifer*. The results suggest that the soyabean cheese samples were contaminated with pathogenic microorganisms and could cause health hazard to the consumers. There is the need to improve personal hygiene and environmental sanitation during and after production of the soyabean cheese.*

Keywords: Soyabean cheese, Quality, Bacteria, Fungi, microbial quality.

Introduction

Food is any substance taken or consumed to provide nutritional support for the body and can be either of plant or animal origin which contains the entire necessary nutrient for growth such as protein, carbohydrate, vitamins and minerals, fat and oils (Davidson, 2006). Foods (such as soyabean cheese) are not only of nutritional value to those who consume them but are often ideal culture medium for microbial growth. Since food is capable of supplying man with nutrients, it is equally capable of supporting the growth of microorganisms (Pelczar *et al.*, 1993)

Soyabean (*Glycine max* merrile) of the family Leguminosea is native of China and is one of the world's oldest crops. The major areas of soyabean production in Nigeria are: Benue, Bauchi, Plateau and Kaduna States (Ikuomola & Eniola, 2010). Soyabean, on dry weight basis, contains about 40% Protein, 21% Oil, 34% Carbohydrate and 4.9% Ash. The amino acid profile of soyabean is close to that recommended by Food and Agricultural Organization (FAO) of United Nations for human nutrition in terms of essential and non essential amino acids. Investigation of the quality of soyabean products has been the subject of intense research for several decades due to increasing importance of soyabeans in human diet.

The seed is used to produce soy-oil and other products such as soy-milk, soy-cheese, soy-flour, soy-meat, soy-ogi, soy-garri, beske and tempeh. Soy flour has several uses in feed, baked products (bread, cake and chin chin) and infant feed formulation. It is also used as condiments in stew, sauce and in vegetable soup preparation, while the cake obtained after oil extraction is utilized to formulate diet for animals and human being.

Soyabean cheese, is an indigenous, non-fermented fried soyabean snack widely consumed owing to its high protein quality and content. The product is usually consumed either alone or along with soaked garri. It is a cheap product because the grains and other ingredients used for its production and packaging are readily available. Furthermore, the processing methods are simple and cheap as no sophisticated equipment and expertise are required. The snack is largely produced on small scale, usually as a family venture, using an indigenous method with unquantified amounts of ingredients (Ikuomola & Eniola, 2010). To make soyabean cheese, soya beans is collected and cleaned, the cleaned grains are then soaked overnight in big uncovered bowls. The soaked grains are then washed in cleaned water and then wet milled into fine particle. The mash is then mixed with large amount of water and then sieved using a muslin cloth. The slurry is then placed in a clean pot and cooked for 30 minutes with continuous stirring to prevent burning. While boiling some amount of 'ogi' whey is added which serves as a coagulant. The resulting paste is poured in a jute bag and pressed manually, the paste is poured into a neat muslin cloth and a heavy clean stone is placed to drain out all water. With the aid of a clean sharp knife, the compressed paste is then cut into desired shapes and sizes. The pieces are then boiled in water with the addition of magi, pepper and salt. After boiling, the cubes are the fried. It is cooled and soyabean cheese is ready for sale. (Ikuomola & Eniola, 2010).

Contamination of soyabean cheese by microorganisms occurs during and after processing. The ingredients, crude processing and retailing conditions predispose the product to microbial contamination. Other sources of contamination include water, utensils, soil dust, food handlers, packaging materials (Frazier & Westhoff, 2004). Contamination of soyabean cheese poses a serious health problem since it is a ready to eat snack and as such they might not be cooked before eating. This study was therefore conducted to determine the quality of ready to eat soyabean cheese retailed on the streets of Ilorin metropolis. The objectives of this research were to determine the bacterial and fungal loads, and their identities and to also determine some physicochemical characteristics of soyabean cheese that may predispose it to microbial contamination and proffer ways of preventing such.

Materials and Methods

Collection of Soyabean Cheese Samples

Freshly prepared fried soyabean cheese samples were collected from five locations within Ilorin metropolis. These were Production point (Tanke), Oja-oba, Ipata market, unity road, Oja-tuntun, and Yoruba road market. Samples from each location were collected separately into clean sterile sampling bags and taken to the microbiology laboratory, University of Ilorin for immediate analysis.

Physiochemical Analyses

pH Determination

The pH of the samples was taken using pH meter (Denver instrument model 20) which was first standardized with buffer solutions at pH 4, 7, and 9. Five gram (5g) of the macerated samples was weighed into 20ml of distilled water. It was mixed together and the mixture was filtered into a clean conical flask. The pH of the suspension was then determined by inserting the electrode of the pH meter into the solution and the pH value read (Daniyan *et al.*, 2011).

Determination of Titratable acidity

The whey of the samples was used to determine the titratable acidity, this was used for titratable acidity. From the whey, 25ml was pipetted into conical flask and 2 drops of phenolphthalein indicator was added. Each of the experiment was repeated 3 times with the

when titrated against 0.1N of Sodium Hydroxide (NaOH). The titratable acidity was expressed as the volume (in ml) of 0.1N NaOH used per 25ml of the filtrate (AOAC, 2006).

Determination of Moisture Content

One gram of each macerated sample was weighed into a crucible of known weight and then dried in an oven at temperature of 170°C, after 1 hour the samples were taken out of the oven and allowed to cool down. The weight of the crucible was subtracted from the weight of the dried sample leaving only the weight of the dried sample (AOAC, 2006). The percentage moisture content was then calculated thus:

$$\text{Moisture (\%)} = \frac{(W1-W2) \times 100}{W1}$$

Where: W1 = weight (g) of sample before drying
W2 = weight (g) of sample after drying

Determination of Protein Content

Using the Kjeldahl method, two grams of the macerated sample was measured into a Kjeldahl flask and 5 grams of sodium sulphate, 1 gram of copper sulphate and 25 ml of concentrated tetra oxosulphate (vi) acid was then added. The flask was then carefully heated to boiling for 30 minutes and then allowed to digest. It was then allowed to cool and then diluted to 250ml with distilled water. Five milliliter of the resulting solution was then pipetted into a conical flask and excess concentration sodium hydroxide was added to make a strong alkaline solution so that all ammoniacal nitrogen changed to ammonium sulphate. Two percent (2%) boric acid was added and was then titrated against 0.01M hydrochloric acid (Kadash & Kusulum, 1992).

$$\text{Total nitrogen (g/100cm}^3\text{)} = \frac{14 \times 100 \text{ volume of acid}}{100}$$

$$\text{Protein/100 cm}^3 = \text{total nitrogen} \times 6.25$$

$$\% \text{ Crude protein} = \frac{14 \times 0.01 \times a \times b \times 6.25 \times 100}{C \times d}$$

Where a = volume of acid used

b = total volume of distilled = 250ml

c = volume of distilled use for titration = 5ml

d = weight of sample = 2g

Determination of Ash Content

This was determined according to the method described by Kirk and Sawyer (1991). The crucible with the 5g of sample was intensely heated on the Bunsen flame until smoke ceased, and then transferred into a muffle furnace where it was ashed for 24 hours at 600°C to white ashes. The crucible and its contents were then removed and placed in a desiccator to cool after which it was weighed to a constant weight and the amount of ash calculated using the following relation:

$$\text{Ash content (\%)} = 100 \frac{A-B}{C}$$

Where:

A = weight of crucible with sample (g)

B = weight of crucible with ash (g)

C = weight of sample (g)

Determination of Fat Content

Determination of fat was carried out by Werner-Schmid process (Kirk & Sawyer, 1991). Proteins are digested with conc. hydrochloric acid. Five gram of samples was weighed in extraction thimble and place in extraction unit. Liberated fat was extracted using alcohol, ethyl ether and petroleum ether. Ethers are evaporated and residue left behind is weighed to calculate the fat content.

$$\text{Fat (\%)} = \frac{B - A}{C} \times 100$$

Where:

A = weight of clean dry flask (g)

B = weight of flask with fat (g)

C = weight of sample (g)

Determination of Crude Fibre content

The crude fibre content was determined using the method described by Kirk and Sawyer (1991). Four gram of sample was defatted using petroleum ether. The defatted sample was boiled under reflux for 30 min with 200 ml (1.25%) H_2SO_4 . It was further filtered and washed with boiling water until the wash in water was no longer acidic. The residue was boiled at 100°C in a round bottom flask with 200 ml (1.25%) NaOH for another 30 min and then filtered and washed with boiling water until the wash water was no longer alkaline. The residue was scraped into a previously weighed crucible and dried at 100°C for 12 hours. It was left in desiccators to cool and weighed. It was thereafter ashed in a muffle furnace at about 600°C for 24 hours, left in a desiccator to cool and then weighed and calculated using the following relation:

$$\text{Crude fibre content (\%)} = \frac{100(A-B)}{C}$$

Where A = Weight of crucible with dry residue (g).

B = Weight of crucible with ash (g)

C = Weight of sample (g)

Determination of Carbohydrate Content

A large number of analytical techniques have been developed to measure the total concentration and type of carbohydrates present in foods. The carbohydrate content of the sample was determined by calculating the percent remaining after all the other components have been measured: %carbohydrates = $100 - \% \text{moisture} - \% \text{protein} - \% \text{crude fibre} - \% \text{ash} - \% \text{fat}$ (Chinma & Igor, 2007).

Microbiological Analyses

Total Bacterial Counts

In order to isolate and enumerate bacteria, 1g of the soyabean cheese sample was macerated and serially diluted up to 10^{-5} . Nutrient agar was used for the isolation using the pour plate technique (Fawole & Oso, 2004).

Total and Faecal Coliform Counts

Plating of 0.5ml of the aliquot was done at 10^{-1} and 10^{-2} dilutions using MacConkey agar and Eosin methylene blue agar medium for the isolation of total and faecal coliforms respectively using spread plate technique. Typical coliforms gave pink or red colonies on MacConkey agar, while faecal coliform (*Escherichia coli*) produced colonies with Greenish sheen on Eosin methylene blue agar medium (Willey *et al.*, 2011).

Fungal Counts

Spread plate method was used to isolate and enumerate fungal population. The medium of choice was potato dextrose agar. Plating of the sample was done at 10^{-2} dilution (Fawole & Oso, 2004).

Preparation of Pure Culture of the Isolates

Subculturing was done in order to obtain pure culture of each isolate from the mixed cultures. The pure culture obtained was then preserved in a slant and kept in the refrigerator until required for identification (Fawole & Oso, 2004)

Characterization of Isolates

The bacterial isolates were characterized on the basis of their colonial, cellular, and biochemical characteristics (Buchanan & Gibson, 1974), while the fungal isolates were identified based on their cultural, macroscopic and microscopic characteristics (Onion *et al.*, 1981). The biochemical tests conducted were: catalase, motility, citrate utilization, coagulase, starch hydrolysis, oxidase, Indole, Methyl Red Voges Proskauer (MRVP), Nitrate reduction, Urease and fermentation of various sugars.

Statistical Analyses

The statistical analysis package, SPSS 16.0 was used to determine the mean, range, and standard error of mean of the data, while means were then separated using Duncan's Multiple Range Test (SPSS, 2010).

Results

Physiochemical characteristics

The pH value of the snacks ranged between 6.48 to 6.58, titratable acidity ranged between 3.62 to 3.70 cm³, the ash content was 3.10 to 3.22%, moisture content ranged between 13.94 to 14.90 %, crude fibre ranged between 0.550 to 0.612 %, crude protein ranged between 15.32 to 16.48 %, fat content ranged between 13.74 to 15.30 %, while carbohydrate ranged between 50.16 to 51.76 g. The sample from Ipata Market had the highest pH of 6.58 while the lowest pH of 6.48 was recorded for both Oja tuntun and Obo Market. The highest protein content was found in samples from Obo Market while the lowest was found in samples from Oja-oba Market (Table 1).

Microbial counts of soyabean cheese samples for different markets

The bacterial count, total coliform and faecal coliform of the soyabean cheese samples ranged from $7.0 - 61 \times 10^5$ cfu/g, nil to 14×10^3 cfu/g, and nil to 3×10^3 cfu/g respectively. While the fungal count ranged from 1 to 33×10^3 cfu/g (Table 2).

Microbial isolates and their occurrence

Eight bacterial species and four fungal species were identified (Table 3) and their occurrences was as presented in Table 4. The bacteria comprise both Gram positive and Gram negative bacteria.

Table 1: Physico-Chemical Properties of the Beske samples collected within Ilorin metropolis

Chemical Properties	Tanke Market	Yoruba Market	Ojo Oba Market	Ipata Market	Oja Tuntun	Obo Market (Unity Road)
Ash(g)	3.16±0.152 ^b	3.20±0.158 ^b	3.10±0.100 ^b	3.20±0.158 ^b	3.18±0.148 ^b	3.22±0.148 ^b
Moisture content(%)	13.94±0.100 ^a	14.22±0.259 ^b	14.90±0.152 ^b	14.20±0.141 ^b	14.22±0.179 ^b	14.02±0.110 ^b
Crude Fibre (%)	0.550±0.500 ^b	0.540±0.198 ^b	0.588±0.075 ^b	0.612±0.081 ^b	0.610±0.061 ^b	0.526±0.026 ^b
Crude Protein(g)	16.35±0.537 ^a	16.45±0.249 ^a	15.32±0.874 ^a	15.60±0.719 ^a	15.79±0.884 ^a	16.48±0.192 ^a
Fat(g)	14.04±0.167 ^b	15.30±0.224 ^b	13.74±0.297 ^b	14.58±0.396 ^b	15.08±0.217 ^b	14.18±0.249 ^b
Carbohydrate(g)	51.76±0.643 ^a	50.16±0.207 ^a	53.26±1.226 ^a	51.82±0.522 ^a	51.28±0.779 ^a	51.60±0.224 ^a
pH	6.54±0.241 ^b	6.56±0.195 ^b	6.54±0.241 ^b	6.58±0.192 ^b	6.48±0.228 ^b	6.48±0.259 ^b
Titratable Acidity(cm ³)	3.62±0.286 ^b	3.62±0.432 ^b	3.66±0.439 ^b	3.64±0.391 ^b	3.62±0.408 ^b	3.70±0.381 ^b

Each value is the mean of triplicate (n=3) ± standard deviation of different markets. The letters and b represent ranking of means across each groups of samples.

Values with superscript A and B are difference between markets.

Values not sharing the same superscript differ significantly at <0.05.

Table 2: Microbial Count of Fried Soyabean Snack from Different Sellers within the Sampled Market

Sampling site	Bacterial count (x10 ⁵ cfu/g)	Total Coliform count (x 10 ⁴ cfu/g)	Faecal coliform (x 10 ³ cfu/g)	Fungal count (x 10 ³ cfu/g)
A1	23	0	0	7
2	11	6	0	3
3	15	1	0	6
4	19	1	0	2
5	18	1	0	1
B1	19	2	1	20
2	20	5	2	13
3	22	10	1	19
4	18	14	1	16
5	16	3	3	12
C1	23	2	0	17
2	32	7	2	14
3	31	11	2	33
4	24	1	0	23
5	26	3	1	14
D1	20	2	0	20
2	7.0	0	0	15
3	21	11	4	13
4	11	2	0	15
5	24	4	1	19

E1	12	1	0	21
2	48	10	4	40
3	40	4	4	17
4	15	3	1	20
5	33	2	0	19
F1	16	3	1	30
2	33	2	2	16
3	19	1	0	14
4	60	10	6	31
5	61	12	7	20

Each value is the mean of triplicate (n=3)

KEY: A, Production point (Tanke); B, Yoruba market; C, Oja-oba; D, Ipata market; E, Oja tuntun Market; F, Unity market.

Table 3: Characterization and identification of bacterial isolates

Table of characterization and identification of bacterial isolates																								
Cellular Characteristics				Biochemical test																				Probable identity
Bacterial isolates	Shape	Cell Arrangement	Gram Stainimg	Catalase	Motility	Citrate	Coagulase	Starch hydrolysis	Oxidase	Indole	Glucose	Sucrose	Lactose	Fructose	Maltose	Methyl red	VogesProskauer	Nitrate reduction	Urease	OF	Spore formation	H ₂ S		
1	Cocci	Pairs	+	+	-	+	+	-	-	-	A	AG	AG	AG	AG	-	+	-	+	Fe	-	+	<i>Staphylococcus aureus</i>	
2	Rod	Single	-	+	+	+	-	+	-	-	A	AG	AG	AG	A	-	+	+	-	Fe	-	+	<i>Enterobacter aerogenes</i>	
3	Rod	Single	-	+	+	-	-	+	-	+	AG	AG	AG	AG	AG	+	-	+	-	Fe	-	+	<i>Escherichia coli</i>	
4	Rod	Single	-	+	+	+	-	+	-	+	AG	A	A	AG	AG	+	-	+	+	Fe	-	-	<i>Proteus vulgaris</i>	
5	Rod	Single	-	+	-	+	-	-	-	-	AG	A	AG	AG	A	-	-	+	+	Fe	-	-	<i>Klebsiella pneumoniae</i>	
6	Rod	Single	-	+	+	+	-	-	+	-	AG	A	AG	AG	A	-	-	+	+	Fe	-	+	<i>Pseudomonas aeruginosa</i>	
7	Rod	Pairs	+	+	+	+	-	+	-	-	AG	AG	A	AG	AG	-	+	+	-	Fe	+	-	<i>Bacillus subtilis</i>	
8	Cocci	Clusters	+	+	-	+	+	-	+	-	A	AG	A	AG	A	+	+	-	+	Fe	-	-	<i>Micrococcus</i> spp.	

KEY: + = positive, - = negative FE = Fermentative, OF = Oxidation- Fermentation A =Acid only AG = Acid and gas

Table 4: Occurrence of Bacterial and Fungal species from different locations

Microbial Isolates	A	B	C	D	E	F
<i>Staphylococcus aureus</i>	+	+	+	+	+	+
<i>Enterobacter aerogenes</i>	-	-	-	-	+	+
<i>Escherichia coli</i>	-	+	-	+	+	+
<i>Proteus vulgaris</i>	+	+	+	+	+	+
<i>Klebsiella pneumonia</i>	+	+	+	+	+	+
<i>Pseudomonas aeruginosa</i>	+	+	-	-	-	-
<i>Bacillus subtilis</i>	+	+	+	+	+	+
<i>Micrococcus spp.</i>	—	-	-	+	+	+
<i>Mucor mucedo</i>	+	+	+	+	+	+
<i>Aspergillus fumigatus</i>	-	-	-	+	+	+
<i>Saccharomyces cerevisiae</i>	+	+	+	+	+	+
<i>Rhizopus stolonifer</i>	-	+	+	-	+	+

KEY: + = Isolated; - = Not isolated; A, Production point (Tanke market); B, Yoruba market; C, Oja-oba; D, Ipata market; E, Oja-tuntun; F, Unity market.

Discussion

The soyabean cheese samples were found to harbour *Staphylococcus aureus*, *Micrococcus sp.*, *Escherichia coli*, *Proteus vulgaris*, *Klebsiella pneumoniae* and *Bacillus subtilis*. The pattern of distribution showed that all the isolates were found in snacks obtained from the hawkers. This is in agreement with the research carried out by Ikuomola and Eniola (2010) who also recorded the presence of similar bacteria. All the bacteria species encountered in the soyabean cheese samples can affect the keeping quality and the health of the consumers (Willey *et al.*, 2011). The samples could also have been contaminated due to exposure and handling by intending buyers, either by touching or talking during bargaining.

Most of the organisms encountered could be found in soil, dust and on bodies of insects, animals and humans (Frazier & Westhoff, 2004). The organisms are of particular interest because of their involvement in different infections. *Staphylococcus aureus* and *micrococcus sp.* are associated specifically with the hands and nasal cavity and an indicator of contamination from human sources. The deposition of these bacteria in soyabean cheese can occur if good sanitary practices are not followed by the food handlers. Growth of *Staphylococcus aureus* on food can lead to production of enterotoxin leading to staphylococcal food intoxication. *Enterobacter aerogenes* is an agent of food spoilage as it causes ropiness or sliminess of food. The presence of organisms such as: *E. coli* and species of *Klebsiella* which are indicators of faecal contamination could be attributed to the water source and the method used in the preparation of the food and it could also be as a result of the unhygienic activities of the handlers. The presence of *E. coli* is of public health concern considering its role in food borne infection. Species of *Pseudomonas* are motile organisms and are widely distributed in water, soil and sewage. *P. aeruginosa* inhabits the intestinal tract of humans and animal. The presence of this organism indicates contamination from any of the mentioned source and suggestive of possible post – production contamination (Simopoulos & Bhat, 2000). All of these suggest that the samples could serve as common vehicle for pathogens transmitted via the faecal oral route. The presence of species of *Bacillus* is an indicator of contamination from the soil as their spores are found in the soil. It produces endospores which help it to survive the heat treatment and is associated with miscellaneous problems (Drobniewski, 1993).

The fungal species encountered in the soyabean cheese samples (*Mucor racemosus*, *Saccharomyces cerevisiae*, *Rhizopus stolonifer*, *Geotrichum candidum* and *Aspergillus fumigatus*) could also come from the environment, their presence buttress the likelihood of post- production contamination. Tudor *et al.* (2009) reported that certain species of *Aspergillus* produce toxic metabolite, while *Mucor sp.* could degrade the biochemical structure of proteins and lipids thereby altering its organoleptic property. Frazier and Westhoff (2004) have implicated *Aspergillus* and *Mucor* in food poisoning and in the spoilage of cheese. *Saccharomyces cerevisiae* occurred in the soyabean cheese samples than the other fungi and this may be due to the fact that they are the dominant organisms found in soya milk. *R. stolonifer* has been reported to cause an elevation in pH beyond the safety value of 4.6 and makes the environment more conducive for the growth of pathogenic bacteria (Effiuevwere & Akoma, 1997). None of the sampled soyabean cheese was mouldy as at the time of sampling suggesting that the fungi were yet to be established; hence contamination is likely due to fungal propagules in the air (Ikuomola & Eniola, 2010). If the moulds get established on the soyabean cheese, mycotoxic substances which would be hazardous to consumers could be produced.

The samples might have been contaminated with microorganisms as a result of unhygienic processing and packaging conditions. The number and type of microbes present on the products are major determinant of quality deterioration. The sampled products were found to contain bacteria and moulds, which under favourable conditions could multiply leading to spoilage of products and render them inedible or make them vehicles of food poisoning or food infection. Therefore, care should be taken to prevent contamination. The hawkers of these products should also handle them in such a way that they would be prevented from insects, especially houseflies which are known to transmit microbes (Ikuomola & Eniola, 2010). These products could also be packed in sealed transparent nylon bags after production, before being packed into buckets with a cover as against exposing them in bowls, trays or glass boxes.

Conclusion

It can be concluded from this study that there is the need to monitor the quality of fried soyabean cheese being sold in the metropolis since potential pathogens were isolated.

Recommendation

It is recommended that it is important to keep soyabean cheese fit for consumption by taking adequate measures to prevent contamination during and after production. In order to achieve this, the following measures should be strictly adhered to: there is the need to improve on the hygienic conditions surrounding soyabean cheese production. Pre- production and post – production operations should be adequately checked. Care should also be taken not to use contaminated water in the course of production; and contact with soil and dust should be avoided. It is also recommended that; If unwell, food should not be handled. Touching of the hair, nose and mouth should be discouraged during food preparation. Suitable light coloured protective clothing should be worn during food preparation. Cuts and abrasions should be covered with water proof bandages and if on the hands suitable gloves should be worn, ring and other jewellery especially those worn on the wrist and fingers should not be worn during food preparation as they can harbour dirt and bacteria, utensils used for cooking should be washed well after each use to prevent cross contamination from air. Lastly, soyabean cheese should not be exposed to contamination from air and flies while hawking.

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PREDICTORS OF MENTORING RELATIONSHIPS OF CERTIFIED LIBRARIANS IN NIGERIA

NGOZI BLESSING OSSAI-UGBAH, CLN. & PATIENCE ONORIODE KAYOMA

John Harris Library, University of Benin, Benin City, Nigeria

E-mail: ngozi.ossai-ugbah@uniben.edu, ladykayee@yahoo.com

Phone No: +234-802-361-3238

Abstract

This paper is a research survey conducted to discover the predictors of mentoring relationships of certified librarians in Nigeria. The survey revealed that: (1) mentor competence is a predictor of mentoring relationship for certified librarians in Nigeria with 90 (75%) respondents, (2) that cross gender in mentoring relationships is not a problem for certified librarians with 57 (47.5%) of respondents; (3) mentoring has helped more certified librarians to cope with the work environment with 87 (72.5%) respondents, and (4) more certified librarians 85 (70.8%) agree that professional development is their mentors greatest contribution to them. This paper urges the Nigerian Library Association and the Committee of University Librarians to explore and develop formal mentoring programmes for librarians in Nigerian universities and colleges as it would bring several professional and career benefits to certified librarians.

Key Words: Predictors, Mentoring, Certified Librarians, Nigeria.

Introduction

Mentoring is used in a wide variety of contexts to refer to coaching, counselling or advise. In today's ever expanding knowledge economy, knowledge and base are becoming competitive especially with specialised training required for job effectiveness. Mentoring has become a tool in professional organisations to develop and grow. Mentoring has its roots in ancient Greek mythology. Mentor, son of Alcumus was a friend to Odysseus. When Odysseus was to leave for Greece's war against Troy, he asked Mentor, a wise man to be in custody of his son Telemachus to guide and counsel him in his absence (Dean, 2009). A "mentor is that person who achieves a one-to-one developmental relationship with a learner; and one whom the learner identifies as having enabled personal growth to take place" (Cronwell-Ward, Bossons & Gover, 2004, p.26). Do younger librarians require the support of their senior professionals in order to assist and guide them in performing their jobs better? This is where mentoring takes centre stage in an ever changing like librarianship where certified librarians operate.

A certified Librarian is a professional that holds a recognized degree in library science from an accredited institution and becomes qualified to practice librarianship. Thus, a certified librarian is responsible in articulating policies and administers certain aspects of library services for effective delivery to patrons within an environment. Therefore, mentoring is important to train and generate knowledge among them so that they can perform better in their jobs.

Literature Review

It has been observed that mentoring may have a significant impact on individuals' career development within an organisation (Allen, Day, Lentz, 2005; Niehoff, 2006; Okurame &

Bologun, 2005). This is because, some scholars like Rajendran (2012) and Nifadkar and Dongre (2014) highlighted that career development is often viewed as helping individuals to acquire the skills and experiences needed to perform current and future jobs, give advice, increase the ability of individuals to positively influence others, and protect individuals' dignities from being affected by negative environments. According to Noe, Greenberger and Wang (2002), mentoring could provide career and psychosocial support to protégés. Psychosocial is a function often seen as helping individuals by building confidence, overcoming pressures and strains. It also includes assisting the personal life of mentees through opinions heard and valued, sharing dreams, providing feedback, awareness of contribution to relationship, and teaching with examples (Okunrame, 2009; Parker-Gibson, 2007). Thus, mentoring appears to offer benefits for both mentors and mentees (Weng, Huang, Tsai, Chang, Lin & Lee, 2010). For mentees, mentoring provide opportunities to develop competencies and technical skills, knowledge and thereby improve performance.

Wanberg, Welsh, and Hezlett (2003) succinctly noted that mentoring is a process by which persons of superior rank, special achievement and prestige, instruct, counsel, guide and facilitate the intellectual and/or career development of persons identified as protégés. A protégé is in a sense a neophyte, learner or beginner in a career path. The mentees' benefits of mentoring include increased competence, increased confidence and a sense of security with decreased stress, leadership development and insight in times of uncertainty and expanded networks (Van Emmerik, H., Baugh, & Euwema, 2005). Other benefits for the mentee are increased job satisfaction, elevated promotions, pay (Starkey, 2011; Sugimoto, 2009), and organizational commitment, and organizational citizenship behaviour (Smallwood, & Tolley-Stokes, 2011; Tella, Ayeni, & Popoola, 2007; Stueart & Sullivan, 2010). Research by Eby, Lockwood, Butts (2006) examined three categories of predictors: relational behaviours, motivational variables, and personality variables. Relational variables hinges on the ability of a protégé to maintain social connections with a mentor, which has a lot to do with attraction. Motivational variables indicate such things as job satisfaction, role model status and skilled level of the protégé to follow a mentor. Personality variable deals with the personality type of a perceived mentor, since each person brings his/her personality to bear in mentoring. Scandura and Williams (2004) pointed out that the perceived benefits to mentoring others by a mentor predict the relationship.

Two other studies by Curtis (2010) and Bosch, Ramachandran, Luévano, and Wakiji, (2010) have underscored the support from an organization has in mentoring others. However, inflexible organizational structures, undefined prospects, job pressures, and a competitive environment hinder the mentor's ability to mentor others. Ethnic and religious affiliation is also identified as a predictor of mentoring relationship among librarians in Nigeria (Salami, 2010).

Study Objectives

The objectives of this study are to:

- (i) To find out the predictors of mentoring relationship among certified librarians in Nigeria
- (ii) To find out if gender is a barrier in mentoring relationships among certified librarians in Nigeria, and
- (iii) To discover if mentoring enhances the professional development of certified librarians in Nigeria

Justification of Study

It is in this manner that the purpose of this research is to examine the predictors of mentoring relationships of certified librarians in Nigeria with specific references to its importance in professional development, job satisfaction and mentor competence for personal, career and professional growth of the certified librarian. Zakari and Okojie, (2011) and Parker-Gibson (2007) in their studies noted that attitudes of librarians towards mentoring can impact their jobs negatively or positively and what predicts mentoring rests with the mentor not necessarily the organisation.

Research Methodology

This research method was a descriptive survey. It was designed to find out the predictors of mentoring relationships among certified librarians in Nigeria. The survey was also designed to find out the personal and psychosocial factors that predict how and why mentoring relationships take place among certified librarians in Nigeria. The research population was certified librarians. The instrument used was distribution of questionnaires by hand. One hundred and thirty (130) questionnaires were administered and one hundred and twenty (120) collected by the researcher. The sample population were participants at the 1st Conference of certified Librarians, National Universities Commission, 18th – 23rd May, 2014, Maitama, Abuja, FCT, Nigeria. The respondents were chosen randomly. A breakdown of the research respondents include:

Position	No of Respondents	Percentage
University Librarian	8	6.7 %
Professor	10	8.3%
Deputy university librarian	8	6.7 %
Associate Professor	10	8.3%
Principal librarian	12	10 %
Reader	6	5 %
Senior librarian	10	8.3%
Senior lecturer	12	10 %
Lecturer 1	8	6.7 %
Librarian 1	12	10 %
Librarian 11	16	13.3 %
Assistant librarian/Graduate	8	6.7 %
Total	120	100 %

Results

Table 1 - Mentor Competence

This section examines and explores mentors' trait of competence as it predicts mentoring relationship of certified librarians.

Question 1	Answer		
My mentor demonstrated professional competence	Agree 90	Disagree 10	Undecided 20
Question 2	Answer		
I am satisfied with the content expertise of my mentor	Agree 75	Disagree 16	Undecided 29

In Table above, professional competence of a mentor is indicative of a predictor as 90 (75%) agree, with 20 (16.7%) undecided and 10 (8.3%) disagree. This agrees with Buchanan, Myers and Hardin (2005) and Moran, Solomon, Marshall and Rathbun-Grubb (2009) that possession of knowledge is a key component trait for a mentor in any mentoring relationship. Knowledge refers to possession information in a field of study. Possession of knowledge is a key component trait for a mentor (Buchanan, Myers & Hardin, 2005; Moran, Solomon, Marshall & Rathbun-Grubb, 2009).

Table shows that 75 (62.5%) are satisfied with the content expertise of their mentor, 29 (24.2%) are undecided and 16 (13.3%) disagree. Content expertise relate to the mentors' professional competence in the job, understanding of core values and knowledge of the profession. This is what bridges the labour gap in library profession. Neely and Peterson (2007) said the growing labour gap in librarianship is a result of an "increasing demand for library and information science professionals, and a declining supply of qualified individuals." A qualified personnel is a content expert necessary for mentoring and mentorship in the profession. Mentoring traits also include flexibility and personality, and not limited to competence. Wilson and Elman (1990) listed other mentors' traits as integrity, courage and care, while Darwin (1999) observed they are authenticity, nurturance, approachability, inspiration and conscientiousness. However, Smith, Howard and Harrington (2005) identified integrity and concern.

Table 2 – Career Development

This section discusses career development as a predictor of mentoring relationship of certified librarians with emphasis on motivation of mentors and mentees for the mentoring relationship.

Question 3	Answer		
What was the motivation of your mentor for the mentoring relationship?	Personal Growth	Career Development	Job Satisfaction
Total	22	73	25
Question 4	Answer		
What informed your need for a mentor?	Career Development	Paper publication /presentation	Skill Acquisition
	57	50	13
Question 5	Answer		
Mentoring has increased my career skills like administration, organisation, synergy etc	Agree	Disagree	Undecided
	75	22	23

In Table above, 73 (60.8%) agree career development as the motivation of the mentor for the mentoring relationship, while 25 (20.8%) indicate job satisfaction, and 22 (18.3%) as personal growth. Career development deals with a circumstance where the mentor instructs the protégé on the proper models of the discipline and prepares them for a career in the field as the mentor guides and provides opportunities for the career growth of protégée(s) by identifying situations and events, which contribute knowledge, experience and values to the life of the protégée.

Again, Career development predict the mentees need for mentoring with 57 (47.5%), while 50 (41.7%) for paper presentation and publication and 13 (10.8%) for skill acquisition. Thus, mentoring is a method of training and development used to increase group and/or individuals'

potentials to carry out particular duties and responsibilities, familiarize with new techniques, and care all aspects of mentees career (Hanford & Ehrich, 2006)

Furthermore, the Table show career skills, 75 (62.5%) dominate the benefit of mentoring to the mentee, but 22 (18.3%) disagree and 23 (19.2%) are undecided. Career skills like administration and general synergy at work can better improve the skill of the mentee for growth. This agrees with Kebede (2010) that mentoring/mentee roles influence professional direction and linked effective mentoring to library leadership as mentoring skills account for greater retention within the library profession.

Table 3 – Gender

This section explores and discusses gender as a part demographic factor in mentoring with regard to same or cross gender relationships. Demographic factors include: age, gender, academic qualification, status and tenure.

Question 6	Answer		
I will not enter into a mentoring relationship with a mentor who is not of the same gender	Agree 46	Disagree 27	Undecided 47
Question 7	Answer		
Cross gender is a barrier in mentoring relationship	Agree 20	Disagree 57	Undecided 43

Table 3 gender is not a factor in mentoring relationships. 46 (38.3%) will not engage in a mentor relationship with someone of another gender, 27 (22.5%) disagree, and 47 (39.2%) are undecided. The reason for this might be because; there is a greater likelihood in cross-gender mentoring relationships in professional contexts. This result disagrees with Chandler and Kram (2010) who affirm that it is easier for anxiety to develop regarding intimacy and physical attraction in cross-gender mentoring relationships, thus leading to negative consequences for both mentor and protege.

57 (47.5%) disagree, 43 (35.8%) are undecided, and 20 (16.7%) agree that cross gender is a barrier to mentoring. This seems to contradict the result of table 3.1 where more respondents will not engage in cross-gender mentoring relationships. Thus, there is no agreement with Chandler and Kram (2010) that cross-gender mentoring (e.g. female protege and male- mentor pair) is less likely to occur due to different expectations.

Table 4 - Professional Development

The tables in this section discuss professional development of the mentee as a predictor in mentoring relationship as professional development focuses on deficient areas amongst others.

Question 8	Answer		
Mentoring has increased my professional development in deficient areas of the library profession	Agree 85	Disagree 30	Undecided 5
Question 9	Answer		
My mentor's greatest contribution to my life is professional development	Agree 85	Disagree 30	Undecided 5
Question 10	Answer		
Mentoring has helped me with proficiency skills	Agree 78	Disagree 30	Undecided 12

In Table 4, 85 (70.8%) agree that mentoring increased professional development in deficient areas, with 30 (25%) disagreement and 5 (4.2%) undecided. Therefore, professional development is a function provided by the mentor as noted by Wijayasundara (2008).

Also, 85 (70.8%) agree that professional development is the mentors' greatest contribution. This is therefore a predictor of mentoring relationship for a mentee, while 30 (25 %) disagree and 5 (4.2%) were undecided. This result also agrees with the submission in table 4.1 above. Mosley (2005) observed that mentoring develops managerial skills among librarians as "Mentors stop rising stars from making stupid mistakes" (p. 189).

78 (65%) agree, 30 (25 %) disagree and 12 (10%) are undecided that mentoring has increased their proficiency skills. This is because, mentoring relationships develop pedagogical knowledge and professional development of librarians. This explains why some mentors and mentees may feel more comfortable to keep a professional relationship and develop a personal bond that may lead to improved mentees' advancement, especially career and psychosocial advancement in organizations (Okurame & Bologun, 2006; Niehoff, 2006).

Table 5- Job Satisfaction

Job satisfaction is the feeling or a general attitude of pleasure of employees in relation with their jobs and the job components such as the working environment, working conditions, equitable rewards, and communication with the colleagues.

Question 11	Answer		
Mentoring has helped me to cope with my work environment	Agree 87	Disagree 9	Undecided 24
Question 12	Answer		
Mentoring has increased my communication skills with colleagues	Agree 67	Disagree 21	Undecided 32

In Table 5, mentoring has helped more certified librarians to cope with the work environment with 87 (72.5%) in agreement, 24 (20%) undecided, and 9 (7.5%) disagree. The work environment also deals with physical relationships, organisational policies and welfare. In Librarianship, mentoring is a way to support new librarians (Hicks, 2012). This conclusion supports Bosch, Ramachandran, Luévano, & Wakiji (2010) who observed that mentoring is a service activity that librarians engage in to ensure a smooth integration of new library faculty.

Mentoring increased communication skills with 67 (55.8%) in agreement, 32 (26.7%) undecided, and 21 (17.5%) disagree. Communication is part of a work environment and can breed non-satisfaction with the job. According to Mullins, Allen and Hufford (2007), the foundational skills and competencies traditionally associated with general education— critical thinking and reasoning abilities, written and oral communication skills, and so forth are obvious mentor traits passed on to mentees.

Findings

This research has found the following:

- (i) That mentor competence is a predictor of mentoring relationship for certified librarians in Nigeria with 90 (75%) respondents in agreement.

- (ii) That mentoring has helped more certified librarians to cope with the work environment with 87 (72.5%) in agreement.
- (iii) That the use of cross gender in mentoring relationships is not a problem for certified librarians as 57 (47.5%) disagree, 43 (35.8%) were undecided and 20 (16.7%) agreed.
- (iv) That more certified librarians 85 (70.8%) agree that professional development is their mentors' greatest contribution to them.

Conclusion

The foundation of this study is to add to documentation that could lead to more efficient mentoring relationships among certified librarians in Nigeria. The aim is to engender personal learning which can also further personal development thus improving the human mind as well as the organisation in this case, the Nigerian libraries. Remarkable advantages can be gained from effective mentoring relationships. Results indicate that certified librarians go into mentoring more for professional development (Bello & Mansor, 2011). Mentoring relationships are predicated on several factors which are open for exploration.

Recommendations

- (i) The Nigerian Library Association should educate members on the benefits of mentoring through her annual conferences and specialized short courses
- (ii) The certified Librarian Council of Nigeria should make mentoring a mandatory supervisory programme for its members
- (iii) The Committee of Nigerian University librarians should make mentoring mandatory for staff to use mentoring in training of younger librarians in the profession
- (iv) Certified librarians should implement the use of mentoring to enrich their libraries and make jobs easier.

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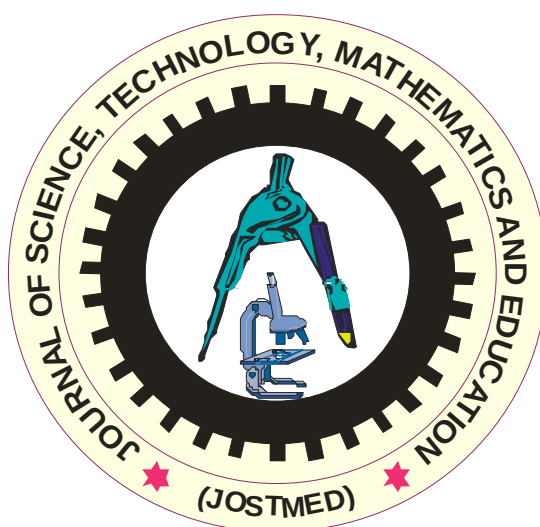
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ARTICLES AND RESEARCH REPORTS ON TECHNOLOGY

ENERGY UTILIZATION, CONSERVATION AND AUDITING IN NIGERIA CEMENT INDUSTRY

ABDULKARIM NASIR¹, BORI IGE¹, TIMOTHY ENITILLO¹,
OLUWATOSIN SARAFA AZEEZ², ABUBAKAR MOHAMMED¹

¹Department of Mechanical Engineering, Federal University of Technology, Minna, Nigeria

²Department of Chemical Engineering, Federal University of Technology, Minna, Nigeria

E-mail: a.nasir@futminna.edu.ng Phone No: +234-803-318-3561

Abstract

Manufacturing of cement is identified as one of the most energy intensive industries in the world. Therefore, there is a need for its effective and efficient utilization and hence conservation. In order to produce clinker, rotary kilns are widely used in cement plants. This study takes a look at the energy source, utilization and conservation in a Cement Company in Nigeria. The company's energy source was determined, utilization pattern investigated and possible areas of energy conservation considered. The rotary kiln of this plant where the large form of energy is consumed has a capacity of 6000 tonnes per day. It was found that about 20% of the total input energy was being lost through hot flue gas (5.09%), cooler stack (12.4%) and kiln shell (2.61% convection and radiation). To recover some of this heat energy losses, a feasible energy management method was introduced and discussed. Findings showed that approximately 4MW of electrical power could be recovered through conservation and proper energy management.

Keywords: Energy Utilization, Auditing, Cement Industries, Thermal energy, Electric Motor

Introduction

Industrial sector energy consumption ranges between 30% and 70% of total energy used in some selected countries (Al-Mansour, Merse, Tomsic, 2003; Onut & Soner 2007; Saidur, 2010). A substantial amount of energy is used up in cement production industries. Therefore, a considerable attention is required for the reduction of energy and energy related environmental emissions locally and globally (Gielen, Taylor, 2009; Sheinabaum, Ozawa, 1998). Based on literatures, the cement industry accounts for about 12% of total energy consumption in Malaysia and 15% of total consumption in Iran (Avami & Sattari, 2007). With the cement industry being an energy intensive industry, this segment of industry typically accounts for 50–60% of total production costs (Singhi & Bhargava, 2010). Typically, electrical energy consumption of a modern cement plant is about 110 – 120kWh per tonne of cement (Mejeoumov, 2007). The bulk of the thermal energy is used during burning process, while electrical energy is used for cement grinding (Junior, 2003). Specific energy consumption in cement production differs with technology used. The dry process uses more electrical but much less thermal energy than the wet process. In industrialised countries, primary energy consumption in a typical cement plant is up to 75% fossil fuel and 25% electrical energy in dry process. Pyro-processing requires the major share of the total thermal energy use. This accounts for about 93-99% of total fuel consumption (Junior, 2003; Khurana, Rangan & Uday, 2002). However, electric energy is mainly used to operate both raw materials handling (33%) and clinker crushing and grinding (38%) equipment. Electrical energy is also required to run the auxiliary equipment such as kiln motors, combustion air blowers and fuel supply, etc (22%) in order to sustain the pyro-process (Engin & Ari, 2005). Consequently, significant amounts of

greenhouse gases (GHG) emissions are released to the atmosphere due to burning of fossil fuel used in supplying the energy need of the cement industries (Gielen & Taylor, 2009). With specific thermal energy consumption in cement industries found to be about 4-5GJ/tonne (Ziya, Zuhal, Hikmet, 2010). It has however been made evident that a thermal energy saving potential of 0.25–0.345GJ/t, an electrical energy saving potential of 20–35kWh/t and an emission reduction potential of 4.6–31.66kg CO₂ is feasible in these industry (Singhi & Bhargava, 2010).

Energy audit has emerged as one of the most effective procedures for a successful energy management program (Pahuja, 1996). The main aim of the energy audit is to provide an accurate account of energy consumption and energy use analysis of different components in order to reveal the detailed information needed for determining the possible opportunities for energy conservation. Waste heat recovery from hot gases (Kamal, 1997) and hot kiln surfaces (Engin, 1997) in a kiln system are known as potential ways to improve overall kiln efficiency. However, it is still fairly difficult to find a detailed thermal analysis of a rotary kiln system in the open literature. This paper focuses on the energy audit of a horizontal rotary kiln system which is in use in one of the Cement Plants in Nigeria.

Materials and Methods

Data Sources and Collection

The cement plant under study is one of the largest cement plant in sub-saharan Africa with 13.25 mmtpa capacity across four lines. The data collected are tabulated in Table 1.

Materials

To carry out energy audit of the plant, the required data was obtained from the plant's laboratories where samples were taken each hour. The Central Control Room (CCR) receives feedback of various technical characteristics of electrical and mechanical equipment. Other materials required include measuring tapes for measuring dimensions where dimension is not available from the plant's equipment list and Infra-red thermometer to directly record temperature values where necessary. The data collected covers the following: The energy reading was recorded daily from electrical substations in the plant for each section of production. The fuel (gas) sample analysis, raw material sample analysis, Kiln-feed sample analysis and Clinker sample analysis were done hourly and the feedback to the Robotic laboratory. The temperature values and flow rates were obtained from the CCR based on feedback from instruments installed on equipment. Infra-red thermometer was used to obtain surface temperatures where necessary. The dimensions of equipment, types and other details were obtained from plant manufacturer's document in the company's library. Electric motor rating was obtained from motor plates, running current and power output are recorded from the feedbacks received in the CCR.

Thermal and Electrical Components Analysis

Thermal and electrical components analysis was done to ascertain the energy utilization. The thermodynamic analyse of the kiln system was achieved using the following assumptions: The working conditions was steady state; The change in the ambient temperature is neglected; Cold air leakage into the system is negligible; Raw material compositions do not change; The average kiln surface temperatures do not change; The preheater is modelled as a vertical cylinder; The cooler surface is modelled as a vertical plate. The kiln system considered for the energy audit is schematically shown in Figure 1. The control volume for the system includes the

preheater group, rotary kiln and cooler. The analysis of these components is discussed in the next sections.

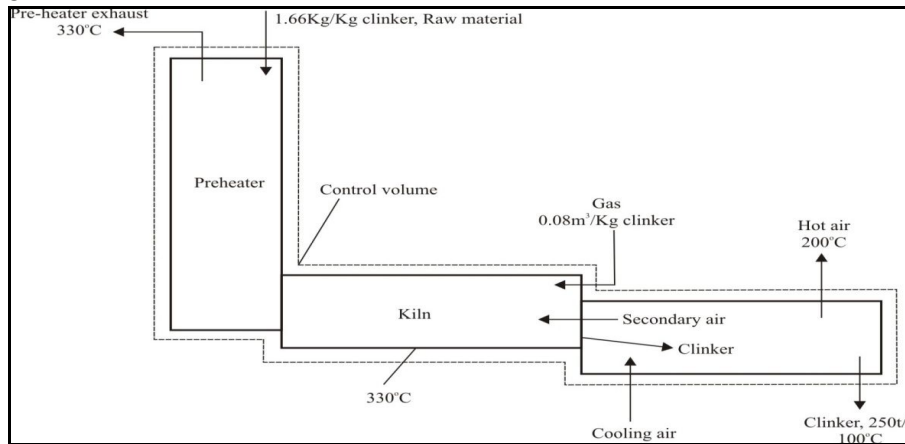


Figure 1: Control volume, various streams and components for kiln system

Thermal Energy Balance Analysis

The thermal energy balance was performed on the fourth line of the plant. The information about several parameters such as temperature, dimension and energy consumption of the utility equipment were obtained. The data were gathered from existing factory laboratories and feedbacks from monitoring instruments installed on each of the equipment. The data required for this case study is outlined in Table 1

Table 1: Information required for Heat Balance Calculation

Parameter	Value	Parameter	Value	Parameter	Value
A_{ch} (m ²)	11.32	$KF_{Al_2O_3}$ (wt)	3.55	T_{Z2} (°C)	250
A_{Kiln} (m ²)	402.96	$KF_{Fe_2O_3}$ (wt)	2.38	T_{Za} (°C)	350
Cl_{SiO_2} (wt)	21.55	KF_{CaO} (wt)	43.01	T (°C)	200
$Cl_{Al_2O_3}$ (wt)	5.42	KF_{MgO} (wt)	0.79	T_{Cooler} (°C)	40
$Cl_{Fe_2O_3}$ (wt)	3.42	KF_{N_2O} (wt)	0.02	T_{Kiln} (°C)	75
Cl_{CaO} (wt)	65.71	KF_{K_2O} (wt)	0.33	$T_{Preheater}$ (°C)	80
Cl_{MgO} (wt)	1.25	KF_{SO_3} (wt)	0.11	V_{Pa} (m ³ /s)	346.4
Cl_{SO_3} (wt)	0.41	KF_{Ig} (wt)	35.02	V_{Ex} (m ³ /s)	113.8
Cl_{Ig} (wt)	1.0264	KF_M (wt)	0.5	V_{Co} (m ³ /s)	208.6
D_{Ig} (wt)	9.7	L_1 (m)	74	V_{Be} (m ³ /s)	145.3
D_{cooler} (m)	5.6	L_2 (m)	5.2	W_{Cl} (Kg/h)	250,000
$D_{preheater}$ (m)	5.6	L_3 (m)	19.63	W_{dF} (Kg/Kg Clinker)	1.66
F_{CO_2} (vol.%)	0.01	L_4 (Mm)	22	W_A (m ³ /Kg Clinker)	0.08
F_{H_2} (vol.%)	0.01	L_5 (Mm)	50	c_{jfuel} (KJ/m ³ °C)	17.27
F_{CH_4} (vol.%)	93.25	L_6 (deg)	2.3	c_{jCO_2} (KJ/Kg°C)	0.80
$F_{C_2H_6}$ (vol.%)	5.14	L_{cooler} (M)	275	c_{jH_2O} (KJ/Kg°C)	1.00
$F_{C_3H_8}$ (vol.%)	0.01	$L_{preheater}$ (M)	16.25	c_{jSO_3} (KJ/Kg°C)	0.70
$F_{C_4H_{10}}$ (vol.%)	1.02	R_h (mm H ₂ O)	0.6	c_{jN_2} (KJ/Kg°C)	0.90
$F_{C_5H_{12}}$ (vol.%)	0.09	T_{amb} (°C)	31	$c_{jair_{31°C}}$ (KJ/Kg°C)	0.95
F_{HV} (KJ/m ³)	37,472	T_C (°C)	50	$c_{jair_{200°C}}$ (KJ/Kg°C)	1.01
G_{CO_2} (wt)	3.6	T_{Pa} (°C)	65	$c_{jair_{330°C}}$ (KJ/Kg°C)	1.98
G_{O_2} (wt)	0	T_{Sa} (°C)	1000	ϕ_{j1} (KJ/hm ² °C)	75
G_{CO} (wt)	29.3	T_{Be} (°C)	330	ϕ_{j2} (KJ/hm ² °C)	96
G_{N_2} (wt)	67.1	T_{St} (°C)	200	ϕ_{j3} (KJ/hm ² °C)	65
KF_{SiO_2} (wt)	14.06	T_F (°C)	100		
		T_{Z1} (°C)	37		

Total heat input and output of the kiln system

The equations for the total heat input and output of the kiln system are presented in equations (1) to (13) as tabulated in Tables 2 and 3.

Table 2: Total heat input of the kiln system

Heat Inputs	Formulation	equ
Combustion of fuel	$W_A \times F_{HV}$	(1)
Sensible heat in fuel	$W_A \times c_{jfuel} \times T_F$	(2)
Sensible heat in kiln feed	$\left(W_{dF} \times c_{jfuel} \times T_C \right) + \left(\left(WGF_{H_2O_{free}} + WGF_{H_2O_{chem}} \right) \times T_C \times 4.184 \right)$ $WGF_{H_2O_{free}} = \frac{100 \times W_{dF}}{100 - KF_M} - W_{dF}$ $WGF_{H_2O_{chem}} = (1 + dl) \times (0.00075 \times KF_{SiO_2} + 0.0035 \times KF_{Al_2O_3})$ $dl = \frac{(W_{dF} - FR)}{W_{dF}}$ $FR = [(0.01784 \times KF_{CaO}) + (0.0209 \times KF_{MgO}) + (0.0135 \times KF_{Al_2O_3}) + (0.01075 \times K$ $+ (0.01 \times KF_{Fe_2O_3})] \times \left(\frac{100 - Cl_{I_E}}{100} \right)$	(3)
Cooler air sensible heat	$\frac{CAB_{CO} \times c_{air} \times T_{amb}}{W_{Cl}}$, where $CAB_{CO} = 4654.44 \times V_{CO}$	(4)
Primary air sensible heat	$\frac{CAB_{Pa} \times c_{air} \times T_{amb}}{W_{Cl}}$, where $CAB_{Pa} = 4654.44 \times V_{Pa}$	(5)
Infiltrated air sensible heat	$\frac{AIH \times c_{air} \times T}{W_{Cl}}$, where $AIH = 11,720.3 \times A_{ch} \times (1.157 \times P_h)^{0.5}$	(6)

Table 3: Total heat output of the kiln system

Heat Outputs	Formulation	
Clinker formation	$(4.11 \times Cl_{Al_2O_3}) + (6.48 \times Cl_{MgO}) + (7.646 \times Cl_{CaO}) -$ $(5.116 \times Cl_{SiO_2}) - (0.59 \times Cl_{Fe_2O_3})$ $(W_{CO_2} \times c_{jCO_2} \times T_{Be}) + (W_{H_2O} \times c_{jH_2O} \times T_{Be}) +$ $(W_{SO_3} \times c_{jSO_3} \times T_{Be}) + (W_{N_2} \times c_{jN_2} \times T_{Be}) +$ $(Excess\ air \times c_{jair} \times T_{Be})$	(7)
Kiln exit gas	Where, $W_{CO_2} = CP_{CO_2} + WGF_{CO_2}$ $W_{H_2O} = CP_{H_2O} + WGF_{H_2O_{free}} + WGF_{H_2O_{chem}}$ $W_{SO_3} = 0.5 \times CP_{SO_3}$ $W_{N_2} = CP_{N_2}$	(8)

	$\text{Excess air} = \left(\frac{EA}{100}\right) [(CP_{CO_2} + CP_{H_2O} + CP_{N_2})]$ $CP_{CO_2} = W_A [(1.97 \times F_{CH_4}) + (3.94 \times F_{C_2H_6}) + (5.9 \times F_{C_3H_8}) + (9.64 \times F_{C_3H_{12}}) + (1.97 \times F_{CO_2})]$ $WGF_{CO_2} = \left(1 + \frac{dl}{2}\right) [(0.0078 \times KF_{CaO}) + (0.0109 \times KF_{MgO})]$ $CP_{H_2O} = W_A [(1.6 \times F_{CH_4}) + (2.4 \times F_{C_2H_6}) + (3.14 \times F_{C_3H_8}) + (5.05 \times F_{C_3H_{12}})]$ $CP_{N_2} = W_A [(9.55 \times F_{CH_4}) + (16.70 \times F_{C_2H_6}) + (23.86 \times F_{C_3H_8}) + (38.19 \times F_{C_3H_{12}}) + (1.25 \times F_{H_2})]$ $EA = \frac{189 \times [(2.0 \times G_{O_2}) - G_{CO}]}{[G_{N_2} - (1.89 \times ((2.0 \times G_{O_2}) - G_{CO}))]}$	
Moisture in feed or slurry	$(WGF_{H_2O_{free}} + WGF_{H_2O_{chem}}) \times 2500.8$	(9)
Dust in the kiln exit gas	$(DI \times c_{jDust} \times T_{Be}) = (W_{dF} - FR) \times c_{jDust} \times T_{Be}$	(10)
Clinker at cooler discharge	$c_{jClinker} \times T_{Cl}$	(11)
Cooler stack	$\frac{CAB_{Ex} \times c_{jair} \times T_{St}}{W_{Cl}}, CAB_{Ex} = 4654.44 \times V_{Ex}$	(12)
Radiation on kiln shell	$\frac{A_{Kiln}}{3} \times \frac{((q_{j1} \times (T_{z1} - T)) + (q_{j2} \times (T_{z2} - T)) + (q_{j3} \times (T_{z3} - T)))}{3}$	
Calcination wasted in kiln dust	$\dot{q} = \frac{\dot{q} \times TC_{Dust} \times 1,592.5}{KF_{Ig} - DI_{Ig}}$ $TC_{Dust} = \frac{((0.01784 \times KF_{CaO}) + (0.0209 \times KF_{MgO}) \times W_{dF} \times dl)}{FR}$	(13)

Electrical Energy Balance Analysis

The need for electrical energy audit is clear when average electrical energy consumption values for Cement plant is compared with world best practice as presented Figure 2. It is observed that in almost all cases, the average energy consumption values are significantly higher than the best practice value, indicating a strong potential for energy efficiency improvement.

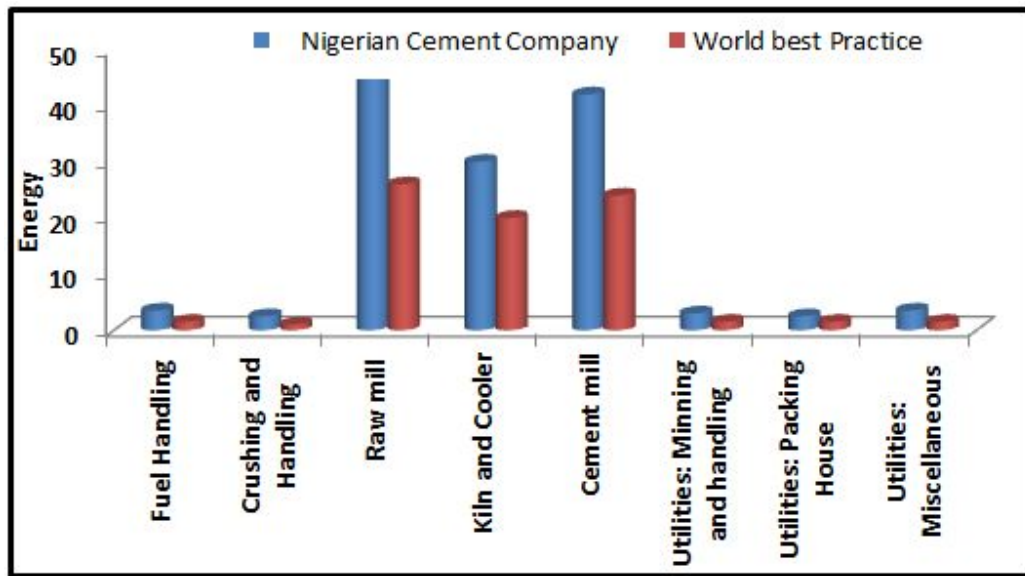


Figure 2: Energy consumption values for cement plant by process

The mathematical model of Garcia (Garcia, 2003) used for estimating the motor load has presented a correlation coefficient of 99.3% with real motor curves (Sola & Xavier, 2007). From the real measured current (I_R), nominal current (I_N) given by the manufacturer, and no load current (I_0), measured or given by the manufacturer. The real load (γ) is then determined from the relation;

$$\gamma = 1 + \frac{1}{\alpha} \ln \frac{I_R}{I_N} \quad (14)$$

Where the load current parameter is calculated by:

$$\alpha = -\ln \frac{I_0}{I_N} \quad (15)$$

The efficiency is the relation between output power and input power including energy losses (Kosow, 1972). Thus, the real efficiency is given by:

$$\eta_L = \frac{P_{out}}{P_{in}} = \frac{P_N}{P_R} \gamma \quad (16)$$

Where, P_N is the nominal output power, P_R is the real input power, γ is the rated load percentage and η_L is the low efficiency.

Improving Energy efficiency in an Industrial Motor System

The industrial motors used for this study are those operating at 690 V and 415 V. Motors nominal data were collected and electric current and power measurements were recorded straight from digital meters attached to each motor and others from the CCR. The motor data are shown in Table 3 and 4 for 690 V and 415 V respectively.

Table 3: Efficiency data from motors at 690V

Motors	Name of motor	P_N	P_R	I_N	I_R	I_0	γ	η_L
56RK01.MO1	Rotary Kiln	900	454	900	454	360	25.32	50.19
84SR01.MO1	Cement Separator (Classifier)	800	398	780	388	312	23.79	47.83

Table 4: Efficiency data from motors at 415V

Motors	Name of motor	P _N	P _R	I _N	I _R	I ₀	γ	η_L
22BC01.MO1	Raw material Handling (Belt Conveyour)	110	64	196	114	78	40.86	70.25
22ST01.MO5	R/material Handling (R/Material Stacker)	90	43	164	78	66	18.89	39.73
22BC04.MO1	Raw material Handling (Belt Conveyour)	250	122	418	204	167	21.71	44.48
35BC04.MO1	Raw material Handling (Belt Conveyour)	132	77	234	136	94	40.78	70.16
52BE01.MO1	Kiln feed Handling (Bucket elevator)	250	122	405	198	162	21.90	44.80
66DP01.MO1	Clinker Handling (Deep pan conveyour)	110	62	194	109	78	37.08	66.00
78RE01.MO1	Clinker Handling (Additive Reclaimer)	132	64	238	116	95	21.57	44.25
83BC05.MO1	High grade Handling (Belt Conveyour)	90	44	154	76	62	22.93	46.46

The improvement in energy efficiency (IEE) indicates the percent of energy saved after the replacement of a low efficiency motor (η_L) with a high efficiency motor (η), and is calculated as follows:

$$IEE = \left(1 - \frac{\eta_L}{\eta}\right) \times 100 \quad (17)$$

The real low efficiency (η_L) and the real rated load (γ) were obtained using equations (14) to (16). The real high efficiency was determined from the performance curve of the motor given by the manufacturer, considering the high efficiency (η). The improvement in energy efficiency (IEE) is determined by equation (17).

The real high efficiency is not necessarily the nominal efficiency of new motors, because this depends on rated load, which varies as a function of the electric current. The quantity of Energy Saved (QES) can be calculated as follows (McCoy & Douglas, 2000):

$$QES = P_N \gamma t \left(\frac{1}{\eta_L} - \frac{1}{\eta} \right) \quad (18)$$

Where, t is the operating time (h/yr). By the calculation of QES and considering the energy cost per kilowatt-hour (C), the Energy Saved Value (ESV) is derived by the following formula [20].

$$ESV = QES.C \quad (19)$$

Considering the Motor Investment Value (MIV) and the calculated ESV, the Simple Payback (SPB) is given by:

$$SPB = \frac{MIV}{ESV} \quad (20)$$

Results and Discussions

Thermal Energy Balance

Thermal Input of Kiln System: The thermal heat input and output balances obtained from equation (1) to (13) are shown in Table 5 and 6. From Table 5, the fuel combustion is the major heat input into the kiln system with a value of 2997.8kJ/kg which represents 86.9% of the total heat input. Sensible heat added from primary air is next to the sensible heat from fuel with a value of 189.9 kJ/kg (5.5%). The cooler air added 114.35 kJ/kg representing (3.3%) of total heat input energy. The other heat input energy into the kiln system include sensible heat from fuel that is burned (natural gas) with a value of 51.10 kJ/kg (1.5%), sensible heat added from the kiln feed is 79.85kJ/kg (2.3%), and sensible heat in infiltrated air is 16.8 kJ/kg (0.5%).

Table 5: Summary of Heat Input of Kiln System

S/No	Parameter	Value (kJ/kg)	Percent (%)
1	Combustion of fuel	2997.8	86.9
2	Sensible heat in fuel	51.10	1.5
3	Sensible heat in Kiln feed	79.85	2.3
4	Sensible heat in Cooler air	114.35	3.3
5	Sensible heat in primary air	189.9	5.5
6	Sensible heat in infiltrated air	16.8	0.5
Total		3449.8	100 %

Thermal Output of Kiln System: Based on the result in Table 6 above, it is observed that the heat energy input and output of the kiln system is in agreement with the law of conservation of energy. Table 6 shows that a large amount of the input energy is used up in the formation of clinker which is the main essence of the input heat energy. Heat used up in clinkerisation is 1759.5 kJ/kg representing 51%. The percentage does not only depict the fraction of the total input heat energy used up in the kiln system for clinker formation but also establish the efficiency of the kiln system. Other heat usage within the kiln is drying of kiln feed prior to burning 101.3 (2.94%). Much of the input energy 601.1 kJ/kg (17.42%) is wasted during calcinations; an important chemical process for clinkerisation. Some of heat escapes with dusts associated with kiln exit gases 188.3 kJ/kg (5.46). About 20% is lost to the atmosphere, this includes losses in kiln exit gas of 175.5 kJ/kg (5.09%), losses in cooler exit gas of 427.6 (12.40%) and radiation losses on kiln shell of 90.1 kJ/kg (2.61%).

Table 6: Summary of Heat Output of Kiln System

S/No	Parameter	Value (kJ/kg)	Percent (%)
1	Clinker formation	1759.5	51.00
2	Losses in kiln exit gas	175.5	5.09
3	Evaporation of moisture in feed	101.3	2.94
4	Dust in kiln exit gas	188.3	5.46
5	Clinker at cooler discharge	77.0	2.23
6	Cooler stack losses	427.6	12.40
7	Radiation losses in kiln shell	90.1	2.61
8	Calcinations wasted in kiln dust	601.1	17.42
9.	Uncountable losses	29.4	0.85
Total		3449.8	100 %

The Sankey diagram in Figure 3 is a specific type of flow diagram in which the width of the arrows is shown proportionally to the flow quantity shows the input and output of the kiln system. It was clear that the bulk of the input energy comes from fuel combustion gas. The thermal energy in the considered line of production is 3449.8KJ/Kg of clinker produced. The efficiency of the system is equal to 51% which is relatively low.

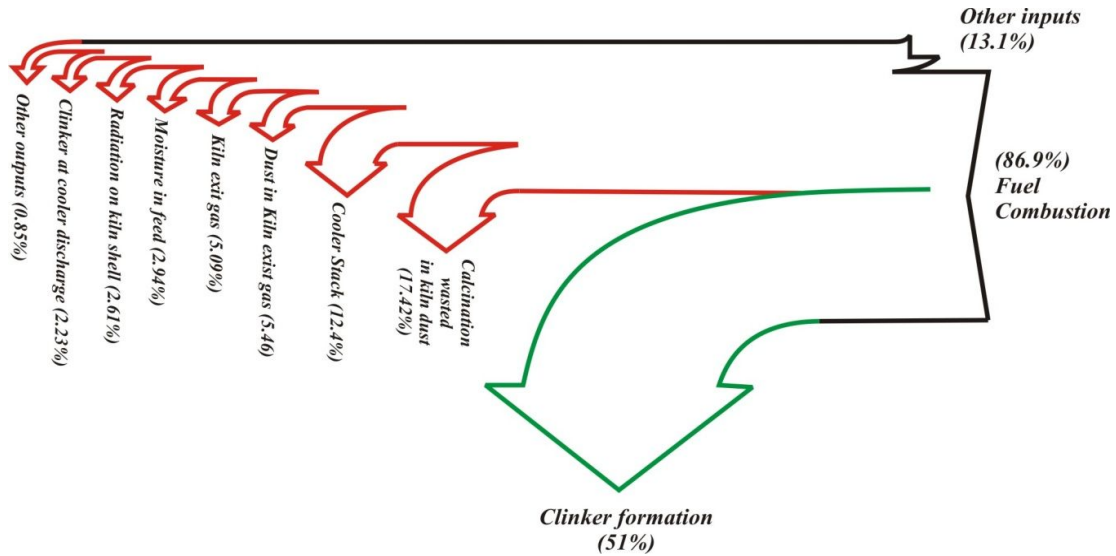


Figure 3: Sankey diagram showing the flow of thermal energy in the plant

Heat Recovery from the Kiln System: The kiln system efficiency (51%), which is relatively low, can be improved by recovering some of the heat losses. The recovered energy can be used to generate electricity, hot water preparation and fuel heating. Some of the major heat loss source that would be considered for heat recovery include; heat losses by the kiln exhaust gas (5.09%) and hot air leaving the cooler stack pipe (11.15%). Since the plant is running on captive power plant, it will be wise to capture the waste heat to the environment and utilize it to generate electricity thereby reducing the fuelling cost of the captive power plants and also their total dependency, it will also extend their life span as their loads reduces. The most feasible and in turn the most cost effective waste heat losses available for such purpose are the clinker cooler discharge and the kiln exhaust gas stack. The kiln exhaust gas temperature is 330°C on the average and the temperature of the discharge air from the cooler stack is 200°C. Both streams would be directed through a Waste Heat Recovery Steam Generator (WHRSG) and the available energy is transferred to the water via the WHRSG. The waste heat recovery system with generator is shown in Figure 4.

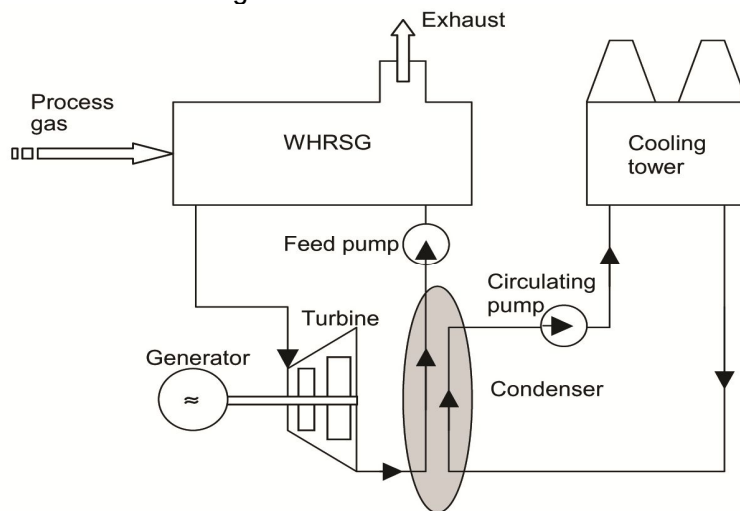


Figure 4: Illustration of waste heat recovery system with generator (Kamal, 1997)

The available waste energy is such that steam would be generated. This steam would then be used to power a steam turbine-driven electrical generator. The electricity generated would offset a portion of the electricity generated from the captive power plant running on gas, thereby reducing electricity demand.

In order to determine the size of the generator, the available energy from the gas streams must be found. Once this is determined, an approximation of the streaming rate for a specified pressure can be found. Having the streaming rate and pressure, the size of the generator can be determined. The following calculation was used to determine the size of the generator.

$$Q_{\text{WHRSG}} = Q_{\text{available}} \times \eta \quad (21)$$

Where η is the WHRSG efficiency.

Because of various losses and inefficiencies inherent in the transfer of energy from the gas stream to the circulating water within the WHRSG, not all of the available energy will be transferred. A reasonable estimate of the efficiency of the WHRSG must be made. Therefore, the efficiency of 85% is assumed for this steam generator. As the gas passes through the WHRSG, energy will be transferred and the gas temperature will drop. Approximation for the streaming rate is 5 kg/s, and a pressure of 800 Pa with a temperature of 40°C flowing through it, being heated from two sources. The control volume should have a single inlet and exit flow with two heat transfer rates coming from reservoirs different to the ambient surroundings. The characteristics of the exit water are 800 Pa and 170°C. The reversible work is obtained from the following equation [22].

$$W_{\text{rev}} = T_o(S_e - S_i) - (h_e - h_i) + q_1 \left(1 - \frac{T_o}{T_1}\right) + q_2 \left(1 - \frac{T_1}{T_2}\right) \quad (22)$$

Where, T_o , T_1 and T_2 is the ambient Kiln, exhaust stack and cooler exhaust stack temperatures respectively. The values of h_i , h_e , S_i , S_e , T_o , T_1 and T_2 were contained from periodic table. Mass flow rate of hot air stream in both kiln and cooler stack is 41.66 kg/s. Therefore q_1 and q_2 is 7,311.33 W and 17,813.82 W respectively. From the above equations, the values of W_{rev} , $Q_{\text{available}}$ and Q_{WHRSG} are calculated as 1892.58 kJ/Kg, 9462.9 kW and 8043.465 kW respectively.

Thermal Energy Cost Savings: The next step is to find a steam turbine generator that can utilize this energy. Since a turbine is a rotating piece of machinery, if properly maintained and supplied with a clean supply of dry steam, the turbine should last for a significant period of time. Considering a turbine pressure of 8bars and a condenser pressure of 10 kPa, it can be shown that the net power which could be obtained from the turbine is almost 4000 kW. Assume that the useful power generated is 4000kW, then the anticipated savings will be based on the load reduction of 4000kW. Assuming a running hours of 8000 h per year, the energy saved can be obtained from the relation;

$$\text{Energy saved} = \text{energy} \times \text{time} \quad (23)$$

The total energy saved is 3.2×10^6 kWh/yr. The anticipated cost savings is calculated from;

$$\text{Cost savings} = \text{Energy saved} \times \text{Unit cost} \quad (24)$$

Considering the average unit price of electricity in Nigeria as published by the National Energy Council for industries is ₦22.04 per kWh excluding fixed charges [22]. The cost savings is ₦705,280,000 per year.

Simple Payback Period: Assume that labour and maintenance costs average out to ₦4,000,000 annually, the saved amount becomes ₦701,280,000 per year. The cost associated with the implementation of this additional system would be the purchase price of the necessary equipment and its installation. An additional cost would be the required maintenance of the power generation unit. For the whole system, estimated cost of shipping and installation is ₦1,230,000,000. Hence the simple payback period can be calculated as follows;

$$\text{Simple payback period} = \frac{\text{Total Annual Savings}}{\text{Total Investment Cost}} \quad (25)$$

The simple payback period is approximately 21 months. The energy savings made through using a WHSRG system would also result in an improvement in the overall system efficiency. It should be noted that these calculations reflect a rough estimation and may vary depending upon plant conditions and other economic factors.

Electrical Energy Balance

The result of electrical energy utilization and efficiency improvement carried out mainly on electric motors showed that 10 out of a total of 46 motors selected for the study in the technical areas (production and maintenance) are operating below the expected specified efficiencies. Eight (8) of these motors are operating at 415 V (Table 7) while two others are operating at 690 V (Table 8). The results obtained from equations (14) to (20) for electric motor operating at 690V and 415 V are tabulated in Tables 7 and 8 respectively. The tables show that there is improvement in energy efficiency (IEE), motor investment value (MIV), quantity of energy saved (QES), the energy saved value (ESV) and the simple payback time (SPB) if a new motor is purchased to replace the ones with low efficiency. Although, from the Table 8, it is apparent that the motor investment value (MIV) for these motors operating at 690V, the simple payback time for the two (2) motors if replaced is less than 2 months.

Table 7: Result of Improvement from Motors at 415V

Motor Tag No.	IEE	MIV	QES	ESV	SPB
22BC01.MO1	25.67	320567.6	143777.60	862665.5814	0.39
22ST01.MO5	56.68	220347.4	212422.03	1274532.152	0.17
22BC04.MO1	52.93	580453.5	565418.38	3392510.277	0.17
35BC04.MO1	25.76	402345.5	173030.23	1038181.376	0.39
52BE01.MO1	52.60	580453.5	562878.07	3377268.399	0.17
66DP01.MO1	30.16	386765.7	163209.19	979255.1252	0.39
78RE01.MO1	53.18	402345.5	299558.01	1797348.084	0.22
83BC05.MO1	49.34	220347.4	191881.77	1151290.632	0.19

Table 8: Result of Improvement from Motors at 690V

Motor Tag No.	IEE	MIV	QES	ESV	SPB
56RK01.MO1	46.89	1568432	1863883.14	11183298.83	0.12
84SR01.MO1	32.03	1385359	1243683.94	7462103.624	0.17

Figure 5 shows that the efficiency of new motors is higher than that of old motors. In all, the motors with improved efficiencies and operating at 415 V, the maximum payback time is 4 months and the new efficiency can reach 94.5%. The cause of the low efficiencies in the motors was found to be due to depreciation in motor windings over time.

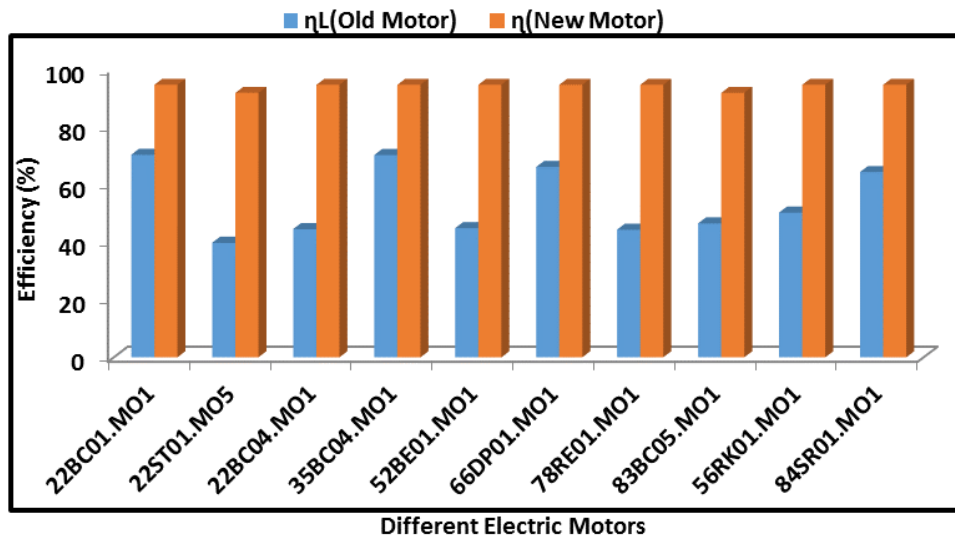


Figure 5: Comparison of old and new Motors operating at 690V 415V

Conclusions

A detailed energy audit analysis which can be directly applied to any dry kiln system has been carried out for the Cement Plant in Nigeria. The distribution of the input heat energy to the system components showed a good agreement between the total input and output energy and gave significant insights about the reasons for the low overall system efficiency. According to the results obtained, the system efficiency is calculated to be 51%. The major heat lose sources have been determined as kiln exhaust (5.09% of total input) and cooler exhaust (12.4% of total input). For these losses, a convention WHRSG system is proposed. Evaluations of energy auditing showed that 4 MW of energy could be recovered. The payback period for the system is expected to be less than 2 years (24 months). There is a significant improvement in the efficiencies of a new motor when compared to the old motors.

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NOMENCLATURE

Symbol	Description	Symbol	Description	Symbol	Description
A	Surface area, m ²	I	Current (A)	T _{Z3}	Average temperature of shell, upper third, °C
A _{ch}	Total effective area of cooler hood, m ²	I ₀	No load current (A)	T	Kiln room temperature, °C
AIH	Air infiltrated at hood	KF	Percentage of specific type of molecule in kiln feed	T _{Cooler}	Surface temperature of cooler, °C
C	Energy cost per kilowatt-hour	L ₁	Kiln length, m ²	T _{Kiln}	Surface temperature of kiln, °C
CAB _{pa}	Primary air at cooler, kg/h	L ₂	Kiln diameter, m	T _{Preheater}	Surface temperature of preheater, °C
CAB _{Ex}	Excess air vented at cooler stack, kg/h	L ₃	Effective burner tip orifice area, m ²	T _{C_{Dust}}	Total carbonates in the kiln dust, kg
CAB _{CO}	Total air flow into cooler, kg/h	L ₄	Refractory thickness, mm	V _{Be}	Air volume of kiln exit gas, m ³ /s
Cl	Percent of a specific type of molecule in clinker	L ₅	Kiln shell thickness, mm	V _{CO}	Air volume of total air into the cooler, m ³ /s
CP	A specific type of molecule from fuel combustion	L ₆	kiln slope, degrees	V _{Ex}	Air volume of cooler vent stack, m ³ /s
c _j	Mean specific heat, kJ/kg.°C	L _{cooler}	Cooler length, m	V _{pa}	Air volume of primary air flow, m ³ /s
D _{Cooler}	Cooler width, m	L _{preheater}	Preheater height, m	W _A	Fuel rate, m ³ /kg of clinker
D _{ig}	Percentage ignition loss in kiln dust (hot meal)	P _h	Hood draft, mm H ₂ O	W _{Cl}	Kiln output, kg/h
D _{preheater}	Preheater diameter, m	P	Electrical power, kW	W _{dF}	Dry feed rate, kg/kg clinker
Dl	Amount of feed wasted as dust, kg/kg clinker	Q	Heat energy, kJ	WGF _{CO₂}	CO ₂ from feed, kg/kg clinker
Dl	Percent dust loss	φ _j	Heat Transfer Coefficient, kJ/m ² .°C	WGF _{H₂O_f}	H ₂ O _{free} from feed, kg/kg clinker
EA	Excess air percent in the kiln	q̇	Percent calcinations of kiln dust	WGF _{H₂O_c}	H ₂ O _{chem} from feed, kg/kg clinker
F	Percent of specific type of molecule in natural gas	T	Operation time, h/yr	W	Total weight of a specific type of molecule in kiln exit gas, kg/kg clinker
F _{HV}	The heat value of natural gas, kJ/m ³	T _{amb}	Ambient air temperature, °C	w _{rev}	Reversible work, kJ/kg
FR	Theoretical amount of feed required to produce 1kg of clinker, kg/kg clinker	T _C	Feed entering kiln temperature, °C	ε	Emissivity
G	Percentage specific type of molecule in kiln exit gas	T _{pa}	Primary air temperature, °C	γ	Rated load
H	Convection heat transfer coefficient	T _{sa}	Secondary air temperature, °C	α	Load current parameter
		T _{Be}	Kiln exit gas temperature, °C	η	Efficiency
		T _{st}	Cooler stack temperature, °C		
		T _{Cl}	Clinker temperature at cooler exit, °C		
		T _F	Fuel temperature, °C		
		T _{Z1}	Average temperature of shell, lower third, °C		
		T _{Z2}	Average temperature of shell, middle third, °C		

EFFECTS OF *SOUTHERN BEAN MOSAIC VIRUS* ON GROWTH AND YIELD OF SOYBEAN

ADAMA, C. J., SALAUDEEN, M. T., MAMMAN, E. W. & ABDULKADIR, A.

Department of Crop Production, Federal University of Technology, Minna, Nigeria

E-mail: cinwoj@gmail.com Phone No: +234-806-333-0183

Abstract

Six soybean lines were evaluated for resistance to Southern bean mosaic virus (SBMV) under screenhouse conditions. The trial was laid out using completely randomised design with four replications. Seedlings were mechanically inoculated with the virus at 10 days after sowing. Disease incidence, disease severity (scale 1 – 5; 1 = apparently healthy plants, 5 = severe mosaic), morphological and yield parameters were recorded. Data were subjected to Analysis of Variance (ANOVA) at 5 % level of probability. One hundred percent infection was observed in all the lines but disease severity was significantly lowest in TGX 2007 – 1F (2.4). The same soybean line exhibited the lowest reductions in number of leaves per plant ((5.1 %)), leaf diameter (5.9 %), number of branches per plant (14.3 %), number of pods per plant (12.5 %), and seed weight per plant (6.3 %). The present results indicated the potential of TGX 2007 – 1F as a source of resistance gene (s) for breeding soybean cultivars against SBMV disease.

Keywords: Disease severity; pathogenicity; seed weight; *Southern bean mosaic virus*; soybean

Introduction

Soybean (*Glycine max* [L.] Merr.) is one of the major legume crops grown in sub-Saharan Africa. The plant originated in Asia, where it has two wild relatives (Carpenter and Gianessi, 2000). It later spread to Europe, America and other parts of the world in the 18th century (Ngeze, 1993). In the year 2013, about 276 million tonnes of soybean was produced worldwide (FAO, 2013). The United States of America was the highest producer with approximately 32 % of the world output, followed by Brazil (30 %), Argentina (17 %), China (5 %), India (4 %), Paraguay (3 %), and Canada (2 %), while output from all other countries was about 7 % of the overall (FAO, 2013). The crop is beneficial in cereal cropping system because it contributes substantially to soil fertility (Yusuf *et al.*, 2006). Soybean is used to supplement cereal foodstuff in many instances because cereals have low protein content and are imbalanced in essential amino acid composition. Studies have shown that cereal grains do not supply adequate protein for satisfactory growth of infants and children or for the bodily maintenance of adults (Singh *et al.*, 2008). Consequently, soybean protein has been the subject of intense investigation and has played an increasing role in human nutrition over the last few decades (Riaz, 2001).

Dry soybean seed contains 36 % protein, 19 % oil, 35 % carbohydrate, 5 % minerals and several other components such as vitamins, isoflavones and saponins (Liu, 1997; Kanchana *et al.*, 2016). Nigeria is the largest producer of soybean in sub-Saharan Africa (SSA) but productivity is usually low. According to FAO (2013), about six million tonnes of soybean were produced in Nigeria in 2013, from 6 million hectares of land. Low productivity of the crop has been partly attributed to several virus diseases including *Southern bean mosaic virus* (SBMV, genus *Sobemovirus*) (Thottappilly & Rossel, 1992). It is transmissible by sap and beetles. Infected plants elicit symptoms such as vein clearing, mosaic, and leaf distortion (Shoyinka *et al.*, 1997; Taiwo, 2001). Adoption of resistant soybean cultivars remains the best management strategy against SBMV disease. Therefore, this study was conducted to identify sources of SBMV resistance genes for genetic improvement of soybean germplasm.

Materials and Methods

Virus inoculum and maintenance: The SBMV inoculum used was obtained from the stock at the Department of Crop Production, Federal University of Technology (FUT), Minna. Its physical properties have been described by Taiwo (2001). Soybean leaf tissues infected with SBMV were preserved on nonabsorbent cotton wool over silica gels in airtight vial bottles. The virus was activated by propagating in 10-day old TVU 76 seedlings. This was accomplished by rubbing the upper leaf surface with virus extract after grinding SBMV-infected leaves (1:10; w/v) with inoculation buffer, pH 7.2 (0.1M sodium phosphate dibasic, 0.1M potassium phosphate monobasic, 0.01M ethylene diamine tetra acetic acid and 0.001M L-cysteine per litre of distilled water). Distilled water was applied to the inoculated plants in order to remove excess inoculum.

Experimental Layout and Crop Establishment: The independent trials were laid out in completely randomized design with four replications. Each genotype was evaluated under SBMV inoculated and healthy (control) conditions. Six soybean lines were obtained from the National Cereals Research Institute (NCRI), Baddegi, Niger State, Nigeria. They were selected from the soybean germplasm bank designated for improvement against biotic stresses at the Institute. Seeds were sown in plastic pots (30-cm diameter) under screenhouse conditions (28 – 40 °C).

Inoculation, Data Collection and Analysis: Seedlings were mechanically inoculated with the virus at 10 days after sowing. Grinding and inoculation procedure were accomplished as indicated above. Both inoculated and uninoculated plants were observed for disease incidence, disease severity, growth and yield performance. Disease incidence was assessed as percentage of inoculated plants showing virus disease symptoms for the first two weeks after inoculation (WAI). Disease severity was recorded from 2 to 5 WAI, based on 1 – 5 visual scale (Arif and Hassan 2002). On the scale: 1 = no symptoms (apparently healthy plant); 2 = slightly mosaic leaves (10 – 30 %); 3 = mosaic (31 – 50 %) and leaf distortion; 4 = severe mosaic (51 – 70 %), leaf distortion and stunting; 5 = severe mosaic (>70 %), stunting and death of plants. Both virus inoculated and healthy plants were assessed for growth and yield characteristics. Data collected were subjected to analysis of variance (ANOVA) using the general linear model (PROC GLM) tool of SAS (Statistical Analysis System, 2008).

Results

Incidence and severity of Southern mosaic virus

Symptom expression started one week after inoculation (WAI) and at 2 WAI 100 % infection was observed irrespective of the soybean genotype. The inoculated plants showed typical symptoms of SBMV infection but at varying levels. At 2 to 4 WAI, the differences in severity scores among the infected plants were not significant ($p>0.05$). However, TGX 2007 -1F exhibited consistently lowest level of infection (score = 1.7) (Fig. 1). At 5 WAI, the differences in reactions of soybean lines to SBMV pathogenicity and severity were statistically significant ($p<0.05$). The lowest severity score was obtained in TGX 2007 -1F, followed by TGX 1951 -3F. Intermediate level of infection was observed in the remaining genotypes but the highest symptom score was found in TGX 2005 -1F (score = 3.3), which was not significantly different from the value observed in TGX 1990 – 46F. The uninoculated plants of all the genotypes were apparently healthy and showed normal green leaf colouration.

Effect of *Southern bean mosaic Virus* on Growth Parameters

Virus infection affected growth and development of the inoculated plants as shown in Table 1. With the exception of TGX 2007 -1F, uninoculated plants (33 to 41) produced significantly higher number of leaves than their infected counterparts (15 to 37) (Table 1). Reduction in leaf number was most conspicuous in the infected plants of TGX 1990 – 46F (63.4 %) while TGX 2007 – 1F was least affected (5.1 %). In TGX 1951 – 3F, TGX 1990 – 57F, and TGX 2007 – 3F leaf reduction was 44.4, 47.2, and 45.5 %, respectively. In inoculated plants of TGX 2005. – 1F, reduction in leaf number was quite high, and the value was approximately 59 %. Uninoculated plants produced broader leaves than infected plants. However, in TGX 1990 – 57F and TGX 2007 – 1F, there was no significant ($p>0.05$) difference between the leaf diameter of infected and healthy plants. TGX 1990 – 46 suffered the highest reduction in leaf diameter (34.2 %) while TGX 2007 – 1F was least affected (5.9 %). Reduction in leaf diameter was also relatively low in TGX 1990 – 57F (9.7 %).

The plants from infected soybean lines were generally shorter (57 and 69 cm) than healthy plants (97.5 to 102.5 cm). Height reductions of the infected plants in TGX 1990 – 46F and TGX 2007 – 3F were 30.8 and 32 %, respectively. In the remaining genotypes, height reductions were greater than 40 %. Branching was more profuse in healthy than infected plants. Inoculated soybean lines produced lower number of branches (5 to 12) than healthy ones (12 to 16) but there was no significant difference between the number of branches of infected and healthy plants in TGX 2007 – 1F. Reduction in number of branches was highest in TGX 2005 – 1F (68.8 %), followed by TGX 1990 – 46F (58.8 %). Furthermore, number of branches was reduced by 50 % in TGX 1990 – 57F and TGX 2007 – 3F, which was relatively lower than 53.8 % reduction observed in TGX 1951 – 3F.

Effect of *Southern bean mosaic Virus* on Yield and Yield Components

Flowering was earlier in healthy plants (39 to 45 days after sowing) than the infected ones (41 to 50 days after sowing) (Table 2). Days to flowering was delayed for two days in the infected plants of TGX 2005 – 1F and TGX 2007 – 1F. In TGX 1990 – 57F and TGX 2007 – 3F, number of days to flowering was increased by three days while the remaining genotypes flowered five days later than their healthy counterparts. Number of days to pod formation of the healthy plants varied between 48 to 52 days after sowing while in the infected ones, it ranged from 48 to 52 days. However, both the infected and healthy plants of TGX 2005 – 1F and TGX 2007 – 1F produced pods at the same time (52 days after sowing). Podding was most delayed in infected plants of TGX 1951 – 3F (6 days), followed by TGX 2007 – 3F (5 days). In TGX 1990 – 57F and TGX 1990 – 46F, podding was delayed for two and three days, respectively. *Southern bean mosaic virus* affected pod production (Table 2). Healthy plants produced 7 to 24 pods per plant while diseased plants produced pods ranging from 2 to 21 per plant. Apart from TGX 2007 – 1F, number of pods in healthy plants was significantly higher than the infected ones. Pod reduction was lowest in TGX 2007 – 1F (12.5 %) while values in other genotypes were generally high. In all, TGX 2007 – 3F suffered the greatest pod reduction (71.4 %), closely followed by TGX 2005 – 1F (69.2 %) and TGX 1951 – 3F (63.2 %). Furthermore, pod reduction was higher in TGX 1990 – 46F (60 %) than TGX 1990 – 57F (53.8 %).

Seeds of some infected plants were tiny and deformed. On the other hand, healthy plants produced large seeds with normal shape. In diseased plants, seed weights varied between 0.5 and 5.9 g which were different from 1.1 to 6.3 g observed in the healthy plants. With the exception of TGX 2007 – 1F, seed weights of infected were significantly different from healthy

plants. Whereas TGX 2007 – 1F exhibited the lowest reduction in seed weight (6.3 %), substantial weight loss was observed in TGX 1951 – 3F (76.2 %), TGX 1990 – 57F (74.2 %), and TGX 2005 – 1F (63.6 %). Seed weight was reduced by 45.5 and 36.4 % in TGX 1990 – 46F and TGX 2007 – 3F, respectively.

Discussion

Appearance of disease symptoms on all the inoculated plants indicated that none of the evaluated soybean lines was immune to SBMV. The symptoms observed on SBMV-inoculated plants were consistent with previous findings (Thottappilly and Rossel, 1992). Also, the varying levels of symptoms were in agreement with the findings of Gergerich and Dolja (2006) that susceptibility or resistance to virus infection is determined by plant genotype. Therefore, disease severity was variable among the genotypes because of the differences in their genetic make-up.

The ability of SBMV isolate to reduce leaf number and diameter is an indication of its virulence on the evaluated genotypes. A similar phenomenon was encountered when some sweet pepper (*Capsicum annuum* L.) genotypes were infected with *Cucumber mosaic virus* (Zitikaitė and Urbanavičienė, 2010). Leaf diameter plays a significant role in photosynthesis which in turn has a direct relationship with plant growth and development. Infected plants were generally shorter because of the effect of the virus on their physiology. Earlier, Taiwo and Akinjogunla (2006) reported significant height reductions when some cowpea plants were inoculated with SBMV. Diseased plants produced fewer branches as a consequence of the stresses posed by the virus. The observation on the number of branches in infected and healthy plants of TGX 2007 – 1F was somewhat comparable which suggests some level of its tolerance to the pathogen. This partly reveals the vulnerability of other genotypes to SBMV.

There was no uniform number of days to flowering between diseased and healthy plants due to adverse effect of SBMV on physiology of the infected plants. A similar result was reported by Salaudeen (2014) when some rice cultivars were infected with *Rice yellow mottle virus* (RYMV). Non-uniform flowering could cause a serious setback to large scale soybean production because plants would not mature at the same time. This in turn would affect simultaneous harvesting of large fields. Again, the fact that number of days to flowering in the infected plants of TGX 2007 – 1F was similar to their healthy counterparts reveals that the genotype probably contains SBMV resistance gene (s). The disparity in number of days to pod formation among the infected soybean lines was probably a carryover effect of non-uniform number of days to flowering. Generally, pod production was better in the healthy than infected plants, confirming that SBMV is an economically important virus disease of soybean (Taiwo, 2001). Reduction in seed weight was relatively lowest in TGX 2007 – 1F probably because it was tolerant to SBMV. The present results indicated that SBMV could be a limiting factor for soybean production. The line TGX 2007 – 1F which exhibited the lowest reductions in leaf diameter, number of branches per plant, number of pods per plant, and seed weight per plant could be a possible source of resistance gene (s) for breeding soybean cultivars against SBMV disease in the study area.

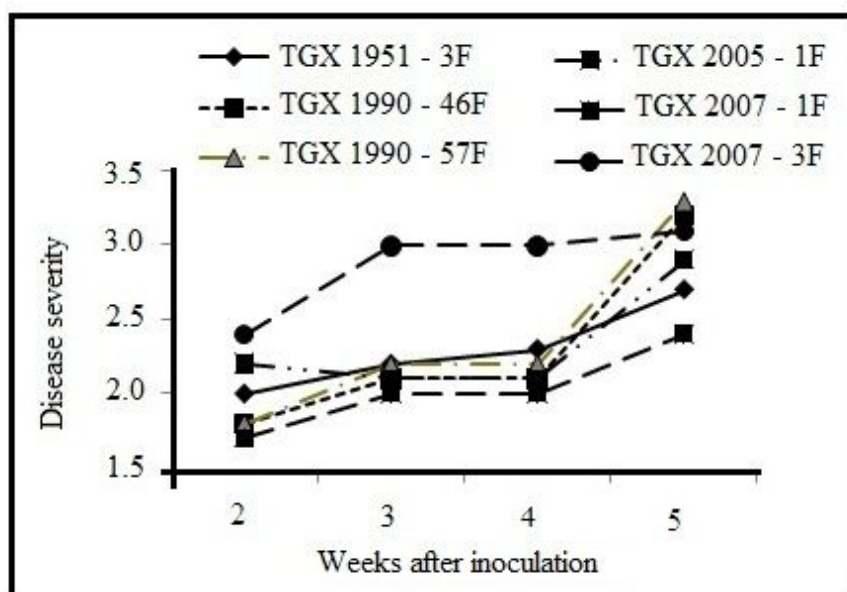


Fig. 1: Progress of disease severity in soybean plants inoculated with *Southern bean mosaic virus* in a screenhouse

Table 1: Growth attributes of healthy and *Southern bean mosaic virus*-infected soybean plants under screenhouse conditions

Soybean	Number of leaves per plant		Leaf diameter (cm)		Plant height (cm)		Number of branches per plant	
	Infected	Control	Infected	Control	Infected	Control	Infected	Control
TGX 1951 – 3F	20 ^b	36 ^a	2.6 ^b	3.7 ^a	58.0 ^b	102.5 ^a	6 ^b	13 ^a
TGX 1990 – 46F	15 ^b	41 ^a	2.5 ^b	3.8 ^a	68.5 ^b	99.0 ^a	5 ^b	12 ^a
TGX 1990 – 57F	19 ^b	36 ^a	2.8 ^a	3.1 ^a	57.5 ^b	97.5 ^a	6 ^b	12 ^a
TGX 2005 – 1F	16 ^b	39 ^a	2.7 ^b	3.3 ^a	60.5 ^b	101.0 ^a	5 ^b	16 ^a
TGX 2007 – 1F	37 ^a	39 ^a	3.2 ^a	3.4 ^a	57.0 ^b	100.5 ^a	12 ^a	14 ^a
TGX 2007 – 3F	18 ^b	33 ^a	2.3 ^b	2.7 ^a	69.0 ^b	101.5 ^a	6 ^b	12 ^a

Means followed by dissimilar letters within the row differ significantly ($p \leq 0.05$) by the Least Significant Difference (LSD)

Table 2. Yield attributes of healthy and *Southern bean mosaic virus*-infected soybean plants under screenhouse conditions

Soybean	Days to flowering (no.)		Days to podding (no.)		Pods per plant (no.)		Seed weight per plant (g)	
	Infected	Control	Infected	Control	Infected	Control	Infected	Control
TGX 1951 – 3F	50 ^a	45 ^b	54 ^a	48 ^b	7 ^b	19 ^a	0.5 ^b	2.1 ^a
TGX 1990 – 46F	46 ^a	41 ^b	51 ^a	48 ^a	4 ^b	10 ^a	0.6 ^b	1.1 ^a
TGX 1990 – 57F	43 ^a	40 ^a	50 ^a	48 ^a	6 ^b	13 ^a	0.8 ^b	3.1 ^a
TGX 2005 – 1F	43 ^a	41 ^a	52 ^a	52 ^a	4 ^b	13 ^a	0.8 ^b	2.2 ^a
TGX 2007 – 1F	41 ^a	39 ^a	52 ^a	52 ^a	21 ^a	24 ^a	5.9 ^a	6.3 ^a
TGX 2007 – 3F	44 ^a	41 ^a	53 ^a	48 ^b	2 ^b	7 ^a	0.7 ^b	1.1 ^a

Means followed by dissimilar letters within the row differ significantly ($p \leq 0.05$) by the Least Significant Difference (LSD)

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SENSITIVITY AND UNCERTAINTY ANALYSIS: APPLICATIONS TO SMALL-LAND SCALE AGRICULTURE SYSTEMS IN KWARA STATE, NIGERIA

AYINDE, O. E., AYINDE, K., OMOTESHO, O. A. & MUHAMMAD-LAWAL. A.

Department of Agric – Economics and Farm Management

University of Ilorin, P.M.B.1515, Ilorin, Nigeria.

E- mail: opeatyinde@yahoo.com

Abstract

Sensitivity and uncertainty analysis is useful in providing information about local and global change tendency of the management of enterprise mixtures to the choice of target return level. Hence the study examined the sensitivity and uncertainty analysis in small-land scale agriculture in Nigeria. The study used both primary and secondary data (time series). A structured questionnaire was employed to obtain information from the five hundred (500) randomly selected small-land scale farmers in Kwara state, Nigeria. Descriptive statistics and Target-MOTAD (Minimization of Total Absolute Deviation) model were used to analyze the data. The result revealed the normative plans for the small-land scale agriculture system in Nigeria. The sensitivity analysis revealed that there is a positive relationship between capital and returns and negative relationship exists between risk level and returns in small-land scale agriculture systems. Hence policies and programmes that increase returns and reduce risk level should be put in place in order to enhance the small land scale agriculture system.

Keywords: Small-land scale, sensitivity, Nigeria and Target-MOTAD model

Introduction

Nigeria is blessed with various climatic zones, enormous resources and the potentials of producing, processing, marketing and exporting of different output and commodities from agriculture (Babafada 2003). Agriculture is an indispensable real sector in Nigerian economy. The roles of agriculture remain significant in the Nigerian economy despite the strategic importance of the oil sector. Agriculture provides primary means of employment in Nigeria (Ogundari & Ojo, 2007), and accounts for more than one-third of total Gross Domestic Product (GDP) (World Bank, 2003). Nigerian agriculture is characterized by: a multitude of small land scale agriculture systems scattered over wide expanse of land area, with small holding ranging from 0.05 to 3.0 hectares per farm land, rudimentary farm systems, low capitalization and low yield per hectare (Ogundari & Ojo, 2007).

Nigerian agriculture has for decades depended largely on these small-scale land holders farmers, in spite of the existence of urban agriculture. This set of small land scale holders representing over 90 % of the farming populace, cultivate produce as much as 85 % of the total agricultural production and 87 % of export crops (Adubi, 2000). More so, these small-land scale farmers will continue to constitute the backbone of Nigeria agriculture for the next twenty-five years. Despite the importance of the small- land scale farmers, they still operate largely under risk and uncertainty and are inadequately equipped against risk and uncertainties (Adubi, 2000).

Risk and uncertainty may result from one or a combination of four factors which may be endogenous or exogenous (Anderson, Hardaker & Huirne, 1997). These factors include prices or markets, production inputs, farm outputs and institutional factors. Invariably, these result into the different types of risk and uncertainty faced by farmers. Production risk could emanate from unpredictable nature of the weather and uncertainty about the

performance of crops or livestock. Price or market risk comes from imperfect knowledge about prices of farm inputs and outputs at the time that a farmer takes decisions.

Financial risk may result from unexpected risk in interest rates on borrowed funds, and the possible unavailability of loan finance when required. Institutional risks may emanate from the instabilities in government and its policies within which the farmer operates. The international environment also creates uncertainties as a result of unpredictability. For examples, the merging of Eastern and Western Europe definitely had an effect in the world market; so also was the outcome of Europe' 92 on commodities. Also globalization has caused the East Asian countries to enjoy remarkable increases in per capita income but sub-Saharan African countries have had effect of low rates of economic performance (LeBel, 2003).

Given this setting of the small-land scale agriculture in uncertainty, the aforementioned small-land agriculture's importance and with the expectation that developing countries such as Nigeria is expected to experience increase in economic growth, Nigerian governments have over time tried several strategies and introduced numerous policies and programmes aimed at shaping the Nigeria agriculture production, increasing the level, grade and varieties of their export crops. These policies and programmes include Agricultural Credit Guarantee Scheme, Operation Feed the Nation, Green Revolution, River Basin Development Authorities, National Accelerated Food Production Programme, Guaranteed Minimum Price Scheme, Marketing Board System, Agricultural Development Projects (ADPs), etc. However, the success of all the various agricultural programmes has been minimal (Ukpong, 1993). This may be due to the fact that the factors at which the small land scale agriculture is responsive are still yet to be considered in the various programmes. This couple with the fact that this small scale agriculture is more exposed to risk and uncertainty than other segment of economy may cause the results of the various programme been minimal in its impact on agricultural and economics growth. Hence a need to understand the factors that can result into the small land scale agriculture stability on the efficiency frontier through a sensitivity and uncertainty analysis. Therefore, the study examines the farm plan(s) that would adequately provide the small-scale farmers with improved income under uncertainty and explores the sensitivity and uncertainty analysis that will consequently raise the efficiency of the small-land scale agriculture in Nigeria.

This study will not only help policy planners but it will also provide useful information to small-scale land agriculture especially on farm size plan, budgets and returns to investments. It will also offer suggestions on how risk efficiency in small scale agriculture could be improved such that it would have greater impact on agricultural and economic growth.

Theoretical and Empirical Framework in Uncertainty Analysis

The concept of uncertainty in any application depends on the behavioural decision model employed. The popular Bernoullian (1738) expected utility criterion utilizes an objective function that is a function of all the statistical properties of the outcome of risky actions a_i , ($i = 1, 2, \dots, n$) available to the decision makers. In practice, it is popular among empiricists to assume that the underlying utility function is quadratic and that profits are normally distributed yielding the simpler function of mean and variance only (Young, 1979). Thus,

$$\text{Max } (E U) \text{ of } a_i = f(\mu_{a_i}, \sigma^2 a_i) - \text{-----}(1).$$

With equation (1), variance or standard deviation or coefficient of variation is clearly the appropriate “measure of uncertainty and risk”.

Different sets of risk concepts are implied by various non-Bernoullian decision models. For example, the “minimax” model would identify the maximum loss of an action (regardless of how remote the probability of its occurrence) as a measure of riskness of an action. The lexicographic “safety first” model identifies the probability (α) that random net income (Y) will fall below some critical or disaster levels (d) as risk,

$$\text{i.e. } \Pr(Y < d) = \alpha \text{----- (2).}$$

There are many criteria in decision making under risk and uncertainty. These are Wald's Maximin, Maximax, Huriwicz Laplace, Salvage Minimum Regrets and Excess Benefit (Tauer, 1983)

Wald's maximin criterion is associated with strategy which maximizes its minimum while maximax criterion is associated with strategy which gives the highest possible outcome. Hurwicz criterion is a hybrid of the maximin and maximax criteria (Young, 1979). It considers the weighted average of the minimum and maximum payoffs under each of the strategies. Savage Minimum Regret criterion aims at selecting a strategy which minimizes the opportunity cost of marking decision. The Excess Benefit is associated with subtraction of the minimum element from original matrix and applying the maximin criterion to it.

Laplace criterion assumes that each state of nature is equally likely to occur (Tauer, 1983). Equal probabilities are, therefore assigned to the various states of nature and the decision maker selects that strategy which gives the highest expected income. This study employed programming model developed from the laplace criterion model with modification given to the Lexicographic “safety first” principle. This study utilized a programming model called target-MOTAD model under safety – first principle.

Target MOTAD Model

This employs the linear programming model called Target-MOTAD (Minimization of Total Absolute Deviation) programming developed by Tauer, (1983). There are other risk programming such as Mean-Gini model which has been criticized based on the fact that some stochastically efficient solutions that would be preferred by strong risk-averse decision makers may be excluded from the efficient set and its tableau is much larger than that for Target MOTAD and direct maximization of expected utility and utility-efficient which are non-linear programming models and are superior to linear programming model (Tauer, 1983). However, they are not widely used as they have been criticized because they can only be applied when an individual decision maker exists who is risk averse and whose utility function is available. Moreover, they are not applicable to a group of farmers considered in this study (Anderson *et al.* 1997). The Target MOTAD model is superior to other programming model under risk because it is computational efficient and generates solutions that meet the second degree stochastic dominance (SSD) test (Tauer, 1983).

Sensitivity Analysis

Sensitivity analysis is the study of how the variation in the output of a model (numerical or otherwise) can be approached qualitatively or quantitatively to different sources of variation (Wikipedia, 2007). Sensitivity analysis can be used to determine model resemblance with the process under study, quality of model definition, factors that mostly contribute to the output variability, region in the space of input factors for which the space of factors for use in a subsequent calibration study, and interaction between factors

(Wikipedia, 2007). It is in fact described as been useful in providing information about local and global sensitivity of the enterprise mixture(s) to the choice of target return level (McCamley & Kliebenstein, 1987).

Sensitivity analysis is popular in financial applications, risk analysis, signal processing, neural network and model-based policy assessment studies and any area where models are developed (Saisana *et al*, 2005). However, sensitivity analysis based on this method is surely inadequate because it is based on subjective judgment about possible increments in project costs of otherwise reduction in project benefits.

Hiller (1983) developed a project appraisal model for estimating the probability distribution of present value (PV) by using expected value $E(PV)$. The author relied on the Central Limit Theorem for approximately normal distribution of PV. By estimating the mean and variance of PV, the decision makers can evaluate the risk consequences of a particular investment. This model, however, is criticized for statistical dependencies and potential correlations of covariance.

Stochastic simulation model was also used for evaluating uncertainty in project appraisal (Anderson, 1983). Monte Carlo sampling technique for estimating distribution of PV and internal rate of return (IRR) was also examined by Reutlinger (1970). This approach as developed and applied by Reutlinger is based on identifying the most applied critical components of the project and simulating the probability of IRR under different assumptions underlying the critical components. However, the most common sensitivity analysis is sampling-based. A sampling-based sensitivity is one in which the model is executed repeatedly for combinations of values sampled from the distribution (assumed known) of the input factors (Cacuci, 2003; Cacuci, Mihaela & Navon, 2005). In general, sampling-based method performed the sensitivity analysis jointly with uncertainty analysis by executing the model repeatedly for combination of factor values with some probability distribution (Cacuci, 2003). The steps involved are as follows: Specify the target function and select the input of interest; assign a distribution function to the selected factors; generate a matrix of inputs with that distribution(s) through an appropriate design; Evaluate the model and compute the distribution of the target function; and select a method for assessing the influence or relative importance of each input factor on the target function. Risk programming models such as Target-MOTAD used in this study perform a sampled-based sensitivity analysis.

Methodology

The study was carried out in Kwara State of Nigeria. The state lies in the central part of Nigeria. It comprises of sixteen (16) Local Government Areas with a population of about 2.4 million (NPC, 2006). It has a total land size of 3682500 hectares (FOS, 1995). Agriculture is major occupation in the State with over 70 % of the population being farmers and majority of the farmers in the state are into small land scale agriculture. The climatic pattern, vegetation and the fertile soil make the state suitable for the cultivation of a wide range of food and tree crops. The major food crops planted are cassava, yam, maize, rice, soyabeans, cowpea, guinea-corn and millet. The sixteen Local Government Areas have been divided into four zones by the Kwara State Agricultural Development Project (KWADP) in consonance with ecological characteristics and cultural practices (KWADP, 1998).

Sampling Design

The population for this study consisted of small scale farming households of Kwara state of Nigeria. A three - stage stratified random sampling technique was utilized to select the

sample for the study. In the first stage, the non-overlapping four zones divided by the KWADP as Zone A, Zone B, Zone C and Zone D were utilized. In the second stage, half of the blocks in each zone were randomly selected while in the third stage, proportion allocation technique was utilized to distribute a sample size of 500 into each zone using proportion allocation technique. Consequently, a random sample of 64 respondents was taken from zone A, 128 from Zone B, 132 from Zone C and 176 from Zone D based on the farming household population's proportion of the zones.

Source and Method of Data Collection

Both primary and secondary data were collected for this study. The primary data were collected during the 2006 production year through a survey with the aid of interview schedule administered to the heads of the selected farming household with the assistance of well trained enumerators. Input-output data were collected on individual farms. The secondary data were collected from the yearly agronomic field records of KWADP to determine the past performance of crops. A seven-year (1999-2005) record was synthesized for all crops. Other information was obtained from the records of the National Bureau of Statistics, journals and relevant texts to supplement the primary data.

Analytical Technique

The study employed Target MOTAD Model and Sensitivity analysis. Mathematically, the model is stated as

$$\text{Max } E(Z) = \sum_{j=1}^n c_j x_j \text{ ----- (1)}$$

$$\text{Subject to: } \sum_{i=1}^m \sum_{j=1}^n a_{ij} x_j \leq b_i \text{ ----- (2)}$$

$$T - Y_r^+ - Y_r^- \leq 0 \text{ ----- (3)}$$

$$\sum P_r Y_r = \alpha \text{ ----- (4)}$$

$$\alpha = (M \rightarrow 0); \quad X, Y > 0$$

Where $E(Z)$ = expected returns of the plan or solution to the plan in C_j ; c_j = expected returns of activity j ; X_j = level of activity j ; a_{ij} = technical requirement of activity j for resource i ; b_i = level of resource i ; T = target level of returns in naira (it was derived from mean absolute deviation); C_{rj} = returns of activity j for state of nature or observation r (N); Y^+ = deviation above expected returns; Y^- = deviation below expected returns; P_r = probability that state of nature or observation r will occur; α = a constant parameterized from M to 0 ; $i = 1, \dots, m$; $j = 1, \dots, n$.

$$Y_r = \sum_{j=1}^n (C_{rj} - c_j) x_j$$

m = number of constraints or resource equation; r = number of state of nature or observation; M = large number (represents the maximum total absolute deviation of return of the model). Points on the risk efficiency frontier are obtained by arbitrarily decreasing the value (α) parametrically. Along the efficiency frontier, the Target-MOTAD model minimizes the mean absolute deviation (MAD) for any given expected gross margins. Essentially, this minimizes the standard deviation of returns to the farm measured by the estimator.

$$\text{Std Deviation} = D \left(\frac{\pi \times S}{2(S-1)} \right)^{\frac{1}{2}} \text{ ----- (5)}$$

Where, S = number of states of nature; D = estimated mean absolute deviation of return to the farm. The mean absolute deviation (MAD) or D for an activity (j) and for the whole farm over all states of nature (years) is estimated respectively as follows;

$$D_j = S^{-1} \sum_r I(C_{rj} - C_j) X_j I \quad \text{----- (6)}$$

$$D = \frac{1}{n} \sum_{j=1}^n D_j \quad \text{----- (7)}$$

All variables are as defined earlier in this risk model; magnitude of standard deviation allows the model to determine a set of efficient farm plans along the E-V efficiency frontier. Furthermore, sensitivity analysis was carried out using the Target MOTAD programming model.

Results and Discussion

Table 1: Availability of Different Resources for the Small Scale Farms

RESOURCES	ZONE A	ZONE B	ZONE C	ZONE D
(a) Average Cultivated Area (Ha)	2.49	4.4687	3.6154	2.8168
(b) Average Available Labour (Mondays/Ha/ Growing Season).	300.00	380.00	214.82	270.54
(c) Capital (₦/Ha/Growing Season)	71,038.46	60,331.3	37907.69	41,442.1
(d) Minimum Food Requirements (MJ)	145.908	118.944	92.484	144.569
(e) Target Level(₦)	32,416.22	27,767.78	36,795.80	43,576.1

Source: Field Survey Data, 2010

The framework for this study was based on incorporating such stochastic elements to evaluate the planning process in a risky agriculture environment. This study assumed that risk in returns arises from price and yield factors. In the risk model, the farmer decides between possible crop combinations on the basis of expected returns and the absolute deviation of returns for each crop from its expected value. Table 1 presents the resource position of small land scale crops farms.

The result of the risk programming model gives the normative plans. The normative plans are divided into risk minimizing plans and profit maximizing plan. The profit maximizing plans for all the zones are only profit responsive. They are therefore likely to be selected by a risk neutral decision maker. The plan has the highest risk expected returns and hence the highest risk. Any risk level higher than that of the profit-maximizing plan's risk level will give no different plan. Also any risk level lower than that of the lowest risk minimized plan will result in no feasible solution. Hence the lowest risk minimizing plan and profit-maximizing plan fall on both extremes and therefore forms the risk efficiency frontier.

Table 2: Normative farm plans

ENTERPRISES	NORMATIVE SITUATION					PROFIT MAXIM- AZING
	RISK MINIMIZING					
PLANS	I	II	III	IV	V	VI
RETURNS	288,793	296,05	311,489.	330,015.	360,891.4	370,257.4
	.4	0	9	5		
YAM(Ha)	0.4828 (29.44)	0.4778 (29.13)	0.4671 (28.48)	0.4541 (27.69)	0.4328 (26.39)	0.4263 (25.99)
MZE(Ha)	—	—	—	—	—	—
GNC(Ha)	—	—	—	—	—	—
MZE/GNC(Ha)	—	—	—	—	—	—
RICE(Ha)	—	0.0632 (3.85)	0.1912 (11.66)	0.3506 (21.38)	0.6280 (38.29)	0.7095 (43.26)
GNT(Ha)	—	—	—	—	—	—
CSV (Ha)	—	—	—	—	—	—
CWP (Ha)	—	—	—	—	—	—
MZE/CSV	—	—	—	—	—	—
PLAN TOTAL	0.4828	0.5410	0.6583	0.8047	1.0608	1.1358
CROPPED AREA	(29.44)	(32.99)	(40.14)	(49.07)	(64.68)	(69.26)
CROPPED AREA	1.64	1.64	1.64	1.64	1.64	1.64
RISK LEVEL	33246	45000	70000	100000	150000	165167.06

Note: *Figures in parenthesis represent the percentages of Cultivated Area*

Source: *Programming model Output*

Table 2 presents normative plans for the small-land scale agriculture in all the zones. This was done by pooling all the resources together and getting the average of their risk coefficient. The result showed that profit maximizing plan suggests the cultivation of both 0.4263 hectare of yam and 0.7096 hectare of rice which gave ₦370, 257.4 as returns whereas the lowest risk minimized plans was cultivation of only 0.4828 hectare of yam gave ₦288, 793.7 as returns.

Sensitivity Analysis

The sensitivity analysis of the optimal farm planning under uncertainty solution varying the target level was explored using the risk programming model (see appendix 1). It was observed that the lower the target income level the higher the returns and the lower the risk level. In another word, there was a positive relationship between target income and risk level and a negative relationship between target level and income.

It was observed that generally, in all the zones the highest return (which is of profit maximizing plans) with the lowest risk level was found in frontier with lowest target (T = ₦10,000 see appendix 1). For instance, in zone A, the highest returns of ₦611,011.80 with the lowest risk level of ₦32,592.11 was found in frontier with the target of ₦10,000. Furthermore, in all the risk minimizing plans, the lowest target had higher returns accompanied with lower risk level. For example, the risk level of ₦30,520 gave a return of ₦566,683.90 in the frontier with target of ₦10,000.00 which was higher than all other targets used.

However, it was further observed that this negative relationship between target and returns was associated with an increase in return which correlated with less risk level. This is more obvious in zone A. This may be due to high amount of available capital since capital resource only becomes a limiting factor in the last risk minimizing plan and profit maximizing plan. This is further shown in figure1 - 4. Generally, in the other zones, amount of capital

was the only limiting resource in all the normative plans. Hence, the response of the optimal farm planning under risk solution to changes in the amount of capital was also explored by using the sensitivity analysis of the risk programming model. Figure 1-4 show the efficiency frontier of risk minimizing plans with increased capital of zone A, B, C, and D respectively.

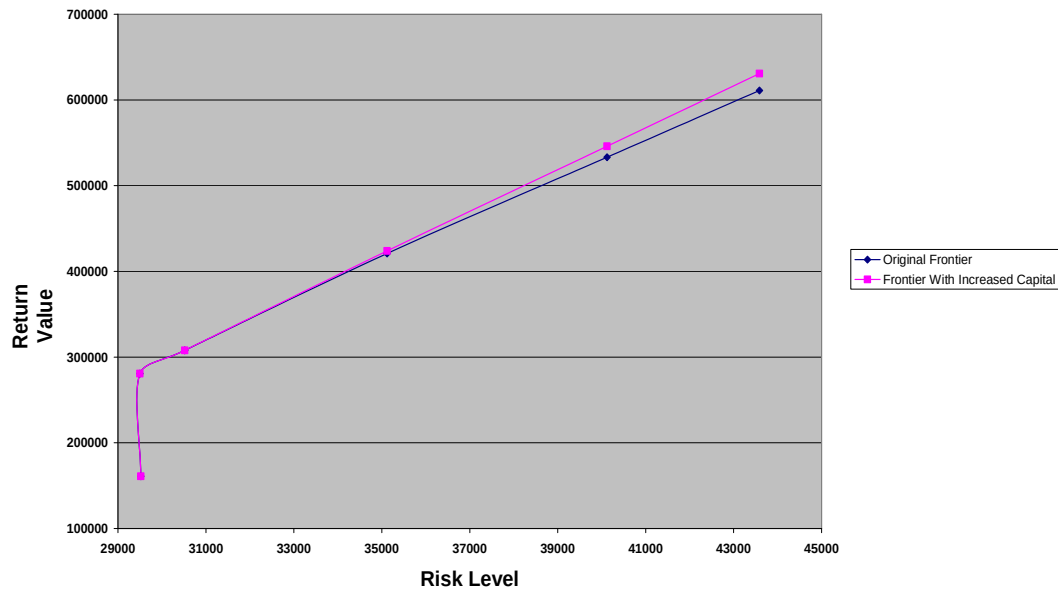


FIG. 1: Sensitivity Analysis: Efficiency Frontier of Risk Minimizing Plans with increased capital of Zone A's Farm

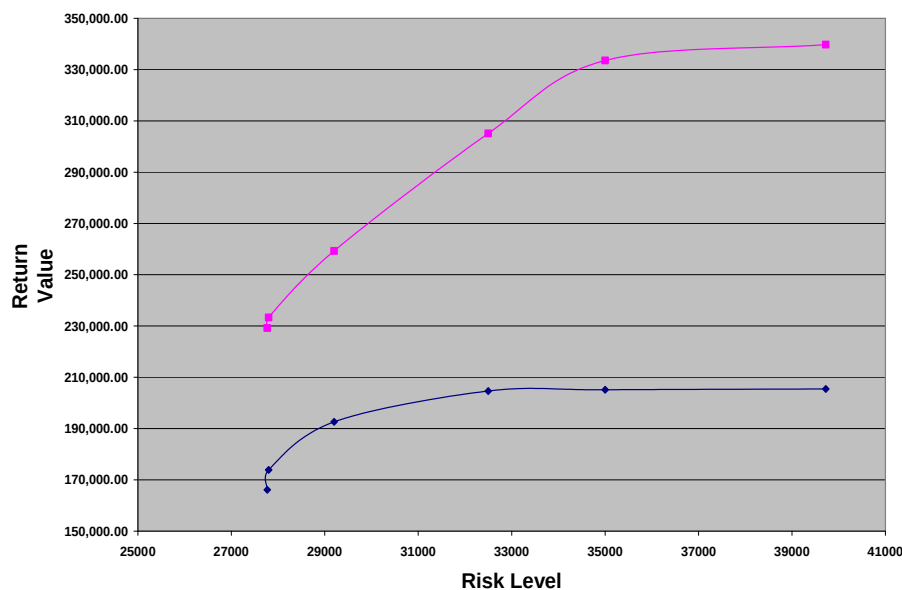


Fig. 2: Sensitivity Analysis: Efficiency Frontier of Risk Minimizing Plans with increased capital of Zone B's Farm

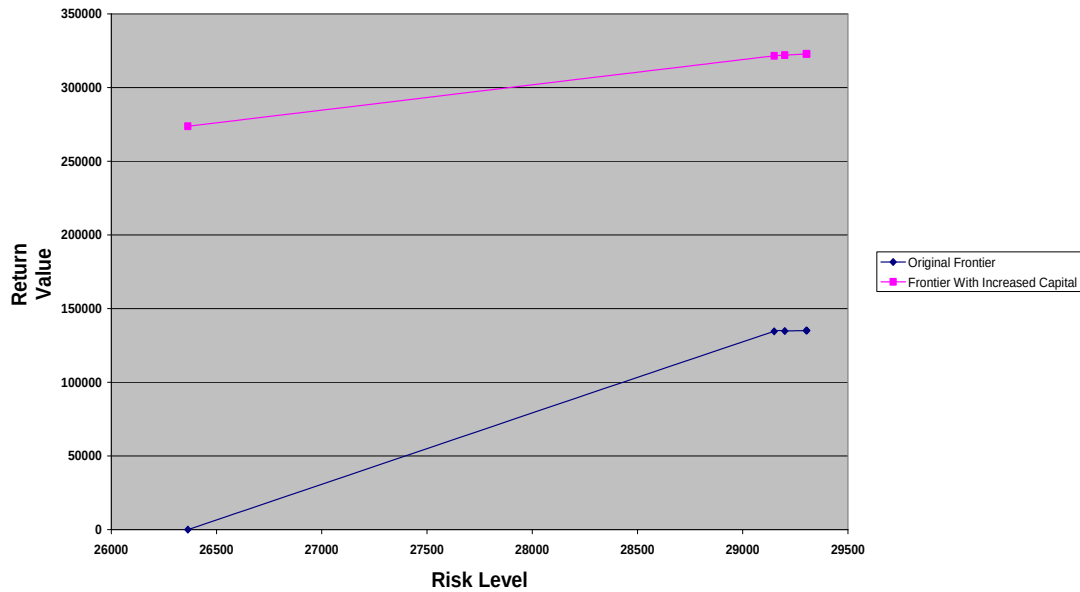


Fig. 3: Sensitivity Analysis: Efficiency Frontier of Risk Minimizing Plans with increased capital of Zone C's Farm

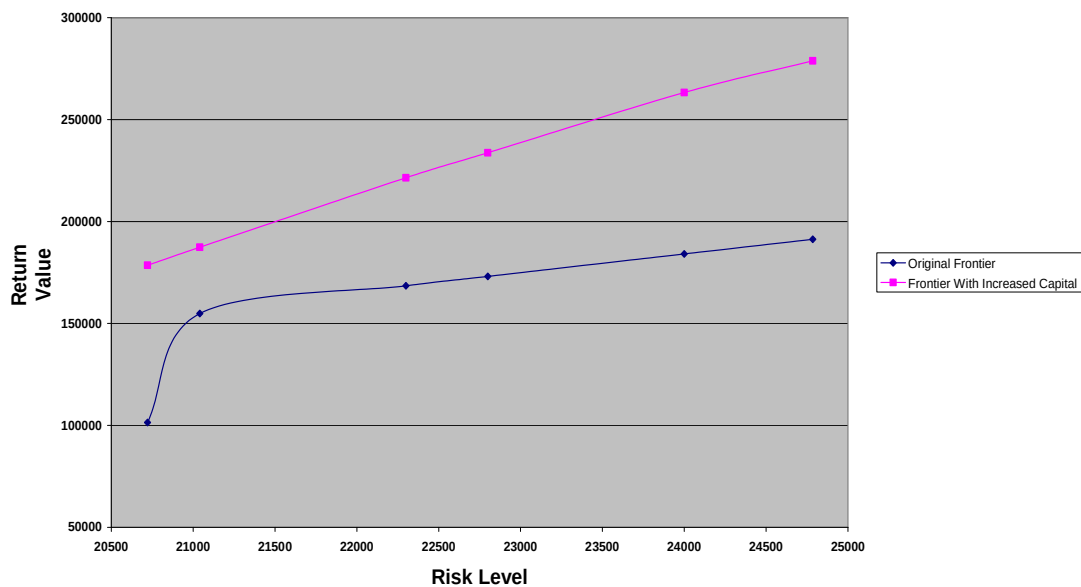


Fig. 4: Sensitivity Analysis: Efficiency Frontier of Risk Minimizing Plans with increased capital of Zone D's Farm

Generally, in all the zones, the sensitivity analysis with increased capital showed an extension of the range of risk-return possibilities available to the decision maker except in zone A where the extension was minimal. It further revealed that an increase in amount of capital increased the plans' returns.

Conclusion and Recommendation

It can be concluded that there is a positive relationship between capital and returns and negative relationship exists between risk level and returns in small-land scale agriculture systems. Hence it is recommended that policies and programmes that increase returns and reduce risk level should be put in place to enhance the small land scale agriculture system. Given that capital is a limiting resource and the use of credit on the farm reduces risk, a

concerted effort should be made by government to facilitate access of small farmers to small scale credits. There should be concerted effort by the farmers, their societies, government and private stakeholder to provide better sources of capital in order to increase the agricultural crop output and returns. The government can stand as guarantor for these farmers who should be organized into Unions or Cooperatives. There should be concerted efforts by the farmers through their societies, government and private stakeholder to provide better infrastructures amenities, health services and education service at reduced cost to decrease target income level which in turn increases returns with a lower risk level.

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APPENDIX 1

Zone	Target level = ₦10,000		Target level = ₦20,000		Target level = ₦30,000	
	Risk level	Return(₦)	Risk level	Return(₦)	Risk level	Return(₦)
A	8,157.31	45,064.44	16,314.31	90,195.55	24,472.00	135,251.50
	8,500.00	65,194.96	17,000.00	130,389.90	26,520.00	238,721.00
	10,000.00	110,352.50	20,000.00	220,705.00	30,520.00	343,279.10
	26,520.00	482,368.00	26,520.00	280,074.00	35,120.00	454,825.00
	30,520.00	566,683.90	30,520.00	477,357.60	40,120.00	567,057.80
	32,592.11	611,011.80	36,542.50	611,011.80	42,078.20	611,011.80
	10,000.00	103,204.20	20,000.00	147,594.00	30,000.00	170,697.00
B	11,640.00	148,666.70	20,300.00	156,778.20	31,327.40	196,854.80
	12,150.00	157,642.90	21,000.00	167,338.50	32,500.00	202,720.50
	15,361.10	200,745.40	22,000.00	180,760.80	35,000.00	205,037.30
	20,000.00	205,037.30	27,767.80	205,055.00	39,725.00	205,348.70
	26,675.20	205,445.20	33,689.60	205,445.20	41,675.20	205,445.20
C	7,149.50	76,481.53	14,628.90	126,568.00	23,238.60	131,499.00
	7,300.00	84,638.11	14,800.00	127,568.00	23,990.00	134,332.80
	8,000.00	110,450.60	15,500.00	129,779.40	24,000.00	134,553.10
	8,565.00	121,477.00	16,500.00	131,812.10	24,100.00	134,556.40
	10,000.00	135,164.80	17,500.00	133,884.90	24,300.00	134,962.90
	12,331.60	135,164.80	18,149.3	135,164.80	24,399.30	135,164.80
	10,000.00	85,273.68	20,000.00	100,758.60	30,000.00	161,427.50
D	12,000.00	128,122.80	20,721.10	156,766.60	30,100.00	176,423.00
	13,000.00	141,297.80	21,041.40	160,240.30	30,200.00	178,515.30
	16,500.00	176,739.70	22,800.00	177,198.00	30,300.00	180,349.00
	17,500.00	185,910.50	24,000.00	188,203.20	30,500.00	184,016.90
	18,315.90	191,271.20	24,334.50	191,271.20	30,961.70	191,271.20

Source: *Programming Output*

ASSESSMENT OF TEACHERS' PERCEPTION ON AGRICULTURAL SCIENCE TEACHING METHODS IN NIGER STATE, NIGERIA

TSADO, J. H¹., O. B. ADENIJI¹, TYABO, I. S¹. & KOLO, E. S².

¹Department of Agricultural Economics and Extension Technology,
Federal University of Technology Minna, Nigeria

²Niger State College of Education, Minna, Niger State, Nigeria

E-mail: jacobtsado2007@yahoo.com

Phone No: +234-806-526-8098

Abstract

The study was conducted in Niger State, Nigeria to evaluate agricultural science teacher's perception of the agricultural science teaching methods. A total of 50 respondents were randomly sampled. Data for the study were obtained through the administration of questionnaire and were analysed using descriptive statistics such as frequency, percentage, ranking and mean. Agricultural science methods highlight the obvious fact that instructional process is a two-way communication process between the instructional agent and the learner. The study revealed that majority (70%) of the teachers were still in their active and productive age, 74 % of the respondents were male and larger proportions of the teachers (94%) were qualified and professionally trained teachers. Lecture method ranked 1st as the most frequently used method by the agricultural science teachers, the teachers however, perceived demonstration method as the best method of imparting agricultural knowledge and skills. The research findings also showed that majority (82 %) of the respondents agreed that students had unfavourable attitude toward agricultural science as a subject and were usually not actively involved in agricultural science lessons and practicals. Agricultural science teachers perceived the following teaching methods as more relevant in imparting agricultural knowledge and skills: demonstration (3.84), field trip (3.77), discovery method (3.62) and laboratory method (3.26), similarly, the teachers also perceived the following challenges in teaching agricultural science as serious challenges: students background; lack of interest on the part of both the teachers and students and the attitude of general public towards agriculture as a profession. It was therefore, recommended that demonstration method be given topmost priority in imparting agricultural knowledge and skills. Also enabling environment should be created for the adoption and use of modern techniques in practicing agriculture, to minimize the drudgery associated with farming to motivate young school leavers to take agriculture as a profession.

Key words: Agricultural science, teachers, perception, teaching methods,

Introduction

Agricultural science is one of the core vocational curricular subjects taught at secondary and in some higher institutions in Nigeria. According to Egbule (2004), it is a process of training learners in the process of agricultural productivity as well as the techniques for teaching of agriculture. Because of its promising role in promoting self reliance through the provision of employment opportunities and production of staple food for the populace together with raw materials for the agro allied industries. Its teaching as a course offering in our schools and colleges has been made compulsory by the Federal Government (Daluba, 2013). Agricultural science is therefore designed for inculcation of the necessary skills for the practice of

agriculture for effective citizenship and contribution to food security for national sustainability (Modebelu and Nwakpadolu, 2013). In an attempt to achieve this national agricultural goal, the Federal Republic of Nigeria (FRN) outlined several objectives of teaching and learning of agricultural science to include the following:

- (i) to stimulate and sustain student interest in agriculture
- (ii) to inculcate in students farming skills
- (iii) To enable students acquire basic knowledge and practical skills in agriculture
- (iv) to prepare students for further studies in agriculture
- (v) to produce prospective future farmers
- (vi) to expose students to opportunities in agriculture (FRN, 1994 and FRN, 2009)

According to Modebelu and Nwakpadolu (2013), attainment of the above objectives depends on teachers' factors such as the various teaching methods used and the pedagogical approaches, agricultural science teachers are trained and groomed from teachers preparation institutions for quality impact of agricultural skills, knowledge, attitude and values for self reliance, promotion of agriculture and for food security in their future lives. Hence it is the responsibility of the teachers to use appropriate methods of teaching to stimulate and sustain students interest in agriculture, that enable them acquire knowledge with skills in agriculture, as well as Prepare and expose students for occupation.

It is generally believed that what students learn is greatly influenced by how they are taught. Teachers teaching agricultural science used varieties of methods, which fit different niches within the agricultural classroom (Allen *et al.*, (n.d.). Some of these teaching methods are completely out of phase with background and local environment of the learners particularly in Nigeria, also some methods are foreign in nature and have no bearing with Nigeria culture and purely derived from other western cultures (Achor *et al.*, 2009).

Teaching Methods

Lecturing remains one of the more popular method of transmitting information and ideas by the teachers, trainers and speakers, for subjects that are practically oriented like agricultural science, lectures can be informative, boring and overwhelming depending on the compelling nature of the message and the presenter style and clarity of the message. Lecture method which is popularly used by agricultural science teachers in Nigeria is usually one-way traffic and allows for little or no audience participation. Here the teacher is seen as the repository of all knowledge while the students are passive (Abdulhamid, 2013; Gbamaja, 1991).

Demonstration method refers to the type of teaching method in which the teacher is the principal actor while the learners watches with the intention to act later, here he does whatever the learners are expected to do at the end of the lesson by showing them how to do it and explaining step-by-step process to them inform of exhibition, this is referred to as method demonstration, while result demonstration is used to show the result of doing something in a particular way (Ameh *et al.*, 2007; Mundi, 2006).

Discussion method involves a group of people or class who get together in order to exchange ideas, facts and opinions orally about a topic of mutual concern and interest. The teacher acts as a conference leader and direct and redirect ideas and information produced by the students. He listens to what is said by each individual student in the group as this give an insight into level of knowledge and understanding of the subject matter (Timothy, 2009).

Field trip is a planned visit to a place of interest outside the class room to obtain information. The method is used to broaden the knowledge of the students as this could see

and hear more than what they are told in the class room, the students usually get first hand information and the method often encourage mutual relationship between the school and the community (Timothy, 2009).

Laboratory method is a scientific approach which the teacher leads the students in the process of conducting a test to produce a particular product; it also involves explaining step-by-step process to them. The teacher is also the principal actor while the learners watch with the intention to act later.

Discovery method allows the students total freedom to find out things for themselves under the guidance and the supervision of the teacher, the teacher however has the predetermined results to be compared with those of the students, students could also discover new things that even the teachers have not discovered, as it is popularly believed that "discovery is the mother of invention".

Not all teachers of agriculture are competent, many university graduates and other graduates from sister institutions trained in specialised areas of agriculture accept teaching as a stepping stone to better jobs, other teachers do not have adequate professional training. A competent teacher of agriculture in schools requires technical knowledge in agriculture as well as good knowledge of teaching methods and learning process. These qualities are however, lacking in many agricultural science teachers. Therefore, teachers must find the most suitable method or combination of methods to teach the students to obtain best results, this will however, be affected directly or indirectly by their perception of various teaching methods.

Objective of the Study

The objective of the study was to determine agricultural science teachers' perception of the relevance of the selected teaching methods in teaching agricultural science for obtaining best results. Specifically, the study was carried out to:

- (i) examine the demographic characteristics of the agricultural science teachers;
- (ii) determine the various teaching methods employed by teachers and the most frequently used by them
- (iii) determine teachers' perception on students' attitude and nature of their involvement in agricultural science lesson and practical; and
- (iv) determine the perception of the teachers on the challenges faced in teaching and learning of agricultural science.

Methodology

The study was a descriptive survey design that elicited relevant information on the respondents' perception of the relevance of various agricultural science teaching methods in imparting agricultural knowledge and skills in Niger State, Nigeria. Purposive sampling method was used to select all the agricultural science teachers in agricultural Zone ii of Niger state agricultural and Mechanization Development Authority, a total of 50 respondents were sampled for the study. Data for the study were analyzed using descriptive statistics such as frequency distribution, tables, percentages, ranking and mean values. A 4-point and 5-point Likert type of scale were used to analyze data on respondents' perception on the various agricultural science teaching methods and constraints faced by agricultural science teachers respectively.

For respondents, perception on teaching methods, Likert rating scale used were: very relevant (4 points), relevant (3 points), slightly relevant (2 points) and not relevant (1 point) the critical mean 2.5 derived from 4-point likert rating scale values $(4+3+2+1/4)$. Also 4-

point rating scale was used to described agricultural science teacher's perception of the various teaching methods. The perception scores greater than or equal to critical mean of 2.5 are considered as relevant method for the teaching of agricultural science. For the constraints 5-point rating scale were used: very serious (5 points), serious (4 points), not sure (3 points), not serious (2 points) and not very serious (1 point) the scores were weighed and weighted average found as used by (Odinwa *et al.*, 2011). The critical mean 3.0 derived from 5-point likert rating scale $(5+4+3+2+1/5)$ was used to describe agricultural science teachers' perception of the constraints faced. The constraints score greater than or equal to critical mean of 3.0 depicts serious constraint to the teaching of agricultural science.

Results and Discussions

Age: The results in Table 1 revealed that majority (70%) of the respondents were below 46 years. This implies that majority of the agricultural science teachers are still in their active and productive age. This is good for agricultural science teachers because teaching of agriculture especially the practical lessons requires strong and energetic individuals. This is consistent with the findings of Modebel and Nwakpadolu (2013), who pointed out that the practice of agriculture is energy sapping, particularly where crude implements are in use, as it requires active and energetic individuals.

Marital Status: The entries in Table 1 showed that larger proportions (80%) of the agricultural science teachers were married. This implies that majority of the teachers were matured and have the ability and the capacity to impart knowledge more responsibly. This will directly or indirectly influence their relationship with the students.

Educational status: the result in Table 1 revealed that 94% of the respondents had one form of education or the other and were also qualified professionally trained teachers because they possessed teachers training qualifications. This implies that majority of them are armed with the principles and practice of teaching agricultural science. This is in agreement with the findings of Afred *et al.* (2009) who indicated that competent teachers of agriculture in school requires technical knowledge in agriculture as well as good knowledge of teaching and learning processe.

Teaching Experience: Table 1 indicated that 90% of the agricultural science teachers have been teaching agricultural science as a subject for more than 10 years. This implies that majority of the agricultural science in the study area were experienced teachers. This will directly or indirectly affect their use of different teaching methods in imparting agricultural science knowledge because it is believed that experience is the best teacher.

Table 1: Socio economic characteristics of the respondents

Age	Frequency	Percentage
Less than 25 years	8	16
26 – 35	13	26
36 – 45	14	28
46 – 55	10	20
56 and above	5	10
Total	50	100
Marital Status		
Single	6	12
Married	40	80
Divorced	-	-
Widow	2	4

Widower	2	4
Total	50	100
Educational Status		
N.C.E.	20	40
B.ed/ B.Sc(ed)	20	40
ND/ HND / B.Sc/ B.Tech	2	4
PGD in Education	5	10
M.ed degree	3	6
Total	50	100
Teaching Experience		
Less than 10 years	5	10
11 – 20 years	30	60
21 – 30 years	9	18
31 and above	6	12
Total	50	100
Sex		
Male	37	74
Female	13	26
Total	50	100

Source: Field Survey, 2015

Sex: Table 1 also indicated that majority (74%) of the respondents were males, while the females were only 26%. The reason for this wide gap between male and female agricultural science teachers could be because teaching agricultural science, particularly the practical aspects is labour intensive and agriculture is generally regarded as male dominated occupation. This is in line with the findings of Modebelu and Nwakpadolu (2013), who indicated that the practice of agriculture appears crude and unnecessary energy supply due to inadequate application of modern agricultural practice.

Table 2: Distribution of respondents according to most frequently used teaching method and best perceived agricultural science teaching method

Teaching	Frequency*	Percentage	Rank
Most frequently used Teaching method			
Discussion	10	20	3 rd
Lecture	20	40	1 st
Demonstration	13	26	2 nd
Field trip	3	6	4 th
Laboratory	1	2	5 th
Discovery	3	6	4 th
Best Perceived Teaching method			
Discussion	3	6	3 rd
Lecture	4	8	2 nd
Demonstration	35	70	1 st
Field trip	3	6	3 rd
Laboratory	2	4	4 th
Discovery	3	6	3 rd

Source: Field survey, 2015

*Multiple Responses

Most frequently used teaching method: The results in Table 2 showed that 20 (40%) of teachers indicated that lecture method was the most frequently used and ranked 1st. Demonstration and discussion methods ranked 2nd and 3rd respectively, while field trip and discovery method which ranked 4th accordingly were the less frequently used agricultural science teaching methods. This finding is in line with the findings of Ngesa (2006), who confirmed the findings by monitoring team that Agriculture teachers in Kenya use lecture, class discussion and group discussion methods than any other method.

Best perceived teaching method: As indicated in Table 2 demonstration method ranked 1st as best perceived teaching method, followed by field trip which ranked second, which is usually both teacher and student centred. This is in line with Fauziah and Jamaluddin (2008), who review on pedagogy and classroom practices revealed that the teacher centred and student centred teaching methods are basic to most theoretical and teaching propositions. The results in table 2 also indicated that several methods are in used for imparting agricultural science knowledge and skills, some were however perceived as better the other. This is in line with a study by Vandebosch (2006), who found that most used strategies in teaching agriculture are, lectures, demonstrations, discussion, educational visits/field trip, projects, question and answers, assignments and practical.

Table 3: Teachers' perception on student attitude towards agricultural science practical's and their nature of involvement in the practical lessons

Students Attitude Towards Practical's	Frequency	Percentage
Very favourable	5	10
Favourable	4	8
Not favourable	41	82
Total	50	100
Nature of Involvement		
Very active	3	6
Active	2	4
Not active	45	90
Total	50	100

Source: Field Survey, 2015

The result in table 3 revealed that majority (82%) of the students have unfavourable attitude toward learning of agricultural science, particularly the practical aspect of the course, as a result students tend to memorise concept that requires analytical thinking. This is consistent with the findings of Ransford *et al.* (2015) who pointed out that one of the challenges of teaching and learning of agriculture was memorization of concepts that requires analytical thinking. Similarly, Table 3 also showed that large proportions (90%) of the students were not actively involved in agricultural lessons, particularly the practical aspect of the course. this is not unconnected with the drudgery associated with the practice of agriculture and the status accorded farmers by the general public. This is in line with findings of Alfred *et al.* (2009) who pointed out that the low status and esteem usually accorded agriculture as a profession negatively affect student attitude and nature of involvement in agricultural lessons.

Table 4: Overall agricultural science teachers' perception on the relevance of the various agricultural science teaching methods in imparting knowledge and skills

Teaching Methods	Weighted score	Weight mean ($\bar{x}$)	Remark
Discussion	79	1.52	*
Lecture	78	1.59	*
Demonstration	192	3.84	**
Field trip	181	3.77	**
Laboratory	163	3.26	**
Discovery	170	3.62	**
Total ($\bar{x}$)		17.6	
Critical Mean		2.5	$\geq 2.5 = **$ $< 2.5 = *$

Source: Field Survey, 2015

Critical mean = 2.5 ** Relevant teaching method

* Not Relevant

According Allen et al. (n.d.) instructors teaching agricultural science curricular have implemented a wide variety of teaching methods which fit different inches within the agricultural classroom. The result in Table 4 showed that teachers of agriculture perceived demonstration method as the most relevant method of imparting agricultural knowledge and skills, this is followed by field trip, discovery and laboratory methods. This implies that, though several methods are used in imparting agricultural knowledge and skills, not all of them are relevant in doing so. This is in line with the findings with the findings of Abdulhamid (2013) who posited that the most suitable method for teaching practical oriented subject like agricultural science is demonstration method.

Table 5: Teachers perception on the challenges to the teaching and learning of agricultural science

Statements	Teachers Weighted score	Weight t ($\bar{x}$)	Remark
1. Poor remuneration/lack of motivation makes Agricultural science unattractive	195	3.9	**
2. Background of the students negatively affect the learning of the subject	183	3.7	**
3. Large class size makes the teaching of agricultural science and practical work difficult	171	3.4	**
4. Lack of interest on the part of the teachers and students alike affect teaching and learning of the subject	191	3.8	**
5. Inadequate teaching and learning materials hinders the teaching and learning of the subject	192	3.8	**
6. Difficulties in planning and executing field trips	181	3.6	**
7. Public attitude to words agriculture negatively affect	178	3.6	**

teaching and learning of the subject.

8. Climate change and its associated problems negatively affect teachers and students considering agriculture as a carrier/profession	167	3.3	**
Total (x)		29.1	
Critical mean	$\geq 3.0 =$		
	* *		
	$< 3.0 = *$		

Source: Field Survey, 2015

Critical mean = 3.0, **Serious Constraint

*Not serious constraint

The entries in Table 6 revealed that all the challenges under consideration were perceived as serious challenges by the teachers. This implies that teaching and learning of agricultural science is faced with serious challenging hampering effective teaching and learning. This is consistent with the findings of Ransford *et al.* (2015) that teaching of agricultural is facing serious problems and coupled with the fact that many university graduates in trained specialised areas of agriculture accept teaching in secondary schools as a stepping stone to a better job. Public attitude to words agriculture negatively affect teaching and learning of agricultural science, and this posed a great challenge to agriculture as a profession.

Conclusion

Based on the findings of this study. Demonstration method was perceived as the best and more effective method of imparting agricultural knowledge and skills. The teaching and learning of agriculture is also faced with serious challenges which includes among others students' background, lack of interest on the part of the teachers and students alike and public attitude towards agriculture, particularly university graduates in trained specialised areas of agriculture who usually accept teaching in secondary schools as a stepping stone to a better job.

Recommendations

Based on the findings of this study the following recommendations were made

- (i) Government and other development agencies should intensify efforts in revitalizing teachers training programmes in the state, through training and re-training of agricultural science teachers.
- (ii) Agricultural science teachers should be motivated by increasing their remuneration and allowances.
- (iii) An enabling environment should be created for the adoption and use of modern techniques in practicing agriculture, to minimize the drudgery associated with farming and to motivate young school leavers to take agriculture as a profession.

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ASSESSMENT OF COST AND RETURNS TO CULTURED FISH PRODUCTION IN KOGI STATE OF NIGERIA

AKANBI, USMAN OLADIPO¹ & MUSA JOHN JIYA^{2*}

Department of Agricultural Economics, University of Ilorin, Ilorin, Nigeria

Department of Agriculture and Bioresources Engineering,

Federal University of Technology, Minna, Nigeria

E-mail: johnmusa@futminna.edu.ng

Phone No: +234-803-668-2747

Abstract

This paper examines the socio economic characteristics, cultured fish production techniques, and the costs and returns to cultured fish production in Kogi state of Nigeria. Data used for this study were collected over one production cycle in 2012 using a structured questionnaire. A total of 51 respondents were drawn from a sampling frame of 94 registered cultured fish farmers through random sampling technique. Analytical tools used for the study were descriptive statistics and farm budgeting technique. The study shows that net farm income was estimated at ₦ 3,316.06 per m²/cycle with a rate of return calculated at 184% was realized from cultured fish production by farmers in Kogi. It was concluded that cultured fish production in the study area is profitable. Based on the findings of the study, it is concluded that fish production is profitable and the potentials for enhancing its profitability exists. However, due to the low access of farmers to formal credit, the study recommended that government should link the farmers to formal source for formal credit in addition; the government should also endeavor to encourage more women participation, particularly in homestead cultured fish production. The government will also do well to create a support system comprising the establishment of a number of one-stop shops at convenient locations for farmers where necessary fish inputs can be accessed by fish farmers at considerable prices. By this, the cost of production will be minimized and this will lead to increase in the farm returns.

Keywords: Cost, Cultured fish, Returns, Farm, Production

Introduction

The agricultural sector is one of the most important components of the Nigerian economy. This is in the sense that it plays significant roles in the nation's economic development. These roles include contribution to the country's Gross Domestic Product, source of income, decent living for a large proportion of the population, provision of food for the people, supply of raw materials required by the industrial sector, generation of foreign exchange through export and provision of employment opportunities for the teeming population [1]. The importance and relevance of the agricultural sector in economic growth and development cannot be over emphasized. However, until recently, there seem to be no consistent pattern of improvement, irrespective of whether activities in the sector are controlled by the government or market forces. The sector contributes 41.15 % of the country's GDP. It employs about 65% of the total population and provides employment to about 90% of the rural population. The fishery sub-sector, which is the focus of this study, accounts for 3.3 % contribution to the GDP on the average [2]. This contribution is relatively low when compared with the crop and livestock sub-sector's contribution to the economy. The best animal protein choices are fish and poultry. It has been estimated that fish constitutes about 3.5% of per capita food consumption in Nigeria, about 36.6 grammes per day in a meal [3]. Fish is a highly acceptable source of protein, accounting for as much as 50 percent of animal protein intake in most developing countries [4]. On a global scale, almost 16 percent of the total intake of animal protein was attributed to fish [4]. However,

of great concern for the stakeholders in Nigeria is the low intake of protein by its citizen which is still below the World Health Organization (WHO) recommendation. WHO recommends 0.45 grams of protein per kilogram of ideal body weight per day [5]. This perhaps might have informed the emphasis placed on the fishery sub-sector by the States and Federal Governments in recent times. Hence, the need for this empirical study that focused on Kogi State where recent statistics revealed an upsurge in the number of new entrants into the cultured fish business.

The main objective of the study is to examine the profitability of the prevalent cultured fish production in Kogi States, to also describe the socio economic characteristics of cultured fish farmers; identify cultured fish production techniques in the study area; and to determine the costs and return to cultured fish production in the study area.

Material and Methods

The Study Area: Kogi State is located in the North central zone of Nigeria. The State which has 21 Local Government Areas was created on the 27th of August 1991 from the merger of parts of Kwara and Benue State. It is bounded by the following States, Edo and Ekiti to the West, Nasarawa and Benue to the east, Anambra and Delta to the south, Kwara, Niger and the Federal Capital Territory, Abuja to the North. It is located on longitude 6.5783° E and latitude 7.5619° N. The two major rivers, Niger and Benue flow through the State exposing expanse of low lying swampy plains. The river Niger which is close to 300 km in length forms a confluence with the River Benue at Lokoja, the State's capital [6]. The two States that constitute the study area have two distinct climatic seasons, the wet (Rainy) and dry (Harmattan) seasons. The rainfall in Kogi extends between November and February. This climatic condition as well as fertile soil makes the States favorable for arable crop production such as rice, millet, yam, cowpea etc [6].

Data Collection: Primary data were collected using a structured-questionnaire. The primary data were collected between the months of December, June, 2012 to June 2013. A minimum of three visits were occasioned to the identified farms in the State under consideration; the first two visits were to pre-test the Data, while the latter were to administer the fine-tuned questionnaire.

Sampling Procedure: The study employed a single stage random sampling procedure. Given the unavailability of a comprehensive sampling frame for the study area, a sampling frame was developed from a list of fish farmers obtained from the Kogi State Ministries of Agriculture, the Kogi State ADP and the Fadama Development Project. Thus a population size of 94 farmers was obtained. A table of random numbers was thus constructed. From this a sample size of 51 farmers were randomly selected for the study. Thereafter, 51 structured questionnaires were respectively administered to cultured fish farmers in the study area. A detail of the samples is required in terms of geographical spread in the State.

Analytical Techniques: The data collected for the study were analyzed using descriptive statistics and farm budgeting technique. The model for estimating the farmer's returns to labour and management is outlined thus: Partial budget analysis was employed to determine Net Farm Income (NFI) and the returns to Farmer's Labour per hectare derived from catfish production in the study area. The model for estimating the farmer's return to labour and management is outlined thus:

Gross Value Output (TR) – Total Variable Cost of production (TVC) = Gross Margin	1
Gross Margin – Fixed cost = Net Farm Income	2
Net farm Income – Imputed cost of Family Labour = Returns to Farmer's Labour and Management	3

Return to Farmer's Labour and Management / Net Farm Income are the focal point for the costs and returns analysis of this study.

Rate of Return (ROR) provides a measure of financial performance of the enterprise employed expressed in percentage (%) (i.e. profit/ ₦ invested)

Returns to Farmer's Labour and Management

Returns to Farmer's Labour and management/Net Farm Income are the focal point for the costs and returns analysis of this study. Rate of return (ROR) provides a measure of financial performance of the enterprise employed expressed in percentage (%) (i.e. profit/ ₦ invested)

$$ROR = \frac{TR}{TC} \times \frac{100}{1}$$

4

Results and Discussion

Socio-economic Characteristics

Table 1 shows the distribution of the cultured fish farmers with respect to their socio-economic characteristics. 90.2% were male; 86.3% had formal education and 88.2% were married; fish farming appear to be a male dominated activity in the study area. This is similar to the findings of [7, 8]. The latter in a study of cost and returns found that fish farming was majorly a male dominated activity. This practice is not peculiar to Nigeria alone as [7]. in their study reported similar trend in China, Philippine, India and Bangladesh. Eighty point four percent of the farmers are 36 years and above. Table 1: Socio-Economic Characteristics of Respondents

Table 1: Socio-economic Characteristics		Frequency	Percent
Sex	Male	46	90.2
	Female	5	9.8
	Total	51	100.0
Formal Education	Had formal	44	86.3
	No formal	7	13.7
	Total	51	100.0
Marital Status	Single	5	9.8
	Widow	1	2.0
	Married	45	88.2
	Total	51	100.0
Age	<35	10	19.6
	36-45	20	39.2
	>45	21	41.2
	Total	51	100.0
Years of Experience	<6	37	72.5
	06-10	7	13.7
	11-15	4	7.8
	>15	3	5.9
	Total	51	100.0
Aquaculture as Main Income	No	33	64.7
	Yes	18	35.3

	Total	51	100.0
Other Sources of Income	Other		
	based	11	21.6
	Trading	13	25.5
	Salaried Job	27	52.9
Source of Fund	Total	51	100.0
	Money Lenders	3	5.9
	Bank loan	2	3.9
	Friends	10	19.6
	Remittance	-	-
	Personal Saving	36	70.6
	Total	51	100.0

Source: Field Survey, 2012

Most of the cultured fish farms examined have at their disposal a mixed blend of labour supply e.g. husband, wife, children or siblings to manage them. Furthermore, the operations of most of the farms encountered required minimal labour as they are mostly small holder farms that requires less than hour per day of farm operations. Of the sampled cultured fish farmers in the study area, 86.3% had formal education to varying levels. This is similar to the works of Olaoye *et al.*, (2013); Adebayo and Daramola (2013). Fish farming was not the main source of income in the State. A good percentage of farmers sampled are salary earners (52.9%). This is similar to the works of Adewuyi *et al.*, (2010). Cultured fishing is largely seen as supplementary enterprise in the study area. Petty trading also serves as an alternative source of income for some farmers in the study areas. Fund for fish farming were mostly from personal savings. Virtually all the respondent did not access financial credit from lending institutions perhaps due to the stringent conditions attached to their services (70.6%).

Production Techniques of Cultured Fish Production

Average pond size was 117 m² and 70.6% of respondents were found to be engaged in mono cultured production (Table 2). This similar to the findings of Olagunju *et al.*, (2007); Ele *et al.*, (2013); and Omobepade *et al.*, (2015). Earthen pond type was prevalent in the study area. The pond type employed no doubt had implication on the system of water supply. The mode of acquisition of Land in the study area is mainly through purchase and leasing, with a few cases of acquisition by traditional inheritance. In fishery, swamps which are particularly good for the construction of earthen ponds are considered as land resource. More over acquired spaces were concrete ponds can be constructed or fibre/plastic ponds are placed are also considered as land resource. The measurement of pond size is in square meters. The location of the land usually pre-determines the production technique. In some cases farmers simply excavate land located in swampy areas to make earthen pond. In other cases, farmers took advantage of little swath of lands bordering their residential abodes. 82.4% of stocked fish in Kogi were catfish, while tilapia accounts for the remaining population. The system of water supply was about 72.5% of stagnant water in Kogi State.

Table 2: Production Techniques of Respondents in Kogi State

Techniques		Frequency	Percent
Pond type	Concrete tank	20	39.2
	Earthen	21	41.2
	Fibre/tarpaulin	10	19.6
	Total	51	100.0
Average Pond size			
		Kwara: 114m ²	
		Kogi: 117m ²	
Labour	Family	36	70.6
	Hired	12	23.5
	Both	3	5.9
	Total	51	100.0
Cultured System	Poly Cultured	16	31.4
	Mono Cultured	35	70.6
	Total	51	100.0
System of water supply	Stagnant Water	37	72.5
	Flow through system	5	9.8
	Circulatory system	9	17.6
	Total	51	100.0
Type of Fish Stock	Others	7	13.7
	Tilapia	2	3.9
	Cat fish	42	82.4
	Total	51	100.0
Seedling system	Juvenile	35	68.6
	Fingerlings	16	31.4
	Total	51	100.0

Source: field Survey, 2012

Costs and Returns to Cultured Fish Farming

The farm budget analysis was used to determine the profitability of the enterprise. The Net Farm Income is basically the difference between the total returns from production (total revenue) and the total costs of production. The total revenue refers to the gross income accruing to fish farms as a result of the sales of table-sized fish, [9]. This is obtained by multiplying the unit price of average table-sized fish by the quantity sold. The variable costs are those costs that vary with the level of output. In this study the relevant variable costs items are fish feed, fingerlings and labor. The fixed costs items under fish farming are land, pond and other equipment. However, for the purpose of arriving at fixed cost of the fish farms for a given year, the straight line depreciation method was used taken into consideration, the expected life span of the different fixed cost items. Using the straight line method, the annual depreciation expenses were calculated on the fixed cost and used to arrive at the net farm income. The various costs incurred on the resources used and the returns from the sale of fish were estimated based on the market price at the period under consideration (one stocking cycle in year 2012. This is as presented in Table 3. The gross returns per m² pond size in the study areas were ₦3, 466.10. The rate of return on investment (ROR) for Kogi State was 184%. This implies that for every ₦1 invested into cultured fish, ₦1.84 was made as revenue for the Kogi. That is, about 84 kobo was realized as returns. The rate of return on investment (ROR) otherwise called efficiency level was

respectively 0.84. This suggest both viability and profitability of fish farm enterprise in the study areas as this value is extensively higher than current lending rate of between 6 and 25% charged by both cooperative society and commercial banks in the study area. The study revealed that for every 1000 unit of fingerlings/juveniles purchased, about 80 to 100 are lost (died) before maturity. This mortality rate of about 10% of total fingerlings/juveniles per farm appeared rather high. The reason behind this high mortality rate may be that most of the farmers do not consider the use of drug and /or fertilizer necessary for their production. This is perhaps because these farmers have not been educated and/or enlightened on the importance of the use of these feed supplements. Another reason could also be low access to meet water requirement of the cultured fish farm. Poor power supply could also lead to poor water supply for most fish farms. This in turn have adverse effect on the health status and performance of fingerlings/juvenile

Table 3: Returns to investment ₦/m²*per one stocking cycle (6 months)

Item	Amount (N)	
Total Revenue		5,194.64
Cost of Labour	90.44 (5.20)	
Cost of Fingerlings/Juvenile	521.78 (30.20)	
Cost of Feeds	994.71 (57.56)	
Depreciation	121.61 (7.04)*	
Total Variable Cost	1,728.54 (92.01)	1,728.54
Gross Margin		3,466.10
Total Fixed Cost	150.04 (7.99)	150.04
Net Farm Income/Profit (NFI)		3,316.06
Rate of Return on investment (RORCI)	1.84 (184%)	
Efficiency level/ (ROR) (%)	0.84 (84%)	

Figures in parenthesis are % of total cost.

*average linear depreciation on all equipment was used, *2012 1st cycle

Source: Field Survey, 2012

The labour used consists of family, hired and group labour. The wage rate varies slightly depending on the operation to be performed on the Fish farm. About ₦90.44 was spent on labour requirement per m² pond size in Kogi. The cost of fingerlings/juveniles does not account for differences observed in the total cost of production. This cost varies from as low as ₦25 to as high as ₦100 per fingerlings or juvenile depending on the market situation. The mean cost of fingerlings/juvenile was estimated at ₦48.5. The study observed that there was high cost of feeding in the study area. Adequate feeding of the fingerlings/juvenile is an important step to better performance of fish farming therefore depends not only on how well the fish are fed but of the quality as well. This explains why feeding took the bulk of the total variable cost. Most respondents agreed that the cost of Fingerlings/Juvenile is increasing by the day. This may have contributed to the slow growth observed in the sub-sector, since most farms identified the cost of feed as one of the problems militating against the enterprise. Furthermore, the study revealed that it cost about ₦355.39 on the average to raise a typical fingerlings/juvenile to approximately 1 kg in the study area. Arithmetically, a unit of 1000 fingerlings/juvenile will cost approximately ₦355,390.00 in Kogi and with the average sales price of ₦578.43 in the study area; a good return in investment is expected.

Table 4: Cost of Cultured Fish Production ₦/ kg

Measured variable	Kogi
Feeds (₦)	124.45
Cost of purchase of fingerlings(₦)	48.50
Other Cost (₦)*	182.44
Total cost	355.39
Average sale price	578.43

*includes cost such as labour, fertilizer/drug cost, water/electricity supply and linear depreciation on machine. Approximate average size of catfish is 0.954 kg.

Conclusion

Based on the findings of the study, it is concluded that fish production is profitable and the potentials for enhancing its profitability exists. However, due to the low access of the respondent farmers to formal credit, the study recommended that government should link the farmers to formal avenues for formal credit. In addition; the government should also endeavor to encourage more women participation, particularly in homestead cultured fish production. The government will also do well to create a support system comprising the establishment of a number of one-stop shops at convenient locations for farmers where necessary fish inputs can be accessed by fish farmers at considerable prices. By this, the cost of production will be minimised and this will lead to increase in the farm returns.

Authors' Contributions

AKANBI, Usman Oladipo designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. MUSA, John Jiya managed the analyses of the study and the search for relevant literature review. The two authors read and approved the final manuscript.

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EXPERIMENTAL STUDY OF A SINGLE PHASE FLOW IN A PIPE SEPARATOR

EYITAYO A. AFOLABI¹ & J. G. M. LEE²

¹Department of Chemical Engineering,
Federal University of Technology, Minna, Nigeria.

²Newcastle University, Newcastle upon Tyne, UK.

E-mail: elizamos2001@yahoo.com

Phone No: +234-807-220-1514

Abstract

An experimental investigation of the hydrodynamic behaviour of a single water flow was performed on a laboratory scale model of a three phase pipe separator. The velocity distributions of swirling flow were measured using the Stereoscopic-Particle Image Velocimetry technique at three different axial positions within the pipe separator. The results show that the shapes of the tangential velocity profiles are independent of axial positions within the pipe separator and the magnitude of the mean tangential velocity decreases moving away from the inlet section to the outlets. The axial velocity measurements show the presence of fluid dynamic instabilities such as vortex breakdown and precessing vortex core caused by the high swirling motion inside the pipe separator.

Keywords: Stereoscopic Particle Image Velocimetry, Pipe Separator, Velocity Profile

Introduction

In the past, the multiphase separation technology used in the oil and gas industry has been based on conventional vessel-type separators which are expensive, heavy and bulky in size. Nowadays, compact separators are widely used as an effective and economical alternative to conventional separators especially in offshore platforms in oil and gas production operations (Erdal, 2001). The choice of this technology is because it is simpler to operate, more lightweight, has neither moving nor internal parts, requires less floor space, and involves lower capital and operational costs (Vazquez, 2001).

A pipe separator is a device that spins a continuous phase stream to remove entrained dispersed phases by centrifugal force (Erdal, 2001). It operates at velocities where the flow is found to be typically turbulent and often characterized with flow reversal, flow separation and three-dimensional boundary layers with strong streamline curvature (Leeuwner & Eksteen, 2008; Slack & Wraith, 1997). Cylindrical cyclone or pipe separator has potential application as a free water knockout system in equipment for the upstream oil and gas production. This includes down-hole, surface (onshore and offshore) and subsea separation. Other applications include, use in flare gas scrubbers, slug catchers and portable well testing equipment. Preliminary studies have shown that the three phase pipe separator is an effective device use for partial separation of air-oil-water mixtures at moderate velocities (Vazquez, 2001). However, the cylindrical cyclone operates as a mixer rather than separator at high velocities.

As shown in Figure 1, the three phase pipe separator consists of a tangential inlet inclined at an angle of 27° to the vertical cylindrical body and an oil finder which is an inner concentric pipe extended through the bottom. The air-oil-water mixture enters through the inclined inlet designed to promote the pre-separation of the gas-liquid mixture. The tangential inlet with reduced area produces a swirling motion in the vertical cylindrical pipe. The gas flows upwards to the gas outlet and leaves the single system compact separator. The liquid-liquid mixture moves to the lower section of the vertical pipe. As a result of differences in density, the centrifugal effect segregates the oil-water mixture, thereby concentrating the oil at the

center of the pipe whereas the water moves towards the wall region. The oil rich core formed at the center flows through the oil finder and the water rich fraction flows to the annulus between the pipe wall and the oil finder, leaving the single stage three phase separator through the water-rich outlet (Afolabi, 2012; Vazquez, 2001). Stereoscopic Particle Image Velocimetry (SPIV) is a new non-intrusive visualization experimental technique which is ideally suited to determining the whole field three-dimensional fluid velocity in a pipe separator. Stereoscopic PIV allows the determination of mean velocity and detailed turbulence quantities such as Reynolds stresses. One of the first attempts to measure the velocities in a cylindrical cyclone using Stereoscopic PIV was presented by Liu *et al* (2006). They investigated the swirling flow structure in a gas cyclone by measuring the instantaneous whole field tangential, axial and radial velocities of air flow. The time-averaged tangential velocity profile showed that the tangential velocity of the gas generated an inner quasi-forced vortex and outer quasi-free vortex. The axial velocity profile revealed an inner upward flow and outer downward flow. They further observed a reverse flow at the inner core of the forced vortex around the cyclone axis. This flow reversal is generated by the motion of precessing vortex core (PVC), which is usually associated with vortex breakdown and insurgence of reverse flow.

The work of Vasquez (2001) did not provide the hydrodynamic flow behaviour of the complex, swirling and turbulent flow in the three-phase pipe separator. This is the main focus that this research work is going to address. Previous study by Erdal (2001) was limited to a Laser Doppler Velocimetry measurement of a single phase flow that passed through a cyclone with a single outlet. However, this research work is aimed at providing SPIV measurement of single flow passing through three different outlets of a pipe separator. A lack of understanding of the complex flow behaviour within the three-phase cylindrical cyclone prevents complete confidence in its design.

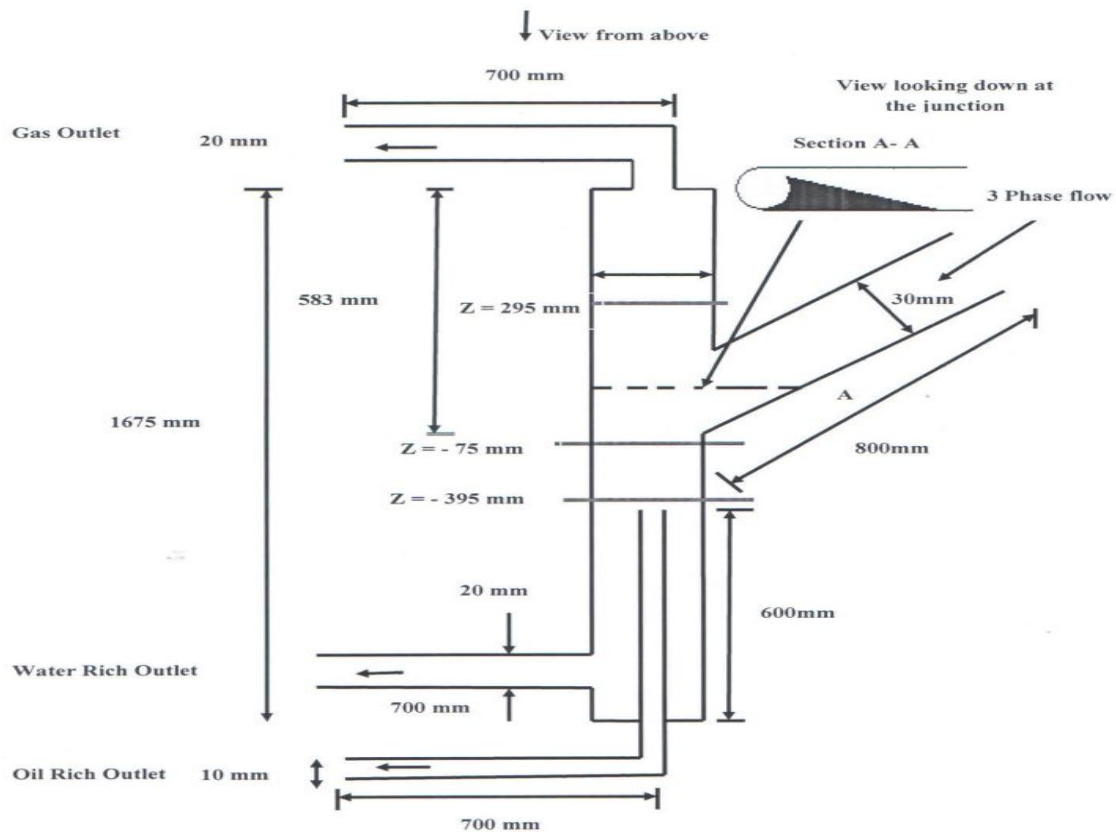


Figure 1: Single Stage Three-Phase Cylindrical Cyclone System (Afolabi, 2012)

Detailed investigation of the hydrodynamic flow behaviour will allow the correct prediction of separation performance, which is necessary for improved design in its applications. The present work focuses on investigating the hydrodynamic behaviour of a single phase flow within the three phase pipe separator using Stereoscopic (PIV) technique.

Methodology

Experimental Facility and Flow Loop: The three phase flow facility used in this study is based on one of the geometries developed and patented for multiphase flow separation by the Separation Technology Project of the University of Tulsa, USA. A 30 mm ID laboratory prototype of a three phase pipe separator was fabricated at School of Chemical Engineering and Advanced Material, Newcastle University, UK to investigate the hydrodynamic behaviour of the turbulent flow and separation efficiency. The separator test section was constructed using a transparent perspex tube. The single phase flow experiment was run with a water flow rate of 196 cm³/s. The outlets were restricted with rubber bungs such that the percentage of water as a fraction of the inlet mass flow was 60 % through the air outlet, 33 % through the water-rich outlet and the balance through the oil-rich outlet (Afolabi, 2012).

S-PIV Set-up: The stereo-PIV system used for this investigation was manufactured by TSI Inc and loaned from the Engineering and Physical Sciences Research Council (EPSRC) engineering instruments pool. The single phase water flow was seeded with light reflecting Silver coated hollow glass spheres marketed by TSI Inc (10089-SLV). This seeding material has very good fluid and imaging properties for the current experiment (Melling, 1997). A CFR-200 double pulsed Nd: YAG laser system designed by Big Sky Laser was used as the light source to illuminate the tracer particles in the measurement plane. As shown in Figure 2, the laser beam passed through a TSI Model 610015 light arm, which helped in aligning the beam to the arm's optical axes so that the beam was not clipped but transmitted properly.

Two TSI Model 630059 POWERVIEW TM Plus 4MP PIV cameras with CCD sensors were installed on the Scheimpflug mounts so as to satisfy the stereoscopic camera condition. The two cameras looked at angle of $\pm 45^\circ$ and $- 45^\circ$ to the light sheet. By tilting the image sensor plane and the lens principle to the Scheimpflug condition, the plane best of focus could be found so that it was aligned with the lightsheet (Prasad, 2000). These cameras were positioned at both sides of the light sheet in order to capture two exposures of the illuminated plane and then connected to a 64 bit frame grabber to subsequently transfer to a computer for automatic analysis using cross correlation method. A TSI 610035 laser pulse synchronizer was used to synchronize the image capturing and laser pulses. A water prism of 45 degrees was constructed and moved to the test section of the experimental rig in order to minimize optical distortion arising from refraction through the perspex wall. Two hundred pairs of images were recorded by the acquisition system at each measuring location. The software INSIGHT 3G from TSI Inc was used to controlled the hardware while capturing, retrieving and processing raw images in order to gain data on velocity vector fields.

Camera Calibration

A single plane calibration target populated by a Cartesian grid of 2 mm white marker dots with a 3 mm cross at the centre on a black background was cut to size to fit into the test section. The calibration target was moved using a micrometer in seven steps of 0.5 mm and images of the target were recorded and analysed by perspective calibration method of INSIGHT 3G software. The calibration image analysis produced a set of calibration points used to create a calibration mapping function, which was then used to combine 2-D PIV vector fields in order to obtain the three-dimensional vector field (Prasad and Jensen, 1995).

Results and Discussion

The experimental data presented were extracted along the $y=0$ line at three axial positions $Z = -395, -75$ and 295 mm of the pipe separator, as shown in Figures 1 and 3.

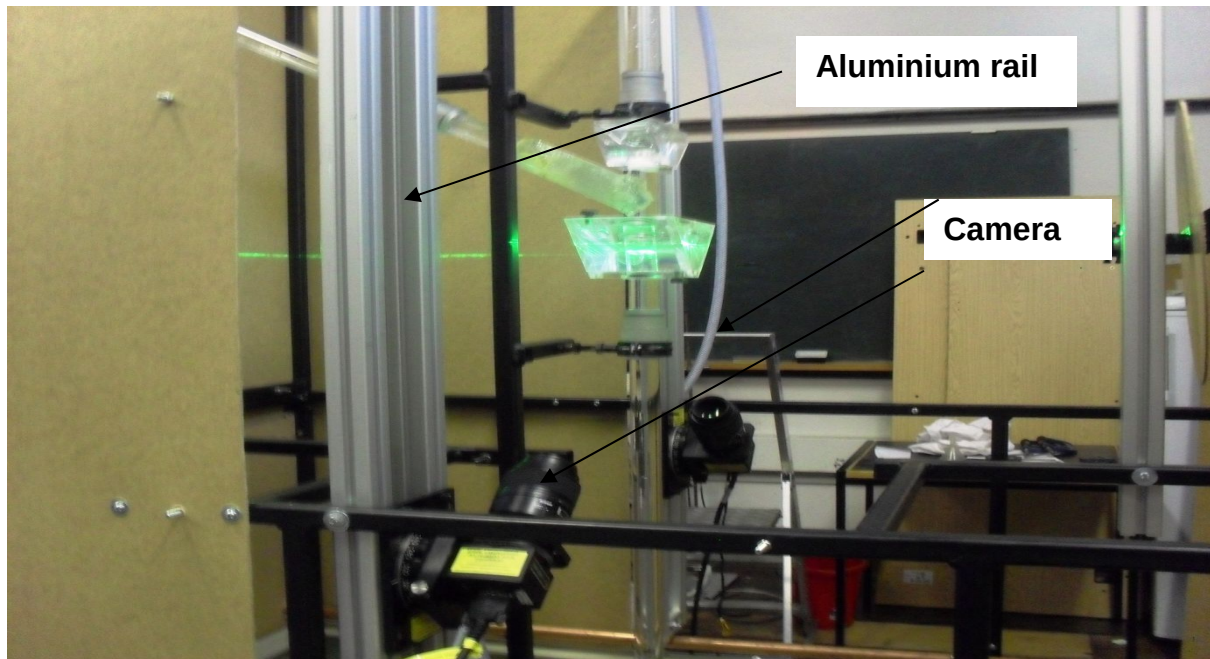


Figure 2: S-PIV Experimental Set-up

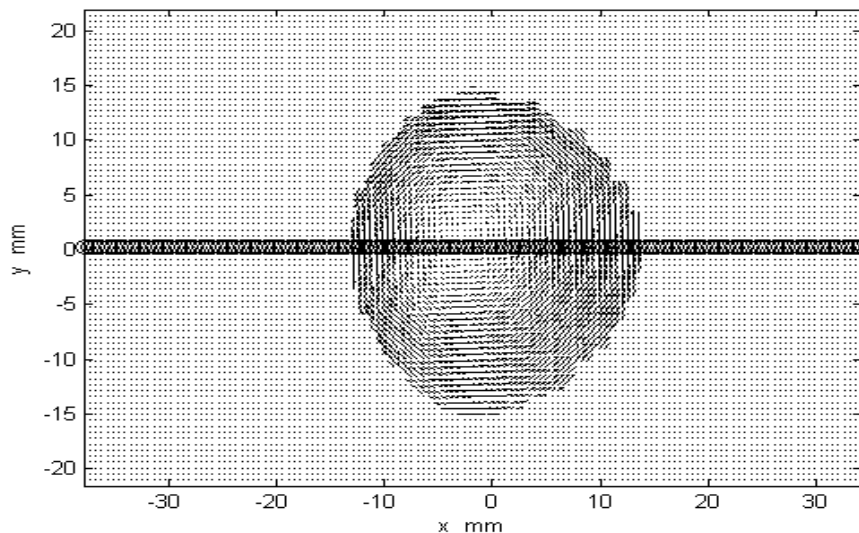


Figure 3: Experimental Data: Position of $y=0$ Sections

Tangential Velocity

Figure 4 shows the comparison of the mean tangential velocities of the water flow at the $Z = -395, -75$ and 295 mm axial positions. It can be observed that the tangential velocity at all axial positions increases moving away from the center of the tube before reaching a maximum and then dropping close to the wall due to wall friction. At $Z = 295$ mm, the maximum tangential velocity occurs at a radius of 7.5 mm. However, at $Z = -395$ mm the maximum velocity occurs at a radius of 10 mm and at $Z = -75$ mm, maximum velocity is observed at a radius of 12.5 mm. By identifying this location, the tangential velocity

distribution can be described as a continuous flow stream with an outer and inner region. The inner region is characterized as a forced vortex where tangential velocity increases directly with radius. However, the outer region is characterized as a free vortex and the rate of rotation is greatest at the center and then decreases progressively (Kelsall, 1952). This can be described by the relationship presented in equation 1;

$$v_{\theta} = Cr^n \quad (1)$$

where v_{θ} is the tangential velocity, C is a constant of proportionality, and r is the radial coordinate of the vortex. For a forced vortex, $n = 1$ and a free vortex, $n = -1$. The observations made are similar to the reports of earlier researchers in the literature (Leeuwner and Eksteen, 2008; Slack and Wraith, 1997). At $Z = -75$ mm, the forced vortex extends over 75 % of the surface area of the separator's plane and decreases to 67% and 50% at $Z = -395$ mm and 295 mm respectively. However, the free vortex occupies 50% of the surface area of the separator's plane at $Z = 295$ mm and decreases to 33.3 % and 25 % at the $Z = -395$ mm and -75 mm axial positions respectively. This means that the surface area occupied by the forced vortex decreases moving away from the inlet section. However, the free vortex increases when moving away from $Z = -395$ mm. The comparison of the tangential velocity profiles at the three axial positions shown in Figure 4 reveals that the surface area occupied by forced vortex decreases moving away from the inlet section. However, surface area occupied by free vortex increases when moving away from $Z = -395$ mm. The comparison of the tangential velocity profiles at the three axial positions shown in Figure 4 reveals that the magnitude of mean tangential velocity decreases as we move away from the inlet section towards the outlets. The reason for this is mainly the decay in swirl intensity as the flow moves away from the inlet. Therefore, as the fluid flow away from the inlet section, the tangential velocity gradually decreases and relatively less strong centrifugal fields are generated. Tangential velocity magnitude is a measure of the centrifugal force in the vortex region and this helps to improve the separation efficiency of the pipe separator.

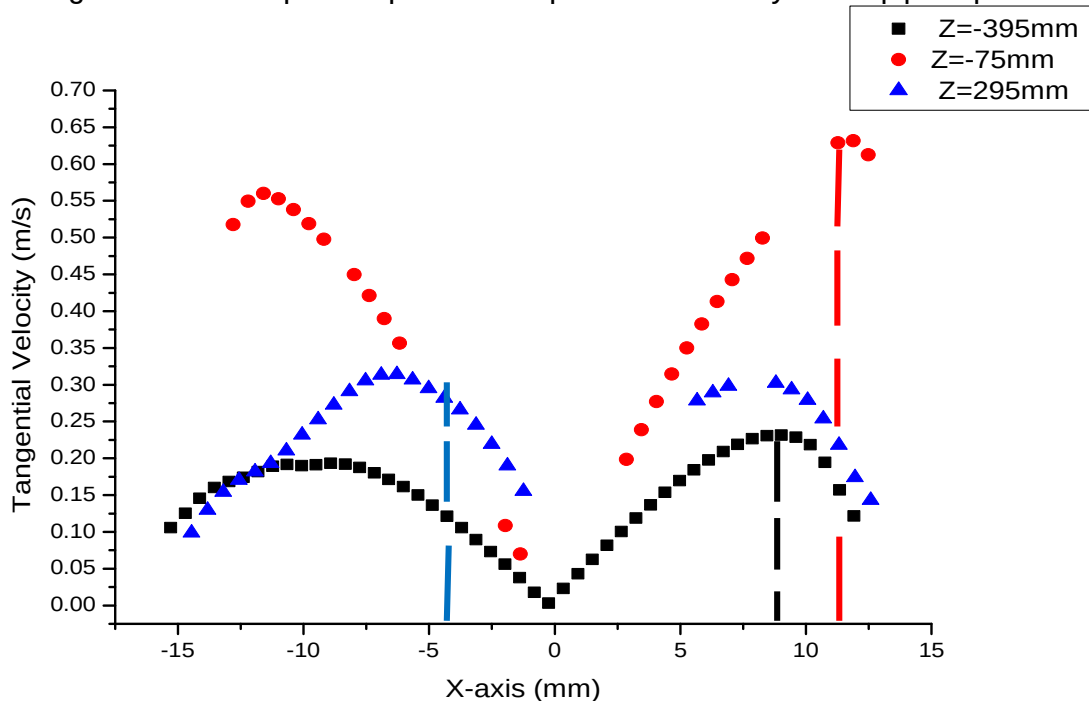


Figure 4: Comparison between the Tangential Velocity Profiles at Three Axial Positions in the Cyclone

It is generally accepted that tangential velocities are directly proportional to separation efficiencies. Therefore, most of the fluid separation occurs immediately at the region where the inlet section joins the vertical axis of the cyclone.

Axial Velocity

In agreement with other researchers such as Peng, *et al* (2002) and Monredon *et al* (1992), the positive axial velocity profile is hereby referred to as region of flow in an upward direction with respect to the rotation axis. A negative axial velocity profile will be taken as a region of flow in a downward direction from the rotation axis. The contour plot shown in Figure 5 reveals the existence of a region of recirculation or reverse flow at the center of the cyclone and a decreased axial velocity near the wall. The reverse flow refers to a region of positive axial velocity and is believed to be generated and dominated by the motion of a Precessing Vortex Core (PVC) usually defined as a time dependent instability that leads to vortex breakdown (Peng, *et al*, 2002; Yazdabadi *et al.*, 1994). Figure 6 shows the comparison between the axial velocity profiles at the three different axial positions in the separator. At $Z=-395$ mm and -75 mm, the positive values of axial velocity decrease with an increase in radial distance and reaches zero at some distance away from the center of the tube.

However, close to the separator wall, the axial velocity reaches a minimum and then increases. This is due to higher friction at the separator wall. Axial velocity profiles at $Z= -395$ and -75 mm reveal a combination of downward and upward flow patterns at the wall and center of the tube respectively. However, at $Z=295$ mm there is no negative axial velocity at any x-axis coordinate. As can be seen in Figure 6, a large amount of water flows in an upward direction at the center of the tube and in a downward direction near to the wall at $Z=-75$ mm. For example, the maximum positive and negative axial velocities are 0.175 m/s at $Z=-75$ mm.

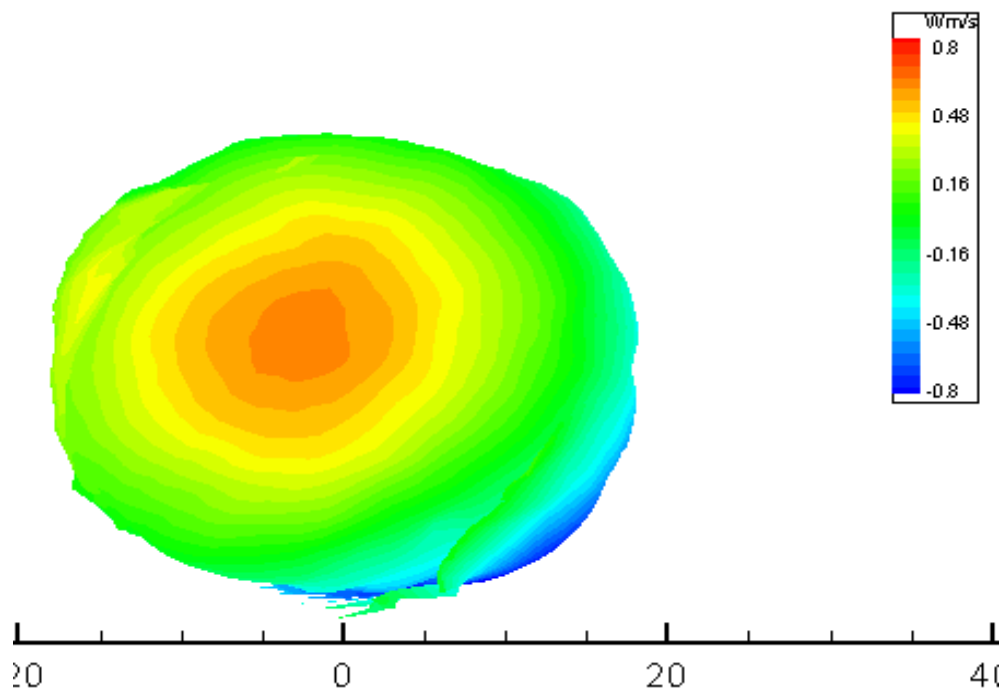


Figure 5: Contour Plot of the Axial Velocity at $Z= -75$ mm

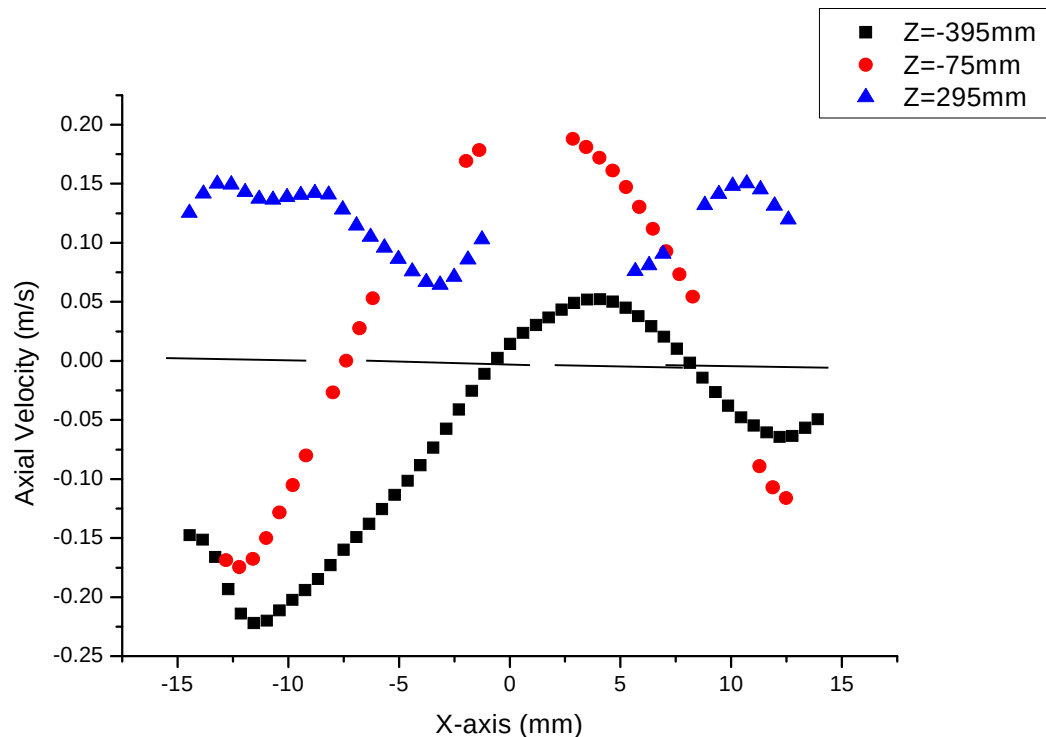


Figure 6: Comparison between the axial velocity profiles at three axial positions in the Cyclone

The maximum positive axial velocity among the three axial positions is 0.175 m/s at $Z=-75$ mm. At $Z=-395$ mm, a large downward flow is observed close to the wall together with small amounts of upward flow at the center of the tube. The location of the maximum axial velocity on the x-axis is at the center of the tube at $Z=-75$ mm, but off center at $Z=-395$ mm. Similar observations of axial velocity flow patterns was made by Leeuwner and Eksteen (2008).

Radial Velocity

Figure 7 shows a graph of the comparison between the mean radial velocity profiles at the three axial positions in the cyclone. In agreement with other researchers such as Kelsall (1952) and Peng *et-al*; (2007), radial velocity flow is said to be directed inward when the radial velocity is negative and outward when its value is positive. As can be seen in Figure 7, radial flow is found to be inwards as we move away from the center of the tube at $Z=-395$ mm. However, close to the wall at the positive value of the x-axis, outward radial velocity begins to develop. At $Z=-75$ mm, radial velocity is observed to be directed outwards at all values of the x-axis. The radial velocity profile at $Z=295$ mm shows inward flow as we move away from the center of the tube. However, close to the wall at a negative value of the x-axis, outward flow is observed. In Figure 7, it can be observed that the magnitude of radial velocity decreases as the flow moves towards the outlets.

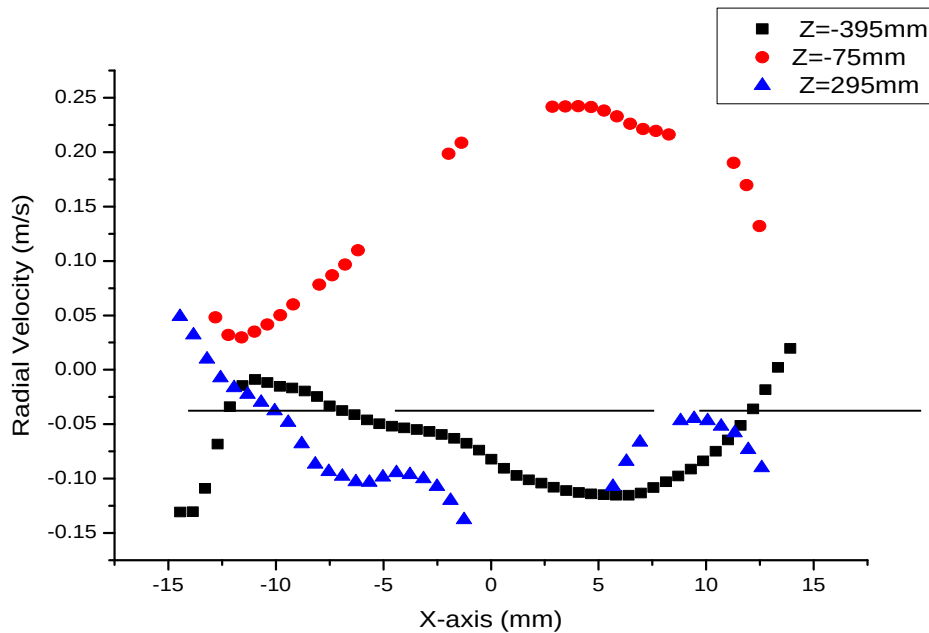


Figure 7: Comparison between the Radial Velocity Profiles at Three Axial Positions in the Cyclone

Conclusions

The stereoscopic PIV measurements were taken to investigate the single phase, water flow fields at three different axial positions within the pipe separator. Tangential velocity measurements showed that a forced vortex occurs at the center of the tube, with a free vortex near the wall region. The location of zero tangential velocity was observed to be off the axis of the pipe separator and the shape of the tangential velocity profile found to be independent of axial positions within the pipe separator. The tangential velocity profiles indicate that the magnitude of the mean tangential velocity decreases moving away from the inlet section to the outlets. The axial velocity measurements had shown the presence of fluid dynamic instabilities such as vortex breakdown and precessing vortex core caused by the high swirling motion inside the pipe separator. There is no general pattern for the radial velocity within the pipe separator. At the inlet section, the radial velocity was found to be directed outward. However, away from the inlet region, a pattern of both outwards and inwards flows was observed.

Acknowledgment

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DEVELOPMENT OF NIGERIAN VEHICLES LICENSE PLATE RECOGNITION AND CLASSIFICATION SYSTEM

A. B. ATTAH, A. P. ADEDIGBA & A. M. AIBINU*

Mechatronics Engineering Department,

Federal University of Technology, Minna, Nigeria

E-mail: [*maibinu@gmail.com](mailto:maibinu@gmail.com), abiiodun.aibinu@futminna.edu.ng,

Phone No: +234-802-949-4164

Abstract

Automatic Vehicle License Plate Recognition and Classification System (AVLPRCS) is a vital process in intelligent traffic system management. It has been used in recent past for identification, recognition and access control purposes. This work took the advantage of the uniqueness of the Nigerian License Plate Number System, especially the colour coding scheme, in the development of automatic vehicle license plate recognition system. The algorithm presented in this paper is targeted towards producing a non-computational time intensive AVLPRCS which can efficiently recognize Nigerian vehicle license plates and classify vehicles into government, commercial or private vehicles. Vehicle plate number images were acquired using low cost digital camera. Then, various pre-processing operation were carried out on the acquired images. Image segmentation was done using watershed (morphological) segmentation techniques while template matching technique was used for image recognition and classification. The system performance analysis shows 80% segmentation and 100% colour code classification accuracy during various test conditions and stages.

Keywords: Automated License Number Plate System, Character Recognition, Colour Recognition, Image Segmentation, Nigerian License Plate Number System

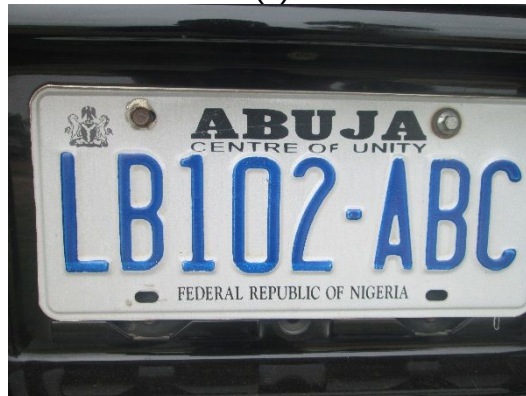
Introduction

In Nigeria, different Vehicle License Plate (VLP) numbering system have evolved over time. The immediate past VLP used in Nigeria has white background with the alphanumeric printed in blue, red or green colour. Mostly, the alphanumeric section is of the format AB-123 CDE; with the last three alphabets representing the Local Government Area in which the vehicle was registered in Nigeria. The alphabets are then followed by three digits and two letters. Similar to the immediate past VLP system, the new VLP is also printed on white background but with Nigerian map embedded in the background of the plate number. However, the alphanumeric is of the ABC-123 DE format. Unlike the immediate past numbering scheme, the first three alphabets represent the Local Government Area in which the vehicle was registered while the last two alphabets represent the zone or the batch production code. However, just like the immediate past VLP, the plate number is also printed in red, blue or green colour. Furthermore, at the upper left-hand corner of the new VLP lies the Flag of Nigeria. The state name and slogan is displayed at the centre of the top row in the VLP. Furthermore, "Federal Republic of Nigeria" is written at the bottom of the VLP. Figure 1a shows the recent VLP numbering system while Figure 1b shows the immediate past VLP numbering system.

Three major colours are typically used for the alphanumeric. The use of red colour for the alphanumeric signify that the vehicle is a commercial vehicle while blue colour means that the vehicle is a privately owned vehicle and the use of green colour means that the vehicle is a government owned vehicle. Many government-owned ministries and parastatals have customized VLP numbering system. Typical example is as shown in Figure 1c.



(a)



(b)



(c)

Figure 1a-c: Nigerian License Plate Number System

In this paper, the use of the VLP colour code scheme and the recognition of alphanumeric numbering scheme have been proposed for AVLPRS using Digital Image Processing technique.

The remaining part of this paper is organized as follows: Section II gives an overview of related work while the proposed methodology is contained in section III of the work. Results and conclusion are presented in section IV and V respectively.

Related Works

Detailed review of Automated Vehicle License Plate Recognition System (AVLPRS) developed around the world have been carried out and presented in this section. The work on Automated License Plate Recognition (ALPR), also known as Automated Number Recognition (ANPR), began in the United Kingdom in 1976 at the Police Scientific Development Branch, now known as the Home Office Scientific Development Branch. It was developed for fighting the use of car bombs in mainland Britain by the Irish Republican Army (IRA). Presently, this

technology is in use in more than 40 countries around the world (Cohen, Plecas, & McCormick, 2007).

An attempt to develop AVLPRS for Nigerian vehicles was reported in (Daramola, Adetiba, Adoghe, Badejo, Samuel, & Fagorusi, 2011). VLP images were captured at the car park using surveillance camera. Watershed segmentation was used for alphanumeric and background segmentation while recognition was done with Hidden Markov Model (HMM). The system was tested with 50 vehicles with recognition rate of 98%. Though, the rate of successful segmentation and recognition of the work was not presented in the work.

In Najeem Owamoyo, Fadele and Abudu (2013), VLP images are acquired through a digital camera under different background and illumination conditions. Vertical edge detection and connected component algorithm were used to locate and extract the plate number. Segmentation was done by carrying out vertical projection analysis on the image and the recognition was done using Support Vector Machine (SVM). The system was tested with 250 images and 85% successful extraction, 80% segmentation and 79.8% recognition were achieved using the proposed techniques.

Further works by Arulogun and Amusan (2013) shows a system tested on 200 images with 96% segmentation and 98% recognition accuracy achieved. In Arulogun and Amusan (2013), image acquisition was done using a digital camera. Pre-processing stages performed on the acquired images include grayscaling, filtering and Sobel edge detection. Artificial Neural Network (ANN) was proposed for the recognition.

A real-time, MATLAB based AVLPRS for Nigerian vehicle was proposed in Iroegbu, Chibuisi, and Okoronkwo (2015) with image acquisition, extraction and recognition was done in real-time. The camera was placed at the entrance to a parking lot; the acquired image was then pre-processed, dilated and edge processed (Iroegbu, Chibuisi, & Okoronkwo, 2015). The resulting image was filtered using a low-pass filter and region of interest was extracted out of the image. The template matching of character was used for recognition. Quantitative performance of the system was not discussed.

An application of AVLPRS in estimating traffic intensity at toll gates was presented in Vincent Olayiwola and Kosemani (2014). The system gathered information about the traffic situation with respect to the VLP number captured at the toll gate. Vehicle arrival time and date was used to generate traffic report. The result shows 80% of license number extraction was successful and the traffic information was successfully done achieving 100% success rate.

Ozbay and Ercelebi (2005) designed the software for the Turkish Number Plate System. Smearing algorithm was used to extract the text region of the plate number, and then segmentation was done by morphological segmentation. Correlation analysis was used for character recognition. The system was tested on 340 images. Results obtained shows 97% of the test images were successfully extracted, segmentation rate of 96% and recognition rate of 92.5% was achieved in this work.

The software application designed by Duan, Du, Phuoc, and Hoang (2005, February) was called '*ISeeCarRecognizer*', and was developed for Vietnam country only. Images were taken into the application and filtered using Sobel filters to extract edge of the plate number while segmentation was achieved through horizontal projection. Hidden Markov Model was used for character recognition. The system achieved 98.7% detection rate, 97.6% Segmentation and 97.5% recognition rate.

An interesting review of 100 paper written on AVLPRS gathered around the world was presented in Anagnostopoulos, Anagnostopoulos, Psoroulas, Loumos and Kayafas (2008) analysing the methodology employed in achieving AVLPRS all over the world. It was observed that segmentation is a very important processing in developing a successful AVLPRS. In Mohamed, El-Kader, Rafaat, and Sharaf, (2013), feature extraction from the whole plate number using Linear Discriminant Analysis and Discrete Cosine Transform methods on the license previously extracted by edge detection. The extracted features from the images were then compare to the one in the database using Euclidean distance method. The extraction success rate of 59.7% while recognition of 79% was recorded compared with 97% recognition rate reported in Badr, Abdelwahab, Thabet, and Abdelsadek (2011) using the same plate number from the same country.

Automatic parking and electronic parking fee collection system using VLP recognition approach was presented in Rashid, Aibinu, Rahman, Farahana and Farhana (2012). Algorithm and technology for license plate extraction from acquired VLP images was reported. The proposed approach performs segmentation of characters using simple Thresholding technique. Application of the developed work in access control was also reported in the work.

From the various review work, and to the knowledge of the authors, the development of low cost and computation time AVLPRS applicable to Nigerian type of VLP using template matching approach have not been reported. Also, using the techniques of Digital Image Processing, an automatic classification of Nigerian vehicle has not been reported. Hence the motivation for this work.

Methodology

This system is developed to recognize the VLP alphanumeric and VLP colour; serving as an intelligent input to access control system. In this work, only the detection has been presented. The proposed block diagram for VLP number extraction, colour code recognition and interpretation and license character recognition is as shown in Figure 2.

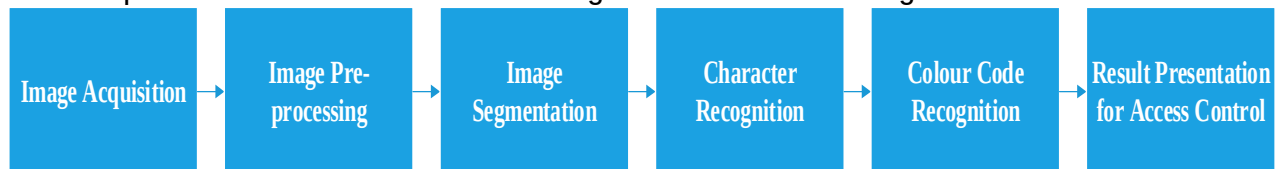


Figure 2: Block diagram for the Development of Nigerian Vehicle License Plate Recognition and Classification System

Image Acquisition

This is the first stage in the proposed system. It involves acquiring front or rear view VLP images where the license plate is usually located. This can be achieved by the use of Digital Camera.

The following factors that affects image quality were taken into consideration while acquiring all required images. The factors are:

- (i) Maximum speed of the vehicle to avoid risk of blurring the picture
- (ii) Illumination aspects (position of camera and light sources)
- (iii) Choice of lenses and
- (iv) The camera specification (resolution and speed)

Image Pre-processing

The pre-processing step is targeted at improving the contrast, reducing noise in the acquired image as well as improving computation speed and cost in the proposed algorithm.

The acquired image is in its true colour (i.e. RGB) where each pixel has a particular colour described by the intensity in the red, green and blue channels. Such an image is a stack of three matrices representing the red, green and blue value; in essence each pixel has three value. To save computation time, the image is converted to a grayscale in which each pixel is a shade of grey, normally ranging from 0 (as black) to 255 (as white). By this range it means each pixel can be represented by eight bit or exactly one byte.

A colour image, I_{colour} , is converted to grey scale, I , using the following transformation:

$$I = \frac{I_{\text{colour}}(R) + I_{\text{colour}}(G) + I_{\text{colour}}(B)}{3} \quad (1)$$

Where $I_{\text{colour}}(R)$, $I_{\text{colour}}(G)$ and $I_{\text{colour}}(B)$ represent the red, green and blue channel respectively in the acquired image.

The grayscaled image is then filtered for noise removal. The result of filtering is then converted to a binary image in the segmentation stage.

Segmentation Process

The segmentation used in this work is called watershed or morphological segmentation. This is achieved by performing morphological dilation and erosion separately on the image using a disk structuring element.

The Dilation of greyscaled image I by a structuring element, B , is denoted as

$$I \oplus B \quad (2)$$

Where

$$I \oplus B = \{z | (\hat{B})_z \cap I \neq \emptyset\} \quad (3)$$

This means that when greyscaled image I is dilated by structuring element B , it results in a set of displacement pixel points, z , such that the reflection of the structuring element B , that is $\hat{B}$, and image A overlap by at least one element of z . Based on this interpretation, (3) can be rewritten as:

$$I \oplus B = \{z | [(\hat{B})_z \cap I] \subseteq I\} \quad (4)$$

Erosion of the gray scaled image I by a structuring element B on the other hand can be defined by:

$$I \ominus B = \{z | (\hat{B})_z \subseteq I\} \quad (5)$$

Equation (5) explains that the erosion of Image A by a structuring element B is a set of displacement pixel points in A , such that B , translated by z , is contained in A . At every point where the elements of B are fully contained in A , the points are retained, otherwise they are discarded. Thus, resulting in shrinking down the image A by B as different from dilation which result in Image A being broader as a result of the structuring element.

When the eroded image is subtracted from a dilated image, the result is a finely and well filtered defined boundary edge better than the conventional edge detection methods. The result is as shown in Figure 3.

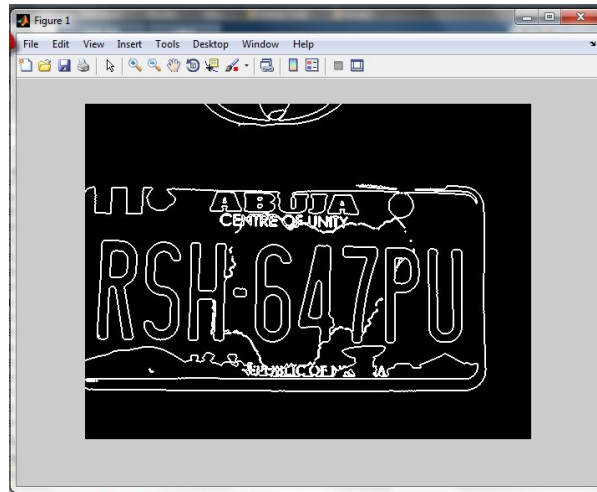


Figure 3: Result of the morphological process

The result of the morphological process is then filled with holes so as to occupy all the missing pixels within the image and isolate each character on the license plate number. The final character extraction was implemented using *regionprop* function of MATLAB and the result is shown in Figure 4:

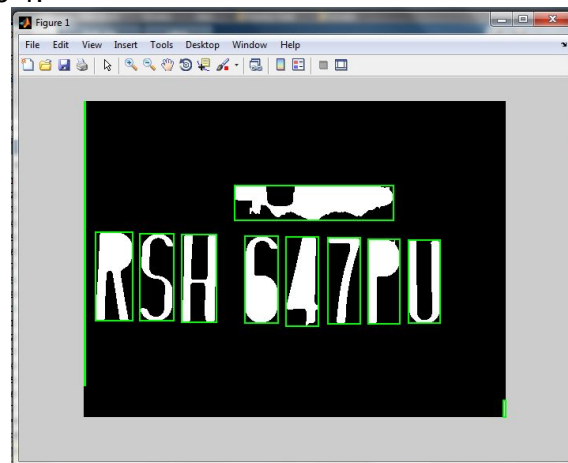


Figure 4: Segmented License Plate Number

License Character Recognition

The character recognition was achieved using a supervised classification. A template of character of standard size containing letters A to Z and numbers 0 to 9 was created which was compared with each segmented character to be recognised.

The matching was done using autocorrelation which matches the segmented image directly with one in the template. Autocorrelation determines the closeness between two images allocating coefficient value which ranges from -1 to +1, where the value +1 means that the two images are highly correlated and the value -1 means that the images are exactly opposite to each other. The correlation coefficient r , is given by;

$$r = \frac{\sum_m \sum_n (A_{mn} - \bar{A})(B_{mn} - \bar{B})}{\sqrt{\sum_m \sum_n (A_{mn} - \bar{A})^2 \sum_m \sum_n (B_{mn} - \bar{B})^2}} \quad (6)$$

Where $\bar{A}$ = mean of image input image to be matched in the template, denoted as A and $\bar{B}$ = mean of image in the template, denoted as B. This was implemented using autocorrelation function of MATLAB, and the character with highest matched correlation value is the character of the segmented character.

The letter O and number 0; letter B and number 8; as well as letter Z and number 2 of the Nigerian license plate number system is always alike, which is the usual error of the system. However, since the license number follows a predictable arrangement of number and alphabet, the system was improved by creating a separate template for letters and number, by this letter O cannot be mistaken as 0, as well as the remaining letters and numbers.

Colour Code Recognition

The colour code recognition is achieved by simply mapping the segmented image back to the original image since the segmented image contained region of interest (the license character region) only, however, it does not contain the colour information of the license plate because it is a binary image. By mapping it back to the original RGB image, we are locating the pixels that are found in the segmented image in the original image, which will enable us to know the colour information of each pixels of the VLP characters.

After this, the average of the individual RGB channels was computed and compared with each other. If the red channel has the highest value, this means the license plate colour is red and therefore, it is a commercial vehicle, if green channel is the highest, the vehicle is government owned vehicle and if blue channel is the highest, then the vehicle is privately owned vehicle. The pseudocode for the implementation is as shown in Plate 1.

```

Map the segmented Image on to the original Image
For every pixel of the segmented Image on the original Image do:
    Extract the RGB channels
    Compute the average of each channels
    The highest with the highest value is the colour code for the Plate number
  
```

Plate 1: Pseudocode for the Colour code recognition

Results

The system was implemented using MATLAB 2013a and tested with 130 images of license plate numbers not only does the system work well for both the 'old' Nigerian License Plate System as well as the 'new' License Plate System but the computation was done speedily within an average computation time of two seconds. The acquired image was taken with conditions stated in section A and the results obtained is as shown in Table 1.

Result of the system

Total Images	Successfully Segmented License Plates	Success Rates (%)	Successfully Colour Code Recognised
130	128	98.5	130

The result is written in a notepad to serve as input to other application such as web applications like Java, MySQL, PHP etc. or microcontroller system. The result presented in a notepad document is as shown in Figure 5.

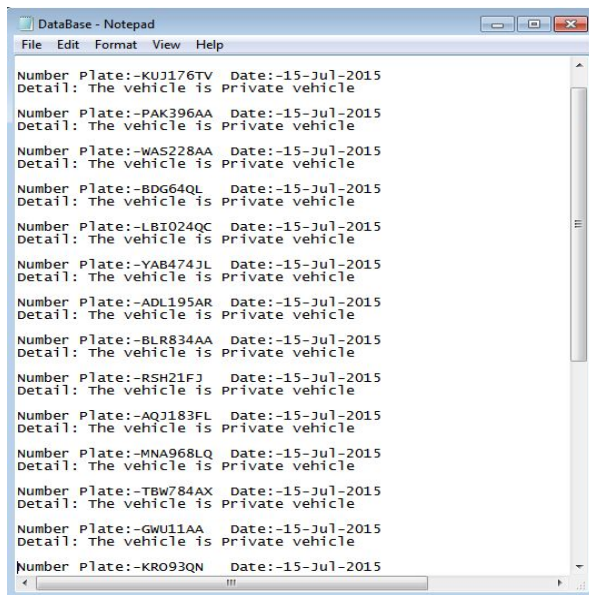


Figure 5: Database of the results

Conclusion

AVLPRCS has been implemented using the technique of Digital Image Processing. The proposed system is designed for a real-time application. The system is very fast with an average computation time of two seconds, the extraction accuracy of 80% and 100% colour recognition. In the future, character recognition will be implemented using an unsupervised classification algorithm.

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A STUDY OF THE EFFECT OF DEGRADATION ON INDUSTRIAL GAS TURBINE PERFORMANCE

ABDULKARIM NASIR¹, SALIHU A. USMAN², ABUBAKAR MOHAMMED¹,
SHUAIBU N. MUHAMMED¹, & BORI IGE¹

¹Mechanical Engineering Department, Federal University of Technology, Minna, Nigeria

²Works and Maintenance Services, Federal University of Technology, Minna, Nigeria

E-mail: a.nasir@futminna.edu.ng Phone No: +234-803-318-3561

Abstract

Component degradation is a very common problem associated with operating industrial gas turbines. The major components so affected by this phenomenon are compressor, combustor and turbine blades. This paper studied the effect of degradation on gas turbine performance. The study involved the analyses of operating parameters effects for Siemens gas turbine engines model SGT5 – 2000E coded GT11 and GT21 in the power stations at Geregu power stations. The parameters considered were ambient temperature, exhaust temperature, combustion chamber pressure and turbine entry temperature, GT11 is degraded while GT21 is newly installed engine both in the same location at Geregu I and II power stations in Ajaokuta, Kogi State in the North central part of Nigeria. Simulations were carried out using Gas turb 11 simulation software, results of engine performance parameters were compared and it was revealed that due to component degradation, the turbine entry temperature (TET) increased to 1049.67°C, the fuel flow increased by 8.49% and power fell by 7.14%. Consequently, the cost of power loss is one hundred and eighty-seven million, one hundred and eleven thousand, seven hundred and fifty-three naira ninety-two kobo (₦187,111,753.92k) over a period of one year for the degraded gas turbine.

Keywords: Gas Turbine Degradation, Turbine Entry Temperature and Combustion Chamber Pressure

Introduction

The history of the gas turbine can be traced back to 1791 when John Barbar conceived the ideas for gas and steam turbines. In 1903, a Norwegian, Aegidius Elling, built the first successful gas turbine using a rotary/dynamic compressor and turbines, and is credited with building the first gas turbine that produced excess power of about 8kW. Frank Whittle in England also patented a jet turbine similar to Elling's gas turbine in 1930. The engine consisted of a centrifugal compressor and an axial turbine and was subsequently tested in April 1937 according to (Tony, 2005; Razak, 2007). Today, gas turbines are used widely in various industries to produce mechanical power and are employed to drive various loads such as generators, pumps, process compressors and propeller (Nasir et al., 2013; Zhihong, 2007). The performance and satisfactory operation of gas turbines are of paramount importance to the profitability of industries, varying from civil and military aviation to power generation, and also oil and gas exploration and production. However, as a result of long operation period, all turbo machinery experience loss in performance (Wolfgang, 2013; Zakwan et al., 2013; Rehab et al., 2008). Degradation is a decline to a lower condition in performance, quality or level as a result of aging, operating and environmental conditions (Bacos et al., 2011).

Gas turbine degradation is classified as either recoverable loss or non-recoverable loss. Compressor fouling is usually classified as recoverable loss and can be corrected by water washing or by mechanically washing the compressor blades and vanes after operation (Ezanwa, 2011). Non-recoverable losses are mainly due to increase in clearance of turbine, compressor and changes in surface finishing and airfoil contour, since this loss is as a result

of reduction in components efficiencies. It is hardly recovered by means of external maintenance or compressor cleaning and operation procedures, except by means of replacement of the affected parts at recommended inspection periods. The economic effect of degradation in a gas turbine power can be severe. All gas turbines deteriorate in performance during operation, leading to reduction in capacity and thermal efficiency (Jonathan, 2002). Loss of capacity results in lost production, affecting revenue. Loss in thermal efficiency increases fuel consumption and therefore leads to higher fuel costs. Both of these factors reduce profit. However, degradation in a gas turbine can only be minimized and cannot be eliminated completely (Salihu et al., 2015). Figure 1 shows a degraded gas turbine blade.



Plate 1: Degraded turbine blade tips (Bacos, 2011)

Materials and Methods

Field Stations and Materials

The major materials used in this research work are the newly installed and old Siemen gas turbines (SGT 5 – 2000E) located at Geregu, in Ajaokuta Local Government Area of Kogi State, Nigeria. The gas turbines were installed in 2005 and 2013 respectively. Simulation software called Gas Turb 11 was also used to generate engine parameters using ISO and design conditions i.e standard atmospheric pressure, temperature and design pressure and temperature. This was done to provide bases for comparison.

This Siemens gas turbine is used mainly for power generation and designed to the capacities of 145MW and 160 MW at base and peak loads respectively. Geregu power stations I (GT 11) has been in operation since 2005 and Geregu power stations II (GT 21) started operating in 2013.

Gas Turbine Performance Data

Performance data of the gas turbine units under investigation are ambient temperature, turbine entry temperature (TET), exhaust temperature (EXT), combustor chamber pressure in bars (CCP) and power output in megawatts (MW). Degraded physical components were also considered. Data collected from Siemens gas turbine SGT5 – 2000E coded GT11 and GT21 in the power stations (Degraded and Newly Installed) engines were analyzed by comparison. Gas Turb 11 was used to produce Design point simulation for the engine. Table 1 shows the specification of SGT 5–2000E gas turbine. The data were collected from the period of May to October, 2014.

Table 1: Specifications of ISO and Siemens Gas Turbine SGT 5–2000E for performance

Parameters	SGT 5 – 2000E	ISO performance
Ambient temperature (°C)	15	15
Turbine Entry temperature (°C)	1050	1013
Pressure ratio (bar)	12.0	12.0
Relative humidity (%)	70	70

Results and Discussion

Influence of Ambient Temperature on Power Output

The variation of ambient temperature and load from day to day are shown in Figure 2. The power output at the terminals decreases from 155.8 MW to 140 MW as the ambient temperature increases from 18°C to 32°C respectively as shown in Figure 3. The range of ambient temperature in Geregu power station varied typically between 29°C to 34°C in June. In gas turbines, generally, temperature variation leads to change in the maximum engine power output as shown in Figure 3. Due to component degradation on GT 11 and the changes in the ambient temperature, it was difficult to achieve the base load requirement of 145MW, unless the parameters were varied. However, all the engine parameters such as mass flow, efficiency and TET fluctuates as a result of changing ambient temperature.

The new and old engines were meant to operate on base load at an output of 145MW. However, it could be observed that as a result of component degradation, the degraded engine (GT11) could not achieve the expected output at base load, while the newly installed engine (GT21) could achieve above the expected Megawatts if the operating conditions are favourable as shown in Figure 4.

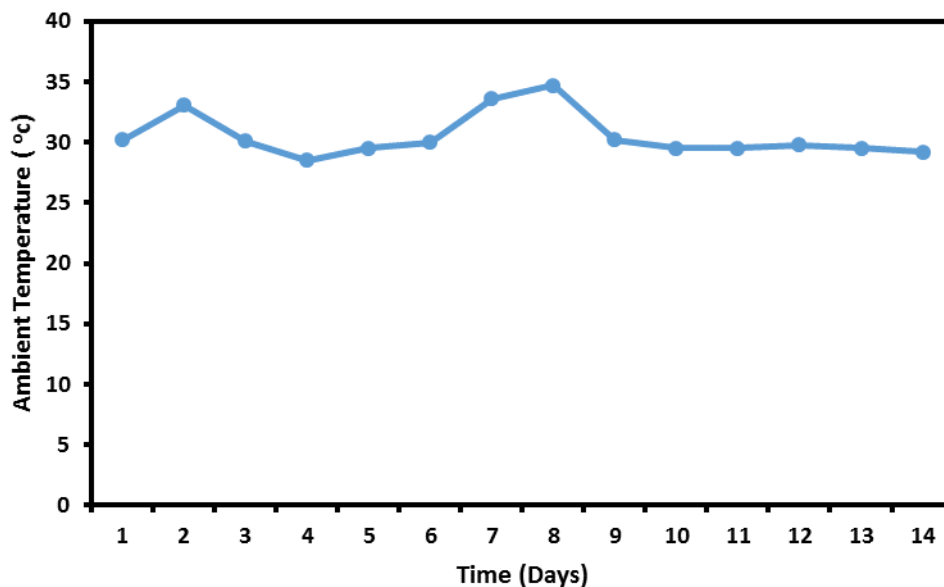


Figure 2: Variation of ambient temperatures

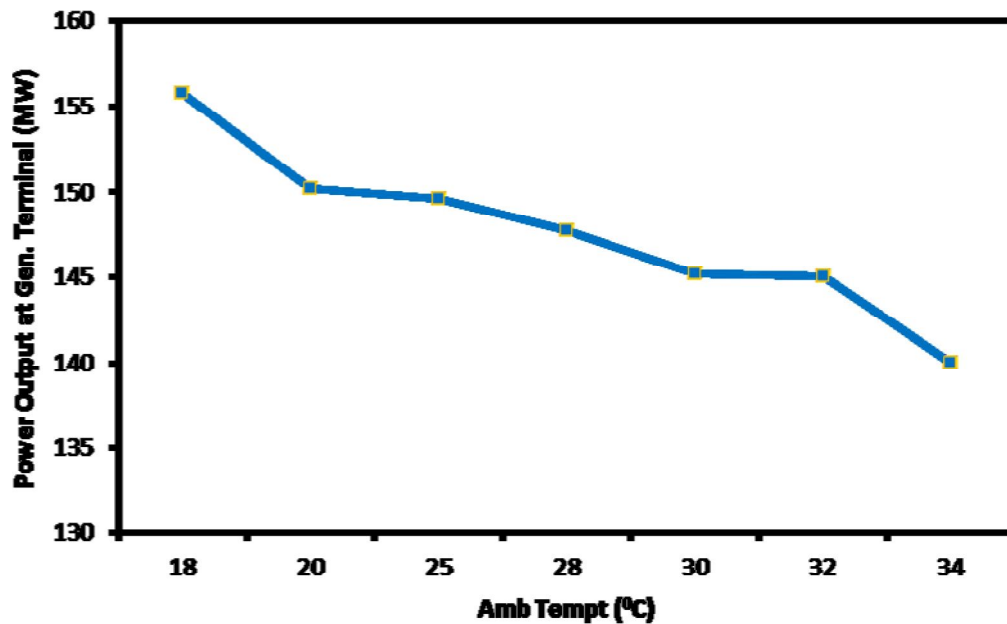


Figure 3: Effect of ambient temperature on engine power output

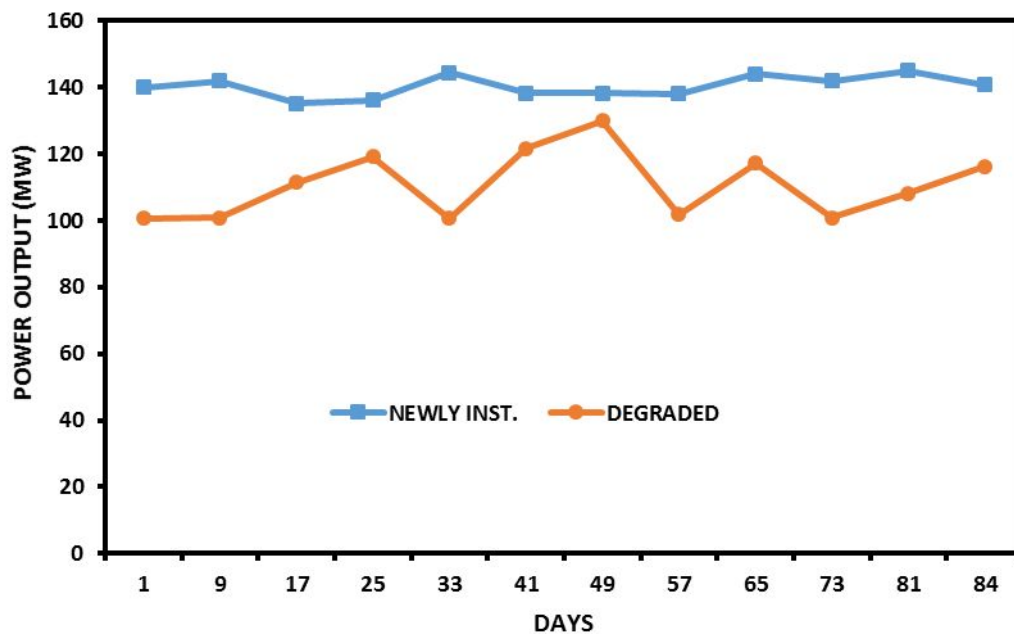


Figure 4: Power output performance of new and old engines

Turbine entry temperature (TET) deviations analysis

Figure 5 shows that on the 29th day of the study, the degraded engine shows a lower TET, with the progress of time especially at day 78; however, this deviation was observed as a result of increase in TET of the degraded engine due to component degradation. Eventually, the degraded engine TET becomes higher than the newly installed engine TET. The results, however, shows that the degraded engine TET at day 29 was 1328.2 K. The newly installed engine TET was 1317.52 K and deviation between them was 10.68 K, also on day 78, the degraded engine TET reached 1333.35 K and the newly installed engine TET reached 1311 K. Normally the higher the TET the higher the power output but due to degradation of GT11 increase in TET does not result in increase in power output.

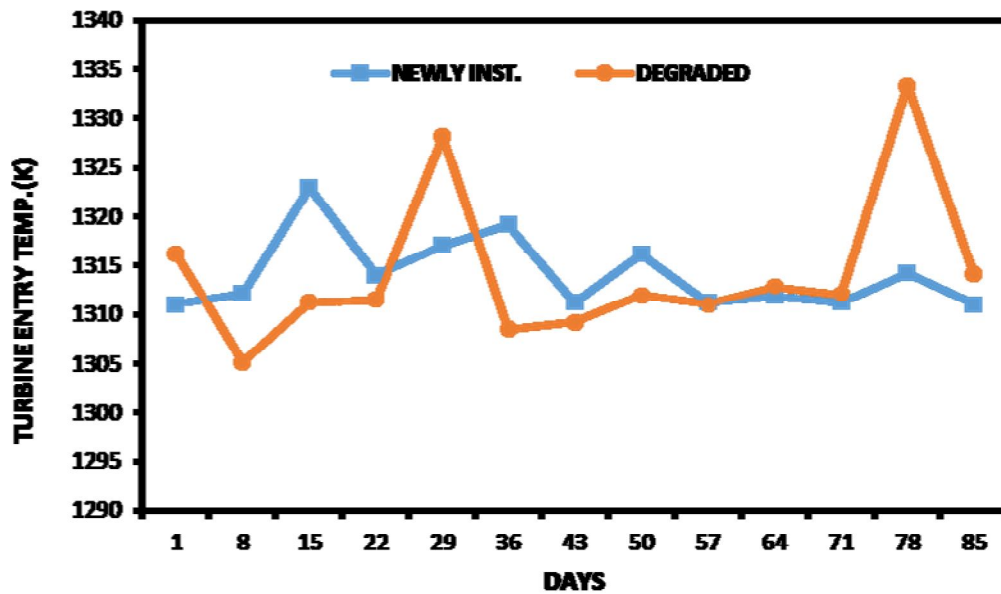


Figure 5: Variation in turbine entry temperature deviation

Combustion Chamber Pressure Deviation Analysis

The combustion chamber pressures (CCP), which were obtained from the engines is shown in Figure 6 and compared for both SGT 21 and SGT 11. From the graph, at day 8 degraded engines CCP indicates relatively low value of 1015Kpa, in day 84 the degraded engine CCP reaches 1067Kpa while CCP for newly installed SGT21 was maintained at 1030 Kpa. The deviation of 37Kpa that occurred in the CCP for SGT11 was due to component degradation. The increasing of CCP as result of increasing turbine entry temperature verified that, the engine performance has degraded with time progress.

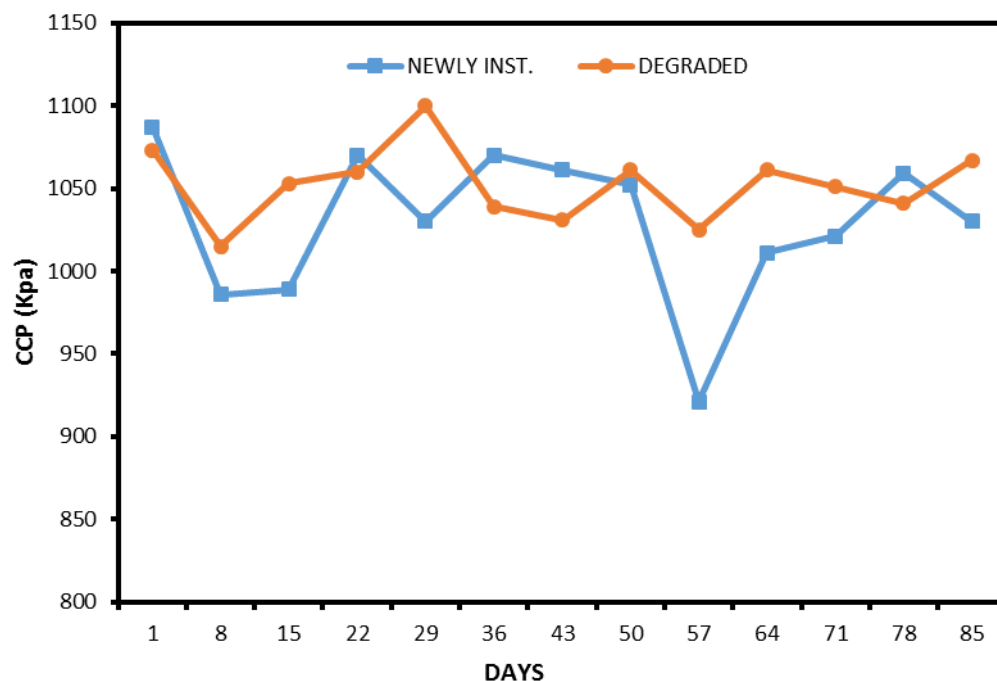


Figure 6: Variation in combustion chamber pressures

Economic Impact of Degradation on Engine Operating Cost

As part of the study of effect of degradation on gas turbine performance, the outcome of degradation has to be discussed from economic point of view. However, to achieve this, the cost penalty has to be analyzed in terms of power loss, increase fuel flow and reduced blade creep life. From the previous section, it was shown that the power reduced from 139.99MW to 130MW as a result of increased TET at 1311K of GT11 engine due to degradation, it was shown that power reduced by 9.99MW. In the remaining period of time, the engine is expected to produce the same power output until a major overhaul. Therefore, the power loss cost penalty will be calculated, in order to determine the effect of degradation on engine operating cost from the result. Assuming the engine on same load operation for 78 days (1872 hours), a power output of 139.99MW, cost of electricity of N5/KWh and a power loss of 7.14% for same period, the power loss cost will be ₦93, 555,876.96k.

Conclusion

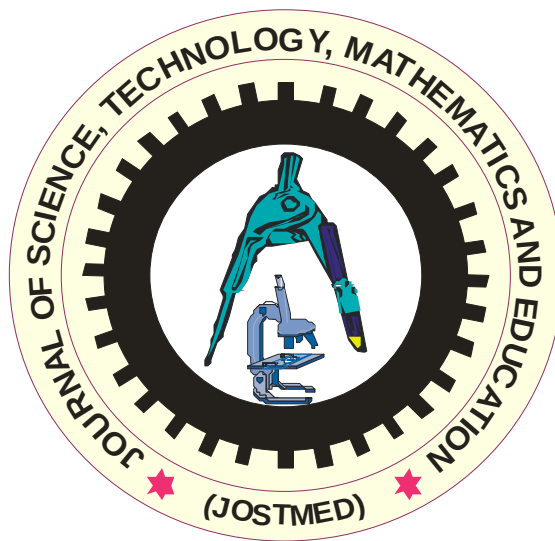
In this research, effects of degradation on gas turbine performance have been studied. The major components affected by degradation are compressors, combustor and turbine blades but the most common form of performance degradation is compressor fouling and this is as a result of ingestion of dirt and dust from the operation environment. Component degradation resulted to reduced compressor capacity, efficiency, turbine creep life and combustion chamber pressure drop. From the findings of this study, the operating parameters especially, exhaust temperature and turbine entry temperature TET of GT11 increased to 555°C and 1049.67°C compared with 540°C and 1038°C of GT21 for a given output of 130.0MW and 139.99MW respectively. If GT11 engine is not overhauled, in a year the company stands to lose the sum of one hundred and eighty-seven million, one hundred and eleven thousand, seven hundred and fifty-three naira ninety-two kobo (₦187,111,753.92k) only, to component degradation.

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ARTICLES AND RESEARCH REPORTS ON MATHEMATICS

ON PERFORMANCE OF SHRINKAGE METHODS – A MONTE CARLO STUDY

GAFAR MATANMI OYEYEMI¹, EYITAYO OLUWOLE OGUNJOBI²,
& ADEYINKA IDOWU FOLORUNSHO³

¹Department of Statistics, University of Ilorin.

²Department of Mathematics and Statistics,

The Polytechnic Ibadan, Adeseun Ogundoyin Campus, Eruwa.

³Department of Mathematics and Statistics, Osun State Polytechnic Iree, Nigeria

E-mail: gmoeyemi@gmail.com

Abstract

Multicollinearity has been a serious problem in regression analysis, Ordinary Least Squares (OLS) regression may result in high variability in the estimates of the regression coefficients in the presence of multicollinearity. Least Absolute Shrinkage and Selection Operator (LASSO) methods is a well established method that reduces the variability of the estimates by shrinking the coefficients and at the same time produces interpretable models by shrinking some coefficients to exactly zero. We present the performance of LASSO -type estimators in the presence of multicollinearity using Monte Carlo approach. The performance of LASSO, Adaptive LASSO, Elastic Net, Fused LASSO and Ridge Regression (RR) in the presence of multicollinearity in simulated data sets are compared using Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) criteria. A Monte Carlo experiment of 1000 trials was carried out at different sample sizes n (50, 100 and 150) with different levels of multicollinearity among the exogenous variables ($\rho = 0.3, 0.6$, and 0.9). The overall performance of Lasso appears to be the best but Elastic net tends to be more accurate when the sample size is large.

Keywords Multicollinearity, Elastic net, Ridge, Adaptive Lasso, Fused Lasso.

Introduction

Multicollinearity can cause serious problem in estimation and prediction when present in a set of predictors. Traditional statistical estimation procedures such as Ordinary Least Squares (OLS) tend to perform poorly, have high prediction variance, and may be difficult to interpret (Brown, 1993) i.e. because of its large variance's and covariance's which means the estimates of the parameters tend to be less precise and lead to wrong inferences (Muhammad, Maria & Muhammad, 2013). In such situations it is often beneficial to use shrinkage i.e. shrink the estimator towards zero vector, which in effect involves introducing some bias so as to decrease the prediction variance, with the net result of reducing the mean squared error of prediction, they are nothing more than penalized estimators, due to estimation there is objective functions with the addition of a penalty which is based on the parameter. Various assumptions have been made in the literature where penalty of ℓ_1 - norm, ℓ_2 - norm or both ℓ_1 and ℓ_2 which stand as tuning parameters (λ) were used to influence the parameter estimates in order to minimize the effect of the collinearity. Shrinkage methods are popular among the researchers for their theoretical properties e.g. parameter estimation.

Over the years, the LASSO - type methods have become popular methods for parameter estimation and variable selection due to their property of shrinking some of the model coefficients to exactly zero see (Tibshirani, 1996), (Xun & Liangjun, 2013). Tibshirani, (1996) proposed a new shrinkage method Least Absolute Shrinkage and Selection Operator (LASSO) with tuning parameter $\lambda \geq 0$ which is a penalized method, (Knight, & Fu, 2000) for the first systematic study of the asymptotic properties of Lasso – type estimators (Xun & Liangjun, 2013). The LASSO shrinks some coefficients while setting others to exactly zero,

and thus theoretical properties suggest that the LASSO potentially enjoys the good features of both subset selection and ridge regression. Frank and Friedman (1993) had earlier proposed Ridge regression which minimizes the Residual Sum of Squares subject to constraint with $\gamma \geq 0$.

Frank and Friedman (1993) argued that the optimal choice of parameter λ yields reasonable predictors because it controls the degree of precision for true coefficient of β to aligned with original variable axis direction in the predictor space. Fan and Li (2001) Introduced the Smoothing Clipped Absolute Deviation (SCAD) which penalized Least Square estimate to reduce bias and satisfy certain conditions to yield continuous solutions. Hoerl and Kennard (1970a) was first to propose Ridge Regression which minimizes the Residual Sum of Squares subject to constraint with $\gamma = 2$, thus regarded as ℓ_2 - norm. Efron, Hastie, Johnstone and Tibshirani (2004) developed Least Angle Regression Selection (LARS) for a model selection algorithm (Wang & Leng, 2008), Wei and Huang (2010) study the properties of adaptive group Lasso. In 2006, Yuan and Lin, (2006) proposed a Generalization of LASSO and other shrinkage methods include Dantzig Selector with Sequential Optimization, (DASSO) (James, Radchenko, & Lv, 2009), Elastic Net (Zou & Hastie, 2005), Variable Inclusion and Selection Algorithm, (VISA) (Radchenko & James, 2008), Adaptive LASSO (Zou, 2006) among others.

LASSO-type estimators are the techniques that are often suggested to handle the problem of multicollinearity in regression model. More often than none, Bayesian simulation with secondary data has been used. When the ordinary least squares are adopted there is tendency to have poor inferences, but with LASSO-type estimators which have recently been adopted may still come with its shortcoming by shrinking important parameters, we intend to examine how these shrink parameters may be affected asymptotically. However, the performances of other estimators have not been exhaustively compared in the presence of all these problems. Moreover, the question of which estimator is robust in the presence of a LASSO-type estimators of these problems have not been fully addressed. This is the focus of this research work.

Material and method

Consider a simple least squares regression model.

$$y_i = x_i' \beta + e_i, \quad (1)$$

where x_i are exogenous, e_i are i.i.d. $i = 1, \dots, n$, random variable with mean zero and finite variance σ^2 . β is $p \times 1$ vector. Suppose β takes the largest possible dimension, in other words the number of regressors may be at most p , but the true p is somewhere between 1 and p . The issue here is to come up with the true model and estimate it at the same time.

The least squares estimate without model selection is

$$\hat{\beta}_{LS} = (\sum_{i=1}^n x_i x_i')^{-1} (\sum_{i=1}^n x_i y_i) .$$

with $p \times 1$ estimates.

Shrinkage estimators are not that easy to calculate as ordinary least squares. Thus the objective functions for the shrinkage estimators:

$$\hat{\beta} = \operatorname{argmin}_{\beta} [\sum_{i=1}^n (y_i - x_i' \beta)^2 + \lambda_n \sum_{j=1}^p |\beta_j|^{\gamma}] \quad (2)$$

Where λ_n is a tuning parameter (for penalization), it is a positive sequence, and $\lambda > 0$. λ_n will not be estimated, and γ will be specified by us. The objective function consists of 2 parts, the first one is the LS objective function part, and then the penalty factor.

Thus, taking the penalty part only

$$\lambda_n \sum_{j=1}^p |\beta_j|^r$$

If λ_n is going to infinity or to a constant, the values of β that minimizes that part should be the case that $\beta = \mathbf{0}_p$. We get all zeros if we minimize only the penalty part. So the penalty part will shrink the coefficients to zero. This is the function of the penalty.

Ridge Regression (RR)

Ridge Regression (RR) by (Hoerl & Kennard, 1970b) is ideal if there are many predictors, all with non-zero coefficients and drawn from a normal distribution (Friedman, Hastie & Tibshirani, 2010). In particular, it performs well with many predictors each having small effect and prevents coefficients of linear regression models with many correlated variables from being poorly determined and exhibiting high variance. RR shrinks the coefficients of correlated predictors equally towards zero. For example, given k identical predictors, each would get identical coefficients equal to $\frac{1}{k}$ th the size that any one predictor would get if fit singly (Friedman, Hastie & Tibshirani, 2010). Ridge regression does not force coefficients to vanish and hence cannot select a model with only the most relevant and predictive subset of predictors. The ridge regression estimator solves the regression problem in [17] using ℓ_2 penalized least squares:

$$\hat{\beta}(\text{ridge}) = \underset{\beta}{\operatorname{argmin}} \|y - X\beta\|_2^2 + \lambda \|\beta\|_2^2 \quad (3)$$

Where $\|y - X\beta\|_2^2 = \sum_{i=1}^n (y_i - x_i^T \beta)^2$ is the ℓ_2 -norm (quadratic) loss function (i.e. residual sum of squares), x_i^T is the i -th row of X , $\|\beta\|_2^2 = \sum_{j=1}^p \beta_j^2$ is the ℓ_2 -norm penalty on β , and $\lambda \geq 0$ is the tuning parameter (penalty, regularization, or complexity) which regulates the strength of the penalty (linear shrinkage) by determining the relative importance of the data-dependent empirical error and the penalty term. The larger the value of λ , the greater is the amount of shrinkage. As the value of λ is dependent on the data it can be determined using data-driven methods, such as cross-validation. The intercept is assumed to be zero in equation (3) due to mean centering of the phenotypes.

Least Absolute Shrinkage and Selection Operator (LASSO)

LASSO regression methods are widely used in domains with massive datasets, such as genomics, where efficient and fast algorithms are essential (Friedman, Hastie & Tibshirani, 2010). The LASSO is, however, not robust to high correlations among predictors and will arbitrarily choose one and ignore the others and break down when all predictors are identical (Friedman, Hastie & Tibshirani, 2010). The LASSO penalty expects many coefficients to be close to zero, and only a small subset to be larger (and nonzero).

The LASSO estimator uses the ℓ_1 penalized least squares criterion to obtain a sparse solution to the following optimization problem:

$$\hat{\beta}(\text{lasso}) = \underset{\beta}{\operatorname{argmin}} \|y - X\beta\|_2^2 + \lambda \|\beta\|_1. \quad (4)$$

Where $\|\beta\|_1 = \sum_{j=1}^p |\beta_j|$ is the ℓ_1 -norm penalty on β , which induces sparsity in the solution, and $\lambda \geq 0$ is a tuning parameter.

The ℓ_1 penalty enables the LASSO to simultaneously regularize the least squares fit and shrinks some components of $\hat{\beta}(\text{lasso})$ to zero for some suitably chosen λ . The cyclical coordinate descent algorithm, (Friedman, Hastie & Tibshirani, 2010), efficiently computes the entire lasso solution paths for λ for the lasso estimator and is faster than the well-known

LARS algorithm (Efron, Hastie, Johnstone & Tibshirani, 2004). These properties make the lasso an appealing and highly popular variable selection method.

Fused LASSO

To compensate the ordering limitations of the LASSO, (Tibshirani, Saunders, Rosset, Zhu & Knight, 2005) introduced the fused LASSO. The fused LASSO penalizes the ℓ_1 -norm of both the coefficients and their differences:

$$\hat{\beta}_F = \arg \min_{\beta} (\bar{y} - X\beta)'(\bar{y} - X\beta) + \lambda_1 \sum_{j=1}^p |\beta_j| + \lambda_2 \sum_{j=1}^p |\beta_j - \beta_{j-1}| \quad (5)$$

where λ_1 and λ_2 are tuning parameters. They provided the theoretical asymptotic limiting distribution and a degrees of freedom estimator.

Elastic Net

Zou and Hastie (2005) proposed the elastic net, a new regularization of the LASSO, for the unknown group of variables and for the multicollinear predictors. The elastic net method overcomes the limitations of the LASSO method which uses a penalty function based on

$$\|\beta\|_1 = \sum_{j=1}^p |\beta_j|$$

Use of this penalty function has several limitations. For instance, in the "large p , small n " case the LASSO selects at most n variables before it saturates. Also if there is a group of highly correlated variables, then the LASSO tends to select one variable from a group and ignore the others. To overcome these limitations, the elastic net adds a quadratic part to the penalty ($\|\beta\|^2$), which when used alone is ridge regression (known also as Tikhonov regularization). The elastic net estimator can be expressed as

$$\hat{\beta}_{EN} = \arg \min_{\beta} (\bar{y} - X\beta)'(\bar{y} - X\beta) + \lambda_1 \sum_{j=1}^p |\beta_j| + \lambda_2 \sum_{j=1}^p |\beta_j|^2 \quad (7)$$

where λ_1 and λ_2 are tuning parameters. As a result, the elastic net method includes the LASSO and ridge regression: in other words, each of them is a special case where $\lambda_1 = \lambda, \lambda_2 = 0$ or $\lambda_1 = 0, \lambda_2 = \lambda$.

Adaptive LASSO

Fan and Li (2001) showed that the LASSO can perform automatic variable selection but it produces biased estimates for the large coefficients. Zou (2006) introduced the adaptive LASSO estimator as

$$\hat{\beta}_{AL} = \arg \min_{\beta} (\bar{y} - X\beta)'(\bar{y} - X\beta) + \lambda \sum_{j=1}^p \hat{\omega}_j |\beta_j| \quad (8)$$

with the weight vector $\hat{\omega} = 1/|\hat{\beta}|$ where $\hat{\beta}$ is a $\sqrt{n}$ consistent estimator such as $\hat{\beta}(\text{OLS})$ and

$\gamma > 0$. where $\hat{\omega}_j (j = 1, \dots, p)$ are the adaptive data-driven weights, which can be estimated by,

$\hat{\omega}_j = (|\hat{\beta}_j^{\text{ini}}|)^{-\gamma}$, where λ is a positive constant and $\hat{\beta}^{\text{ini}}$ is an initial consistent estimator of β obtained through least squares or ridge regression if multicollinearity is important (Zou, 2006). The optimal value of $\lambda > 0$ and γ can be simultaneously selected from a grid of values, with values of λ selected from $\{0.5, 1, 2\}$, using two-dimensional cross-validation (Zou, 2006). The weights allow the adaptive LASSO to apply different amounts of shrinkage to different coefficients and hence to more severely penalize coefficients with small values. The flexibility introduced by weighting each coefficient differently corrects for the undesirable tendency of the lasso to shrink large coefficients too much yet insufficiently

shrink small coefficients by applying the same penalty to every regression coefficient (Zou, 2006).

Monte Carlo Study

In this section we carried out simulation to examine the finite sample performance for LASSO, Adaptive LASSO, Elastic LASSO, Fused LASSO and Ridge Regression using AIC and BIC.

We infected the data with multicollinearity by generating sets of variables of sample sizes n ($n = 50, 100$ and 150) using normal distribution respectively. The level of multicollinearity among the variables are small ($r = 0.1 - 0.3$), mild ($r = 0.4 - 0.6$) and serious ($r = 0.7 - 0.9$). Each simulation was repeated 1000 times for consistency using R package.

Table 1: Mean AIC and BIC of the fitted model using the five methods

N	R	Ridge Regression		Adaptive		Elastic Net		Fused		LASSO	
		AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
50	0.1 –	-65.62	-65.39	-65.57	-65.35	-65.62	-65.39	-	-	-65.62	-65.39
	0.3	-65.68	-65.45	-	-	-65.63	-65.40	65.64	65.41	-65.56	-65.34
	0.4 –	-65.60	-65.37	65.79	65.56	-65.64	-65.41	-65.63	-65.41	-65.56	65.33
	0.6			-65.69	-65.36			-	-		
	0.7 –							65.79	65.56		
	0.9										
100	0.1 –	-	-	-67.27	-67.12	-67.20	-67.04	-67.35	-67.20	-66.82	-66.67
	0.3	67.48	67.32	-64.64	-64.49	-64.65	-64.49	-	-	-64.69	-64.53
	0.4 –	-64.58	-64.42	-	-	-67.39	-67.23	64.87	64.72	-68.03	-67.87
	0.6	-67.44	-67.29	69.61	67.46			-68.14	-67.99		
	0.7 –										
	0.9										
150	0.1 –	-65.22	-65.09	-	-	-65.12	-64.99	-65.15	-65.03	-65.19	-65.07
	0.3	-65.79	-65.67	65.30	65.18	-65.77	-65.65	-	-	-65.75	-65.62
	0.4 –	-65.50	-65.38	-65.64	-65.52	-65.48	-65.36	65.94	65.82	-65.66	-65.54
	0.6			-	-			-65.58	-65.46		
	0.7 –			65.73	65.61						
	0.9										

Table 2: Summary of the result

Sample size (n)	r	Best
50	Low	Lasso
100		Adaptive Lasso
150		Elastic Net
50	Medium	Elastic Net
100		Lasso
150		Lasso
50	High	Lasso
100		Lasso
150		Elastic Net

Table 1 shows both the AIC and BIC of the fitted model using the five methods while Table 2 presents the summary of Table 1. It is of interest to note that both criteria agreed in selecting the best method in all the cases considered. It can be observed that LASSO performed better at all the three levels of multicollinearity (small sample with low multicollinearity, medium sample size with medium multicollinearity and at small and medium sample sizes with high multicollinearity).

Elastic Net competed favourably with LASSO because it was also better at all levels of multicollinearity (high sample size with low multicollinearity, small sample size with medium multicollinearity and large sample size with high multicollinearity). Adaptive LASSO performed best only with medium sample size at low multicollinearity. Generally, it can be seen that LASSO performs best when the correlation is high but Elastic net tend to be more accurate when the sample size n is large. LASSO appears to have best overall performance among all the five methods. Therefore, the LASSO method is more suitable due to its significant advantage over others.

Conclusion

We have considered Lasso type estimators in the presence of multicollinearity in linear regression model. The Ordinary Least Squares (OLS) method brings about poor parameters estimate and produce wrong inferences. Lasso type estimators are more stable and provide performances better than OLS approach of parameters estimation in the case of correlated predictors and produce consistent solution. Elastic net performed better for large sample size especially for high value of multicollinearity. While the LASSO is better for medium and high level of multicollinearity. Performances of both Fused and Ridge regression were poor compared with the other methods considered.

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ANALYSIS OF STOCK MARKET EXCHANGE WITH PARTICULAR INSTANCE FROM NIGERIA STOCK IN MATLAB AND R

VICTOR O. WAZIRI¹, PATIENCE WOYE ADAMA² & AUDU ISAH³

Department of Cyber Security Science,
School of Information and Communication Technology,
Federal University of Technology, Minna

²Department of Computer Science and Mathematics, FPI, Bida

³Department of Statistics, Federal University of Technology, Minna, Nigeria

E-mail: victor.waziru@futminna.edu.ng, Yapacie123@gmail.com,
aisah@futminna.edu.ng

Phone No: +234-806-351-8931

Abstract

This paper presents an analysis of arbitrary dataset for Nigeria Stock Exchange Market in Matlab and R software. The simulated outputs from the dataset are applied to compute and predict the future trends of the Nigerian Stock Exchange Market. The analytical processes of the dataset are achieved in phases. First, the dataset is preprocessed, then learn and trained using Neural Network (NN) for Matlab and Multiple Linear Regression (MLR) for R. The simulation of the model is categorized into subsystems that are based on Artificial Neural Network Multilayer Perceptrons (ANN MLP). The ANN MLP that is applied in the simulation consists of three layers; one input layer, three Hidden Layers and the Output Layers. Their Mean Squared Errors and Coefficient of Determinants were used to compare and discuss results through graphical and simulated figures. The graphical representations and the mathematical models of Matlab and R were derived and compared. It is discovered that the ANN algorithm in Matlab gives more efficient and acceptable outputs forecasts than MLR in R.

Keywords: Nigeria Stock Exchange, Analysis, Neural Network, Multiple Linear Regression, Pre-processed

Introduction

Stock-exchange market is a public entity for the trading of company stock (shares) or equity and derivatives at an agreed price by the brokers. Stock exchange market prediction is a very important aspect of the economy that requires consideration due to the re-occurring challenges in the stock market. All the investors need to know when to make a buying or selling decision in the expected direction of the stock. Studies have also shown that predicting direction as compared to value can generate higher profit Kimoto, *et al.* (1990). The stock exchange markets have become an integral part of the global economy. Our personal and corporate financial lives and the economic health of a country are influenced by any fluctuation in the market.

The Nigerian Stock Exchange (NSE) which was established in 1960 has grown rapidly and would continue to evolve to meet the needs of its valued customers. For example, the Nigerian Stock Exchange (NSE) as of December 31, 2012 has about 198 listed companies with a total market capitalization of about ₦8.9 trillion (\$57 billion) (www.nse.com.ng/.../PRESCO%20DEC%202012%20AUDITED.pdf). This makes NSE *champion* the acceleration of Africa's economic development and to become "the Gateway to African Markets". The prediction of the movement of stocks helps the investors to know when and where to invest in stocks, for analyzing price patterns and predicting stock prices and index changes. The investors and traders depend so much on the intelligent trading

systems which help them in predicting prices with the knowledge of previous situations and conditions.

The research focused on developing a better approach to successfully predict stock market prices that could achieve higher profits with the aid of least complex stock market models. First, we pre-processed the data obtained from the Nigerian Stock Exchange (NSE) by normalizing it. The Methods to be adopted are Neural Network in Matlab and Multiple Linear Regression in R; its models would be given and discussed. Necessary diagrams and utilities shall also be stated and discussed appropriately.

The data from NSE daily returns was pre-processed using normal transformation of a normal curve ($0 < x < 1$) using the MINITAB Version 13.0 software, and was also analyzed so that there are no leaking values (that is, redundant stock data owing to technical suspension of the stock by the Nigerian Stock Exchange) and the pre-processed data were used for the experiments.

The rest of the paper is arranged as follow: Section two reviews the related works, section three is on material and methods, section four presents software implementation of results, while section five presents the experimental results and section six is on conclusion and recommendation.

Related Works

We explored various literatures on the application of artificial intelligence systems and time series prediction models such as Artificial Neural Network, Support Vector Machine, Expert System, and Traditional Forecasting Method. Among them are these few that are related to our area of interest. Mackinlay and Lo, (1988) defined stock market as a complex, non-stationary, noisy, chaotic, nonlinear and dynamic system but it does not follow Random Walk Hypothesis (RWH). The financial market movement is caused by so many factors that include: Economic situations, Political situations, Traders' expectations and other unexpected events. Stock prices are very dynamic and are quick to changes because of the underlying nature some known parameters like Previous Day's Closing Price, and other unknown factors (like Election Results, Rumors, an outbreak of disease such as the recent Ebola disease in Africa. Haykin, (1994) described Neural Network as an adaptive machine or more specifically as a massively parallel distributed processor that has a natural propensity for storing experiential knowledge and making it available for use. It resembles the brain in two respects: Knowledge is acquired by the Network through a learning process, and interneuron connection strengths known as synaptic weights are used to store the knowledge. With the knowledge of Artificial Neural Networks techniques (ANN) many researchers have applied these techniques to various fields including stock market prediction. Zahedi, (1993) described Expert Systems and Artificial Neural Networks as the qualitative methods offer for business and economic systems than traditional quantitative tools in Statistics and Econometrics cannot quantify due to the complexity in translating the systems into precise mathematical function. Kartalopoulos, (1996), Vasant, and Roger (1996) and Ward, and Marge, (1995) all mentioned to varying degrees that Neural Networks have the capability to forecast financial markets. Bulter and Daniyal (2009) attempt to make accurate prediction of the movement of stock market with the aid of Evolutionary Artificial Neural Network (EANN) and it was constructed for Multi-Objective Optimization (MOO) which was trained to build up data and its effect on Market performance. It was observed that the main contribution was to show that an EANN trained to recognize direction and magnitude in the Stock Market and to recognize direction changes. ANN can be used to perform classification and regression tasks. It was also proved by (Clarence and Tan, 1997)

as the one that best deals with uncertainty in finance. Primarily, it involves recognition of pattern in data and using these patterns to predict future events.

Hsieh (1993) states that many potential corporate finance applications including Financial Simulation, Predicting Investor's Behavior, Security and a host of others can be significantly improved with the adaptation to ANN technology. Khan and Gour (2013) used some technical indicators and BackPropagation Neural Network (BPNN) to predict the Stock price of the day. The stock rate prediction accuracy of the technical indicators is compared with that of the BPNN and the result show that the BackPropagation Neural Network is more accurate than the other techniques.

Jason (1998) examined and analyzed the use of Neural Networks as a forecasting tool. He tested the Neural Network's ability to predict future trends of Stock Market Indices. The accuracy was compared against a traditional forecasting method, multiple linear regression analysis. Finally, he calculated the probability of the model's forecast using conditional probabilities. His research determines the feasibility and practicality of using Neural Networks as a forecasting tool for the individual investor. Jason, (ibid) builds up his study on the work done by Gately (1996) in his book. The research validates the work of Gately, (1996), and described the development of a Neural Network that achieved a 93.3% probability of predicting a Market rise, and an 88.07% probability of predicting a Market drop in the Standard and Poor 500 (The Standard & Poor's 500, often abbreviated as the S&P 500, or just "the S&P", is an American stock market index based on the market capitalizations of 500 large companies having common Stock listed on the NYSE or NASDAQ. The S&P 500 index components and their weightings are determined by S&P Dow Jones Indices). He concluded that Neural Networks do have the capability to forecast financial Markets and, if properly trained, the individual investor could benefit from the use of this forecasting tool.

The ANN has been used by many other researchers to predict Stock Exchange of different Country's Markets. (Idowu, Osakwe, Kayode, and Adagunodo, 2012), used ANN for the prediction of Nigeria Stock Market. (Refenes, Zaprakis, & Francis, 1995) applied ANN for the prediction of Tokyo Stock Exchange index.

Material and Methods

This section gives a general outlook of Neural Network (NN) as a Machine Learning tool

Neural Network

NN is a Connectionist model that is well suited for machine learning where connection weights are adjusted to improve the performance of a network. An ANN is a network of nodes connected with directed arcs each with a numerical weight, $w_{i,j}$, specifying the strength of the connection.

These weights indicate the influence of previous node, u_j , on the next node, u_i , where positive weights represent reinforcement; negative weights represent inhibition. Generally, the initial connection weights are randomly selected. During the training process a set of pattern examples is used, each example consisting of a pair with the input and corresponding target output. The patterns are presented to the network sequentially, in an iterative manner, the appropriate weight corrections being performed during the process to adapt the network to the desired behavior. This iteration continues until the connection weight values allow the network to perform the required mapping. Each presentation of the whole pattern set is named an epoch. The back propagation learning generally involves the following four steps:

Step 1: Initialization:

Initialize the weights and thresholds of the Network.

Step 2: Activation:

Activate the back-propagation Neural Network by applying inputs $x_1(p), x_2(p), \dots, x_n(p)$ and desired outputs $d_1(p), d_2(p), \dots, d_n(p)$

Step 3: Weight training:

Update the weights in the backpropagation Network by propagating backward the errors associated with output neurons.

Step 4: Iteration:

Increase iteration p by one, go back to Step 2 and repeat the process until the selected error criterion (usually mean squared error) is satisfied.

Fig. 3.1 depicts an abstractive concept of the Artificial Neural Network Multilayer Perceptron algorithm that would be applied in the dataset analysis for the prediction of the stock exchange Market.

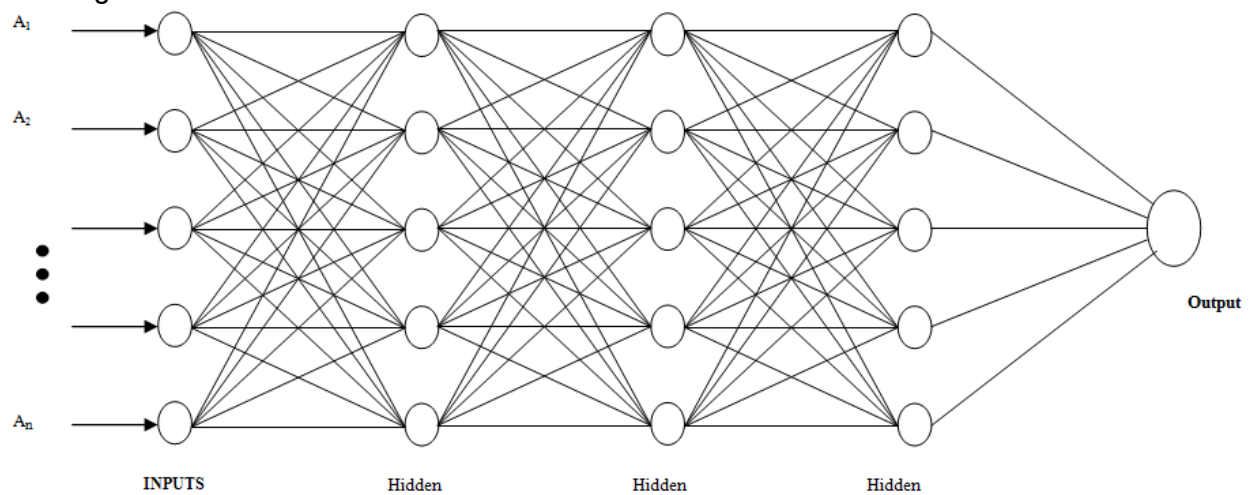


Fig. 3.1: The Multilayers depicting one Input layer, three hidden layers and one Output layer

Multilayer Perceptron

Fig. 3.1 expounds the structure of a Multilayer Perceptron. A Multi-Layer Perceptron (MLP) Network is composed of several layers containing nodes. The lowest layer is the input layer where external data is received. Generally, neural processing will not occur in the input layer. Therefore, the input layer is not treated as a layer in Neural Network processing units, but as merely input units Kecman, (2001). The highest layer is the output layer where the problem solution is obtained. In the case of predicting the currency market, the inputs will be the past observations of the Exchange Market Stocks and the output will be the future value of the Exchange Market Rate. Between the input and output layer, there can be one or more intermediate layers that are called the hidden layers.

The main advantage of MLP networks is their ease of use and approximation of any input/output map. The main disadvantage is that they train slowly and require lots of training data. The connections between individual neurons that make up the ANN allow the

neurons to signal each other as information is processed. If the flow of information through the ANN is from the input layer to the output layer, the ANN is said to be *feed forward*. Each connection between the neurons is assigned a certain weight. The weight equals zero when there is no connection between two particular neurons. In addition, a bias neuron may be connected to each neuron in the hidden and output layers which has a value of positive one. These weights are what determine the output of the ANN.

To explain how the weights, determine the output, consider the following. Let the MLP inputs be represented by x_i with $i = (1, 2, \dots, l)$, and representing the number of inputs. In addition, let the hidden nodes be represented by h_j with $j = (1, 2, \dots, m)$, and m representing the number of hidden nodes. Finally, let the actual value and the MLP output be represented by y_k and $\hat{y}_k$, respectively, with $k = (1, 2, \dots, p)$. The input vector X and the series of weight vectors w_j is then defined as x_i .

The output of each processing unit for the forward pass will be defined as follows:

$$S_i = \sum_{j=0}^n w_{ij} \eta_j \quad (3.1)$$

where S_i is the total input at layer i , w_{ij} is the weight of the input from node j in layer i , and η_j is the activation function which is defined as:

$$\eta_j = f(S_i), \text{ where } f(\text{input}) = \frac{1}{(1 + e^{-\text{input}})} \quad (3.2)$$

Training the Arbitrary Dataset and Normalization Output

Due to lack of time and space, it is not possible to present the raw arbitrary Stock Market Exchange dataset. The computing process for the normalization of the acquired raw dataset result has no computational space as an algorithm; but Table 3.1 depicts the dataset normalized outputs which shall be applied in experimental section.

Table 3.1: Normalized dataset of our

Training Parameters	NN1 Train	1 st Retrain	2 nd Retrain	3 rd Retrain	4 th retrain	5 th retrain	6 th retrain	7 th retrain
Iterations	13	9	15	8	12	14	15	13
Training MSE	0.00618566	0.00735707	0.00583144	0.00787549	0.00662532	0.00551117	0.00657987	0.00553799
Validation MSE	0.00944252	0.00698658	0.00793371	0.00603267	0.00744463	0.00833006	0.00862000	0.00816243
Testing MSE	0.00788424	0.00681670	0.00954940	0.00520126	0.01047210	0.00934746	0.00962382	0.00838818
Regression	0.48749	0.47795	0.53002	0.50716	0.50484	0.5807	0.49665	0.59163
Duration	1sec	3secs	7secs	3secs	4secs	0sec	4secs	41secs
Mu	0.00100	0.00100	0.00001	0.00100	0.00010	0.00010	0.00100	0.00100

The dataset was pre-processed using normal transformation of a normal curve ($0 < x < 1$) using the MINITAB Version 13.0 software tool. The experiment was carried out for Neural Network and the topologies based on the efficient computing of equations (3.3) - (3.5). The Training Function used was Levenberg-Marquardt Backpropagation Algorithm. The learning rate per layer used is 0.001 while the training tolerance is of maximum epoch size of 1000; the Levenberg-Marquardt Backpropagation layering equations are:

$$x_i - s - s^2; \quad (3.3)$$

$$x_i - s - s^2 - s^3; \quad (3.4)$$

$$x_i - s - s^2 - s^3 - s^4 \quad (3.5)$$

The variable x_i represents the i th input into MLP, the s_i 's in equations (3.3)-(3.4) are as defined in equation (3.1) are the output processing units of the MLP topology.

Software Implementation of Results

In this section, presentations of basic experimental details are given using two Machine Learning tools; Matlab and R software.

Implementation of the MLP in Matlab

The Neural Network Model (NN1) with the Topology 3-7-1 was implemented and the Training Function Levenberg-Marquardt Backpropagation was executed as the simulation model. The results from its First training and two other retraining are given in Table 4.1 below. The NARX Neural Network view and the NARX Neural Network Closed Loop view are presented in Fig 4.1 and Fig 4.2, respectively. Table 4.1 and Table 4.3 simultaneously presented the performance results from the best NN1 Model.

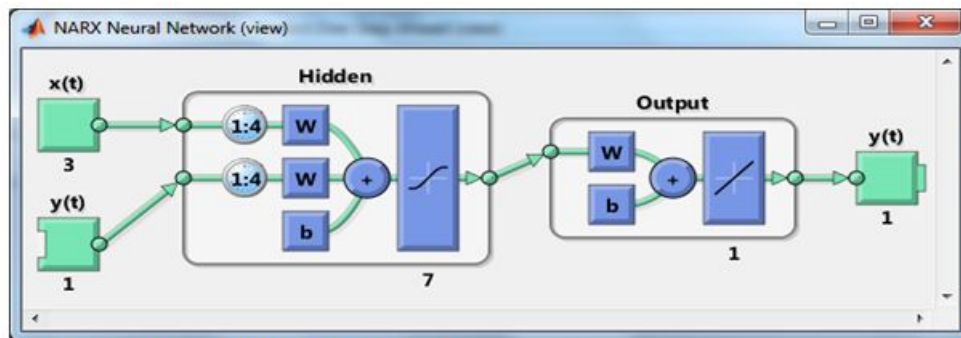


Fig4.1: A NARX MLP with 3-7-1 Topology

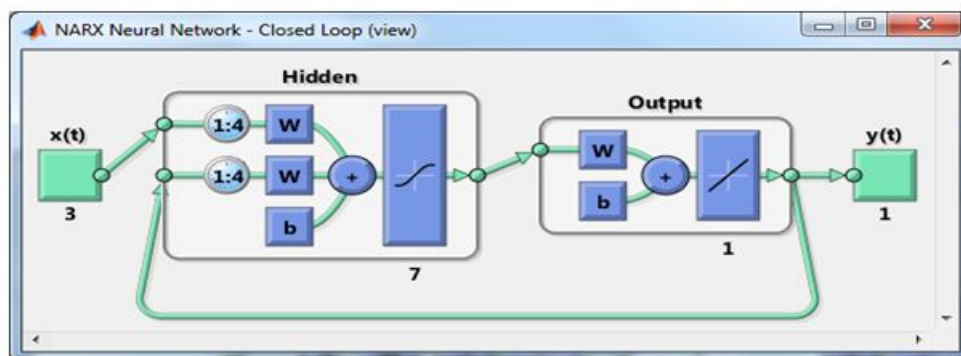


Fig4.2: A Closed Loop of NARX MLP with 3-7-1 Topology

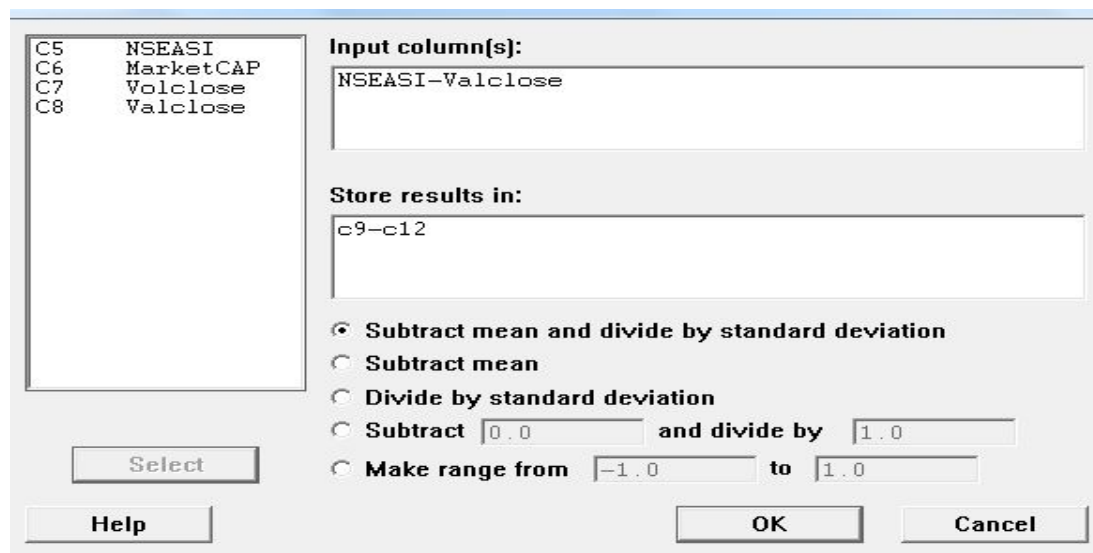
Table 4.1: Performance Result of Model NN1

Topology	Types	Performance
3-7-1	NARX	0.0065
3-7-1	NARX Closed Loop	0.0094

Table 4.2: Performance Result of Model NN1

Table 4.2: Result of the best convergence training of NN1 Model

Data set	Target	Mean Squared Error	Regression
Training	608	0.00735707	0.589887
Validation	131	0.00698658	0.322966
Testing	131	0.00681670	0.326430

Fig. 4.3: Application of Matlab with stock inputs classified as $c_i, i = 5, \dots, 8$

Matlab offers a unique simulation and prototype environment as demonstrated in fig 4.3 for analyzing dataset. It has a concise and descriptive dialogue spaces that allows one to model complex and dynamic systems like the Stock Market with small sections of easy-to-flow-code. MATLAB offers an array of tools for simulation and modeling techniques. Applying specific tool boxes, such as Optimization, Control System, and Neural Network allows one to quickly build simulations and models for applications across a range of disciplines with limited coding from scratch. To visualize the simulation results as they calculate or for post-processing, built-in animation functions with graphics allow one to view model behaviors for analysis, testing and debugging, and presentation purposes. All these features and more make MATLAB an indispensable tool for use in this work. A Nonlinear Autoregressive with External (Exogenous) input (NARX) was used to predict series $y(t)$ given the past values of $y(t)$ and another series $x(t)$.

This gives the equation:

$$y(t) = f(x(t-1) \dots x(t-1)y(t-1)y(t-d)) \quad (4.1)$$

Equation (4.1) is an essential ingredient for making computational forecast (prediction) when a given dataset has been pre-processed.

Application of R Software

The R project for statistical computing (or in Short R) is a powerful data analysis tool. It is a programming language, a computational and a graphical environment for data analysis. It has the advantage to run on other operating systems like Mac, Windows and Unix. R has its root from S language developed by Chambers (1998) at Bell Laboratories.

Multiple Linear Regression (MLR)

This is a technique used for predicting an unknown value of a variable from a known value of two- or- more variables. The multiple regression equation is of the form:

$$y_i = \beta_0 + \beta_1 x_{i1} + \dots + \beta_q x_{iq} + \varepsilon_i \quad (4.2)$$

where β_0 is the intercept and $\beta_1, \beta_2, \dots, \beta_q$ are regression coefficients. y_i 's are the attributes and the x_{i1} 's are the individual predictors, ε_i are error terms and $i = 1, 2, \dots, q$. The basic assumptions are that: the relationship between the attributes and referers are linear, the referers are not related among themselves, normality and homoscedasticity.

Experimental Results

This section gives both the tables and visualization of our computational experiments based in Matlab and R simulated outputs

Implementation of the NN with one hidden layer

The Neural Network Model (NN1) with the Topology 3 – 7 - 1 was implemented and the Training Function Levenberg-Marquardt Backpropagation was used. The results from its first training and six other retraining were done using the NARX Neural Network. The regression outputs are presented in table 5.1.

Table 5.1: Result from the iterations of NN1 model training

Training parameters for NN1	Iterations	Regression
First Train	13	0.48749
Second train	9	0.47795
Third train	15	0.53002
Fourth train	8	0.50716
Fifth train	12	0.50484
Sixth train	14	0.58070
Seventh train	15	0.59163

Table 5.1 shows the effect of the training of the stock dataset and the regression coefficients over iterative training epochs. It shows that the regression coefficients change alternatively as the iterative counts is modified. Pick out the fourth train and the second train effects, in the fourth execution of the simulation; the iteration count is 8 epochs with regression 0.50716 while the second train gives a count of 9 number of iteration with regression 0.47795. This interpretation depicts the fact that the training, the observed iterations and regression coefficients are independent. This means that the Responses and the Predictors are not the same in each training interval. In a nutshell, the responses and the predictors' relation may turn out to be correct, while others can be way off the mark.

Table 5.2: Result of the best convergence training of NN Model

Data Set	Target	Mean Squared Error	Regression
Training	608	0.00735707	0.589887
Validation	131	0.00698658	0.322966
Testing	131	0.00681670	0.326430

The data set was divided into the Training set of 70%, the Validation of 15% and the Testing set of 15%. The Testing set performed best in the Mean Squared Error and the Training had the best Regression.

Interpretation

Table 5.2 shows that the more the training, the better the model gives realistic prediction. The more the test data, the more accurate the error estimates. As it is generally known, the error rate percentage gives the incorrectly classified instances of the dataset. For a cogent interpretation of Table 5.2, however, more Data Mining construct formulations such as the Occam's razor and the practical issues in cross-validation models would have to come into analysis to make adequate and comprehensive interpretation. This task is beyond the horizon of the current paper space and time.

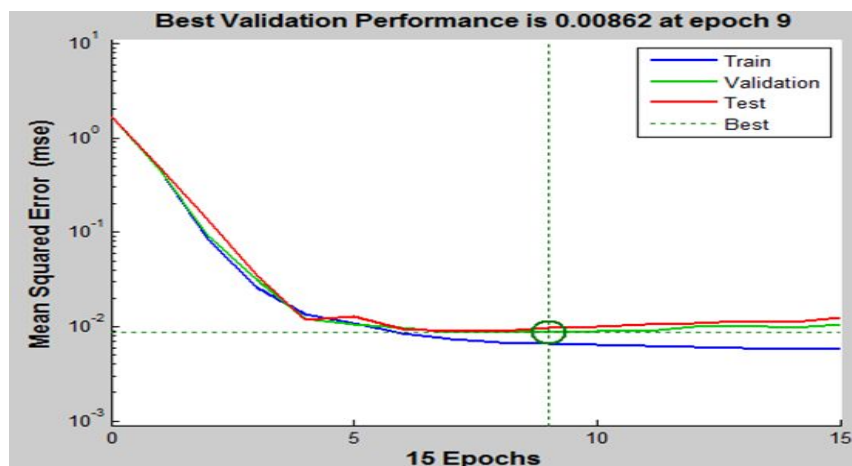


Figure 5.1: The Matlab Plot of Table 5.2

Figure 5.1 is the plot of the seventh train in Table 5.1 that has its Best Validation Performance as 0.00862 at epoch 9, and the Test and the Validation curves converged to the Best line. The training curve is close to the best line. Hence, it was considered to be the best plot and the train that had the best convergence.

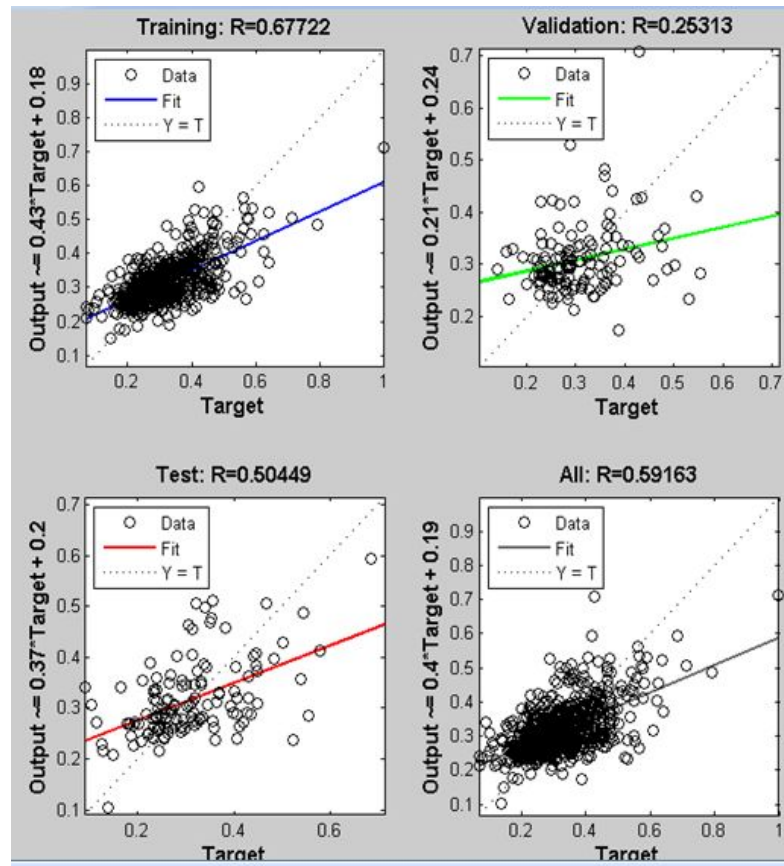


Figure 5.2: Best training Graphs showing the Training, Validation, Test and All Regression Value

The best train in figure 5.2 also gave the best training graphs. It's All Regression value had the highest of 0.59163 with its coefficient of determination to be 0.3500. Note that the values given are acquired from the inherent Matlab Program Codes for the Training, Validation and all regressions. Thus, there is no need for the models to be outlined here as this work is implemented as a Machine Learning software, a tool; in this case, Matlab.

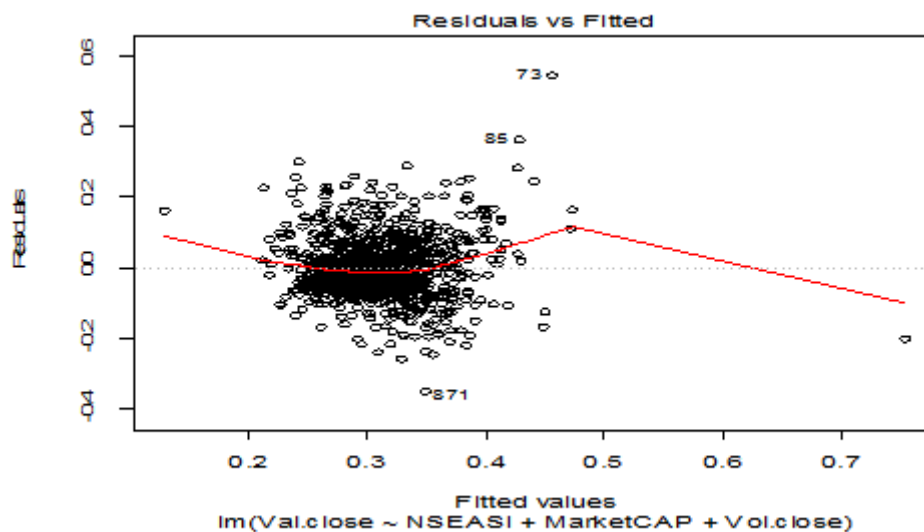


Figure 5.3: Plot of Table 5.1 Input Dataset

Figure 5.3 depicts the Training effects on Dataset Graphical Inputs of Table 5.1. The Plots in Fig 5.3 shows that at the seventh train it converged and had the best regression plot.

Implementation of the NN with two Hidden Layers

The Neural Network Model (NN2) with the Topology 3-7-5-1 was implemented and the Training Function Levenberg-Marquardt Backpropagation was applied.

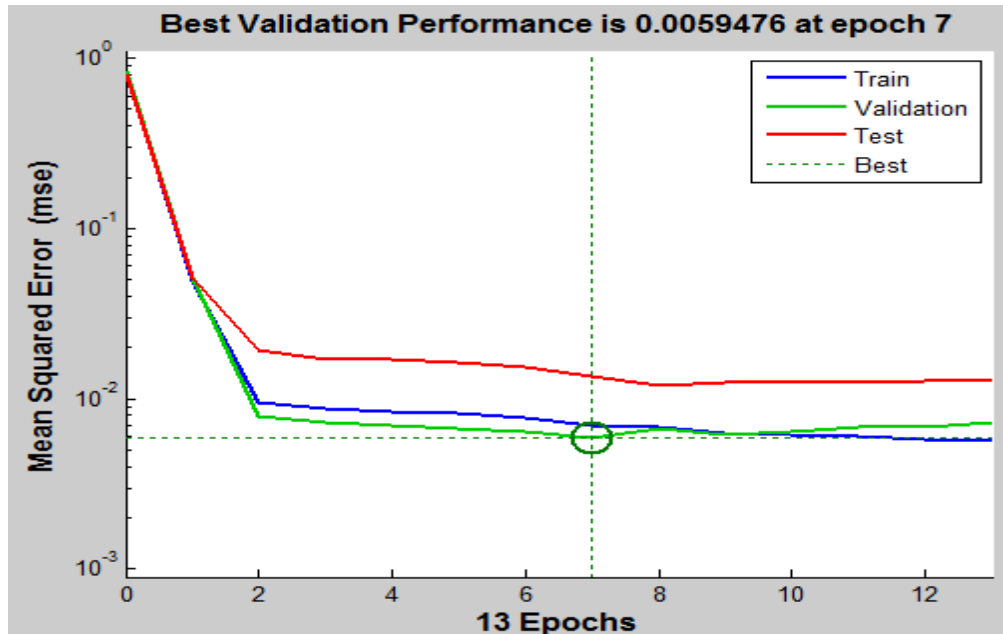


Figure 5.4: Plot from the Train of NN with two Hidden Layers

The plot of the train of NN in figure 5.4 shows that the test curve and the validation curve converged to the best line and had similar trend but the train curve did not converge to the Best line. The selection of the optimal number of units in the hidden layer is very important, because it impacts the model performance. Hence, the implication of this convergence to the NSE implementation is that at this probabilistic stage, the stock exchange would make predictive positive forecast on the Stock Market Exchange.

Table.5.3: Ranking results of the MSE and the R^2 of all the three NN models

Models	MSE	R^2	MSE	R^2
			Rank	Rank
NN1	0.0065	0.3500	1	1
NN2	0.0069	0.2826	2	2
NN3	0.0070	0.2735	3	3

From Table 5.3, the results were compared using their Mean Squared Error (MSE) and the coefficient of determination (R^2) to see which approach performed best. The result of the NN with one hidden layer was ranked first in both the MSE and the R^2 . From Table 5.3, it implies that the training test which converges to the best line has its regression above 0.5 which gives better prediction equation.

Hence, the mathematical model for the ANN is:

$$A \cong 0.4 * T + 0.19 \quad (5.1)$$

The letter A is the actual stock price to be predicted while T is used as the training data (for today's stock price) which will be used for making prediction.

Multiple Linear Regression Analysis

Multiple linear regression analysis was performed on the normalized data using the R version 3.1.1. The output of this process for the final model is presented in figures 5.5 -5.7 below. The plot in figure 5.5 shows the residual errors plotted versus their fitted values. The residuals should be randomly distributed around the horizontal line representing a residual error of zero. For each variable, there did not seem to be major differences in the variability of the residual for different values of the independent variable. Therefore, the Homoscedasticity assumption is valid.

The plot in figure 5.5 suggests that the residual errors are normally distributed. The points on the plot seemed to deviate from a straight line in a random manner. This indicates normality which is also a necessary assumption. The plot in figure 5. 5 suggests that the residual errors are normally distributed. The points on the plot seemed to deviate from a straight line in a random manner. This indicates normality.

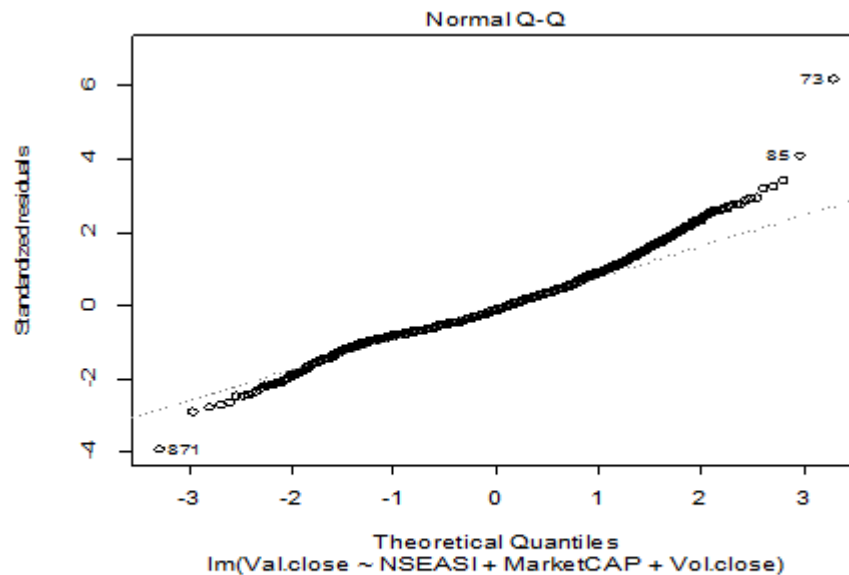


Figure 5.6: The Impact of Normal Distribution

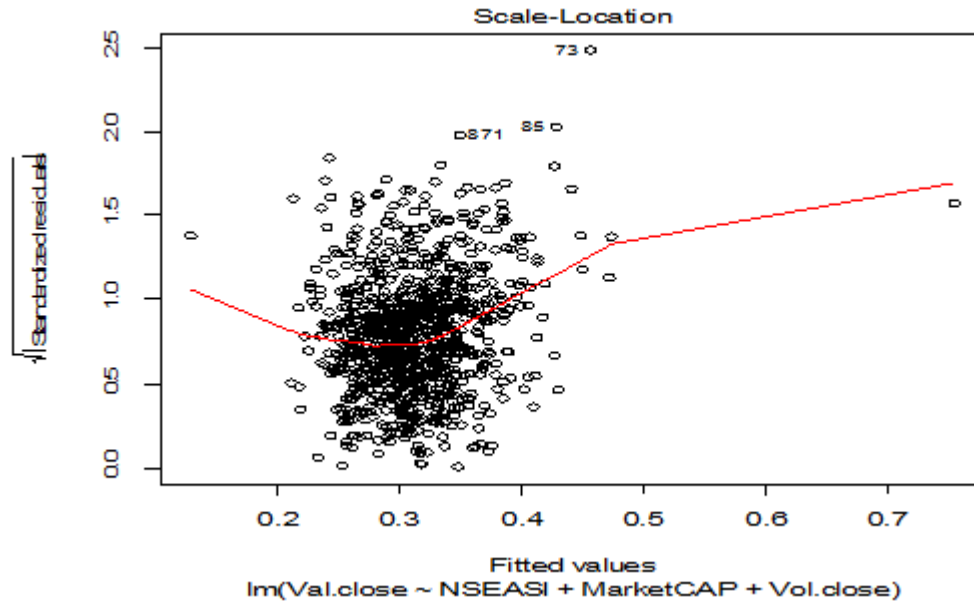


Figure 5.6: Regression Plot Scale versus Location

The scale-location plot in figure 5.6 shows the square root of the standardized residuals (sort of a square root of relative error) as a function of the fitted values. There was no pattern in the residual plots for each independent variable. Therefore, the linearity assumption is valid.

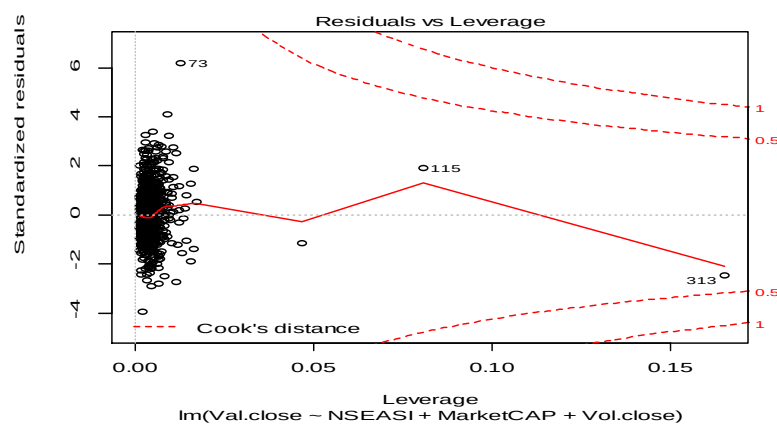


Figure 5.7: Regression Result Plot Residuals versus Leverage

Finally, Figure 5.7 shows each point's leverage, which is a measure of its importance in determining the regression result. This shows no pattern and indicated the absence of Autocorrelation. Hence, the independence of errors assumption is valid. From the plots in figures 5.5 – 5.7 above, all the four assumptions of regression analysis were verified. Therefore, a linear regression model is appropriate. Hence, the Regression model equation is

$$Val@close = 0.0634 + 0.0523V@close + 0.240NSEASI - 0.024marketCap \quad (5.2)$$

This can also be written as:

$$Y = 0.0634 + 0.0523X_1 + 0.240X_2 - 0.024X_3 \quad (5.3)$$

Table 5.4 gives the outcomes of MLR, the Multiple Regression value was less than 0.5 which made the coefficient of determination (R^2) and the adjusted (R^2) very low and the MSE was very high Table 5.5: Ranking results of the MSE and the R^2 of Type A, Type B and MLR Models.

Table 5.4: The Outcome of the MLR

	Result
Multiple R	0.44
R^2	0.194
Adjusted R^2	0.192
MSE	0.08865
Observations	870

Table 5.5: MLR statistical outcomes.

Models	MSE	R^2	MSE Rank	R^2 Rank
NN1	0.0065	0.3500	1	1
NN2	0.0069	0.2826	2	2
NN3	0.0070	0.2735	3	3
MLR	0.0887	0.1940	4	4

Table 5.5 is the general comparison of the three subsystems of NN and the MLR result. The NN1 was ranked 1st in both MSE and the R^2 which came out to be the best, the NN2 was 2nd and NN3 was 3rd while the MLR was ranked 4th in both the MSE and R^2 .

Conclusion

The NN was trained and retrained to see which one performed better. We discovered during the training process that the train, validation and test plot was shown on the same graph and at some points of the retrain they diverged from the best line but also converged at some points. We considered the retrain that gives better convergence and the higher regression value as the best.

The experiment carried out to predict the NSE future values was considered to be best in Model NN1, followed by NN2 and then NN3 in both MSE and R^2 . This agrees with work done by Refenes Zaprani and Francis (1995), Gately (1996), Idowu, Osakwe, Kayode and Adagunodo (2012), and Khan and Gour (2013). Mathematical Model was developed from the best NN model as seen in equation (4.1). The study tested the ANN with different Hidden layers and different Neurons per layers, computing their MSE and R^2 keeping in mind the problem of over fitting the model. The NN1 was manually chosen as the best possible Network. This model ranks best in both the MSE and the Coefficient of Determination R^2 .

Recommendation

It is recommended that more data mining construct formulations be used for the analysis of Stock Market data. Other practical issues in cross validation could also be explored.

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STABILITY ANALYSIS OF ENDEMIC EQUILIBRIUM OF A LASSA FEVER MODEL

ONUORAH, M. O.,¹ AKINWANDE N. I.,² FARUK ADAMU KUTA³ & ABUBAKAR, U. Y.⁴

¹Mathematics & Statistics Department, Federal Polytechnic, Nasarawa, Nigeria

^{2,4}Mathematics & Statistics Department, Federal University of Technology, Minna, Nigeria

³Micro Biology Department, Federal University of Technology, Minna, Nigeria

Email: martins.onuorah@yahoo.com

Phone No: +234-803-076-4334

Abstract

A Mathematical Model was developed for the spread and control of Lassa Fever. The disease free and endemic equilibrium states were obtained and analysed for stability. Key to the analysis is the basic reproductive number (R_0), which is an important threshold for disease control. The analysis showed that the endemic equilibrium points E_1 is locally asymptotically stable for R_0 close to 1, and the bifurcation at $p^* = 0$ is subcritical when $a > 0$

Keywords: Stability, Sensitivity, Endemic, Lassa fever, Equilibrium, spectral radius,

Introduction

Lassa fever is an acute viral Hemorrhagic fever (VHF) first isolated in a town called Lassa in the Yedseram River Valley in the present Borno State of Northern Nigeria in 1969 (Tara, 2004). Lassa fever is endemic in Nigeria, Liberia, Sierra Leone, Guinea, and other West African countries, affecting about 2 – 3 million persons with 5000 - 10,000 fatalities annually (McCormick et al., 1987). Since its initial discovery in Lassa-Nigeria, rural and nosocomial outbreaks of Lassa fever have occurred repeatedly in other parts of Nigeria: Jos, Onitsha, Zonkwa, Ekpoma (Tomori et al., 1988).

In 2012, 397 cases with 40 deaths were recorded cutting across 12 states of Nigeria (Healthmap, 2012). More recently, between August 2015 and 23 January 2016, 159 suspected cases of Lassa fever including 82 deaths, were reported across 19 states in Nigeria (WHO, 2016).

Promed (2006) reported outbreaks in some cities of West African countries of Sierra Leone, Liberia, Guinea. Lassa fever therefore appears to have 2 geographically separate endemic areas: The Mano River region (Guinea, Sierra Leone, and Liberia) in the West, and Nigeria in the East.

Lassa fever is a zoonotic disease, i.e., it can be transmitted from infected animal to a human. The natural Reservoir of the Lassa virus is Multimammate Rat species known as *Mastomys natalensis* (Fisher-Hoch et al., 1995). Because certain varieties of *Mastomys* often live in human homes, the virus is easily transmitted to humans. Transmission occurs via direct contact with rat urine, faeces, and saliva; via contact with excretion- or secretion-infected materials; or via ingestion of excretion-contaminated food. Victims can also become infected via skin breaks, and via mucous membranes from aerosol transmission from dust-borne particles. In some areas, the rodents are used as a food source, thus providing additional exposure to the infected rat blood, as well as allowing ingestion of potentially contaminated meat. Eze et al., (2010) stated that Health workers become infected usually from contact with rodent saliva or contamination of needles.

Unlike other arena viruses, Lassa virus can be fairly easily transmitted from human to human (WHO, 2004). Richmond (2003) stated that humans can contract the disease from other humans via aerosol transmission (coughing), or from direct contact with infected

human blood, urine, or semen. Lassa virus has been isolated from semen 6 weeks after acute illness; thus the virus can be transmitted to sexual partners by convalescent men (Tara, 2004).

The symptoms of Lassa fever develop about 21 days after infection with acute illness involving multi organs. Specific symptoms include fever, facial swelling, muscle fatigue, vomiting, cough, meningitis, and hypertension. In some patients' neurological problems, including hearing loss which may be transient or permanent, tremors, and encephalitis, have been described the (Omilabu et al., 2005).

Literature

Okuonghae and Okuonghae (2006) formulated an SIS model coupled to a population of rat species, for the transmission of Lassa fever disease. They obtained the equilibrium states of their model and examined them for endemic and epidemic situations. Further, they calculated the basic reproductive number for their model and gave conditions for disease outbreak. Ogabi, et al., (2012) developed an SIR model for controlling Lassa fever transmission in northern part of Edo state, Nigeria. They advocated for health policies that will keep the basic reproductive number R_0 below 1, thereby keeping the transmission of the disease under control.

The Lassa fever model developed by (Bawa et al., 2013) is a major shift from the first two papers cited. The researchers divided the human population into susceptible human S_H , the Infected human I_H , the reservoir population they divided into Infant I_R and the Adult reservoir A_R and interestingly represented the virus in the environment by V . They explained that the virus compartment is generated from the urine and faeces of infected Human and adult reservoirs. The major parameters of their model are b_H per capital birth rate of Human, b_R per capital birth rate of the reservoir, μ_R per capital natural death rate of Human, μ_H per capital death rate of the reservoir, δ_H Lassa fever induced death rate, δ_R mortality death of the reservoir due to hunting, β_1 effective contact rate for human, β_2 effective contact rate between reservoir and human, γ recovery rate of Infected human and σ progression rate from Infant to adult reservoir. They recommended that efforts should be made to keep the basic reproductive number below unity to ensure that the virus is contained. Tolulope et al., (2015) complemented the work of Bawa et al., (2013) by introducing the quarantine parameter (I_Q) and assume that the virus confers permanent immunity to the sufferers upon recovery. The rest of their parameters are the same with that of Bawa et al., (2013). James (2015) developed a mathematical model of Lassa fever using three ordinary differential equations; they discovered that the zero equilibrium state is stable when the birth rate of the human population is less than the death rate. Their analysis also gave the condition for the non-zero equilibrium to be unstable.

Onuorah et al. (2016a) developed a Lassa fever model using the sex structure approach. Their model represented the transmission dynamics of the Lassa fever disease using a set of ordinary differential equations. The total human population at time t denoted by $N_H(t)$ was sub-divided into four (4) mutually exclusive sub-populations of Susceptible Male $S_1(t)$, Infected Male $I_1(t)$, Susceptible Female $S_2(t)$, Infected Female $I_2(t)$, such that $N_H(t) = S_1(t) + I_1(t) + S_2(t) + I_2(t)$. Similarly, the total Natural Reservoir/host population at time t , denoted by $N_R(t)$ was sub-divided into dormant Reservoir $R_1(t)$, active Reservoir $R_2(t)$, such that $N_R(t) = R_1(t) + R_2(t)$. Their model had the following

assumptions. Susceptible individuals, male/female can be infected via interaction with the active Reservoir (*Mastomys Natalensis*), and via sexual interaction with opposite sex. Two major controls were considered, the use of condom to reduce contact via sexual interaction and the use of pesticide or Rat poison to kill the natural Reservoir (*Mastomys Natalensis*). And finally, horizontal transmission for human and vertical transmission for the Reservoir.

Onuorah et al. (2016b), is an extension of Onuorah et al. (2016a), specifically, they included a schematic diagram, sensitivity analysis, numerical computation of the basic Reproductive number R_0 and numerical simulation. All the works cited above did not consider the endemic equilibrium (equilibrium state where at least one of the infected compartments is non-zero) of their Lassa fever model. In this work we intend to bridge this gap identified, by extending the analysis of Onuorah et al (2016a) to endemic equilibrium states of the various state variables of our model. We also carried out bifurcation analysis.

Methodology

Parameters of the Model

- β_H The natural birth rate of human population
- β_R The natural birth rate of vectors
- θ The proportion of human birth that is male $0 < \theta < 1$
- ρ Spectral Radius
- α_1 The rate of transmission resulting from sexual interaction between infected female and susceptible male
- α_2 The rate of transmission resulting from sexual interaction between infected male and susceptible female
- α_3 The rate of transmission resulting from interaction between active virus Reservoir and susceptible male
- α_4 The rate of transmission resulting from interaction between active virus Reservoir and susceptible female
- c_1 Average number of male partners acquired by a susceptible female
- c_2 Average number of female partners acquired by a susceptible male
- μ_1 Natural death rate of human population
- μ_2 Natural death rate of Reservoir population
- γ Recovery rate of infected human
- σ Progression rate from dormant to active Reservoir host
- δ_1 Death rate of human population due to infection
- δ_2 Death rate of Reservoir population due to application of pesticide
- ε Efficacy of condom
- τ Compliance of condom usage

The Model

From the assumptions above we have the following equations:

$$\frac{dS_1}{dt} = \beta_H \theta N_H + \gamma I_1 - \frac{(c_2 \alpha_1 (1 - \varepsilon \tau) I_2 + \alpha_3 R_2) S_1}{N_H} - \mu_1 S_1 \quad (1)$$

$$\frac{dI_1}{dt} = \frac{(c_2 \alpha_1 (1 - \varepsilon \tau) I_2 + \alpha_3 R_2) S_1}{N_H} - (\mu_1 + \delta_1 + \gamma) I_1 \quad (2)$$

$$\frac{dS_2}{dt} = \beta_H (1 - \theta) N_H + \gamma I_2 - \frac{(c_1 \alpha_2 (1 - \varepsilon \tau) I_1 + \alpha_4 R_2) S_2}{N_H} - \mu_1 S_2 \quad (3)$$

$$\frac{dI_2}{dt} = \frac{(c_1 \alpha_2 (1 - \varepsilon \tau) I_1 + \alpha_4 R_2) S_2}{N_H} - (\mu_1 + \delta_1 + \gamma) I_2 \quad (4)$$

$$\frac{dR_1}{dt} = \beta_R N_R - (\sigma + \mu_2 + \delta_2) R_1 \quad (5)$$

$$\frac{dR_2}{dt} = \sigma R_1 - (\mu_2 + \delta_2) R_2 \quad (6)$$

The total human population size is given by;

$$N_H = S_1 + I_1 + S_2 + I_2 \quad (7)$$

The total Reservoir population size is given by

$$N_R = R_1 + R_2 \quad (8)$$

By adding equations (1) to (4), we have;

$$\frac{dN_H}{dt} = \beta_H N_H - \mu_1 N_H - \delta_1 (I_1 + I_2) \quad (9)$$

By adding equations (5) to (6), we have;

$$\frac{dN_R}{dt} = (\beta_R - \mu_2 + \delta_2) N_R \quad (10)$$

Basic Properties of the Model

In this section, the basic dynamical features of the model equations (1) to (6) will be explored.

Theorem 1 The closed set

$$D = \{(S_1, I_1, S_2, I_2, R_1, R_2) \in \mathfrak{R}_+^6 : S_1 + I_1 + S_2 + I_2 \leq N_H; R_1 + R_2 \leq N_H\}$$

Is positively-invariant and attracting with respect to the basic model equations (1) to (6)

Proof

From equations (7), to (10);

$$\frac{dN_H}{dt} \leq (\beta_H - \mu_1) N_H, \quad \frac{dN_R}{dt} \leq (\beta_R - \mu_2 - \delta) N_R.$$

It follows that $\frac{dN_H}{dt} < 0$ and $\frac{dN_R}{dt} < 0$ if $N_H(t) > \frac{\beta_H}{\mu_1}$ and $N_R(t) > \frac{\beta_R}{\mu_2}$ respectively. Thus

a standard comparison theorem as in (Lakshmikantham et al, 1999) can be used to show

$$\text{that } N_H(t) \leq N_H(0) e^{\mu_1(t)} + \frac{\beta_H}{\mu_1} (1 - e^{-\mu_1(t)})$$

$$\text{and } N_R(t) \leq N_R(0) e^{\mu_2(t)} + \frac{\beta_R}{\mu_2 + \delta_2} (1 - e^{-(\mu_2 + \delta_2)(t)}). \quad \text{In particular } N_H(t) \leq \frac{\beta_H}{\mu_1} \text{ and}$$

$$N_R(t) \leq \frac{\beta_R}{\mu_2 + \delta_2} \text{ if } N_H(0) \leq \frac{\beta_H}{\mu_1} \text{ and } N_R(0) \leq \frac{\beta_R}{\mu_2 + \delta_2} \text{ respectively. Thus } D \text{ is positively-}$$

invariant. Further, if $N_H(0) > \frac{\beta_H}{\mu_1}$, and $N_R(0) > \frac{\beta_R}{\mu_2 + \delta_2}$, then either the solution enters

D in finite time or $N_H(t)$ approaches $\frac{\beta_H}{\mu_1}$, and $N_R(t)$ approaches $\frac{\beta_R}{\mu_2 + \delta_2}$, and the infected

variables $I_1 + I_2$, $R_1 + R_2$ approaches 0. Hence D is attracting, that is all solutions in $\mathfrak{R}_+^6$ eventually enters D . Thus in D , the basic model equations (1) to (6) is well posed epidemiologically and mathematically according to (Hethcote, 1978). Hence it is sufficient to study the dynamics of the basic model equations (1) to (6)

Disease Free Equilibrium (DFE)

At equilibrium states, the rate of change of the state variables with respect to time is zero, i.e.

$$\frac{dS_1}{dt} = \frac{dI_1}{dt} = \frac{dS_2}{dt} = \frac{dI_2}{dt} = \frac{dR_1}{dt} = \frac{dR_2}{dt} = 0$$

We define disease compartments as the Infected male, Infected female compartments that is I_1 and I_2 . we let $(S_1, I_1, S_2, I_2, R_1, R_2) = (x, y, z, u, v, w)$ at disease free equilibrium, equating the right hand side of our model equation (1) to (6) to zero and solving with the above change of variable, we have our DFE

$$E_0 = (x, y, z, u, v, w) = \left(\frac{\beta_H \theta N_H}{\mu_1}, 0, \frac{\beta_H (1 - \theta) N_H}{\mu_1}, 0, 0, 0 \right) \quad (11)$$

For the analysis of Local Stability and is Globally Asymptotically stable of Disease Free Equilibrium E_0 of the model, the reader is referred to Onuorah (2016b)

At DFE, the Jacobian matrix is

$$J_{E_0} = \begin{bmatrix} -\mu_1 & \gamma & 0 & \frac{px}{N_H} & 0 & \frac{\alpha_3 x}{N_H} \\ 0 & -A_1 & 0 & \frac{px}{N_H} & 0 & \frac{\alpha_3 x}{N_H} \\ 0 & \frac{qz}{N_H} & -\mu_1 & 0 & 0 & \frac{\alpha_4 z}{N_H} \\ 0 & \frac{qz}{N_H} & 0 & -A_1 & 0 & \frac{\alpha_4 z}{N_H} \\ 0 & 0 & 0 & 0 & -A_2 & 0 \\ 0 & 0 & 0 & 0 & \sigma & -(\mu_2 + \delta_2) \end{bmatrix} \quad (12)$$

where $p = c_2 \alpha_1 (1 - \varepsilon \tau)$, $q = c_1 \alpha_2 (1 - \varepsilon \tau)$, $A_1 = (\mu_1 + \delta_1 + \gamma)$ and $A_2 = (\sigma + \mu_2 + \delta_2)$
 $A_3 = (\mu_2 + \delta_2)$

Basic Reproductive Number (R_0)

We use the next generation matrix approach as described by (Driessche and Wathmough, 2005) to derive our Basic Reproductive Number diseases.

Here, the basic reproductive number R_0 is the spectral radius of the product matrix

$$FV^{-1}, \text{ i.e. } R_0 = \rho(FV^{-1})$$

Our model has four Infected compartments namely the Infective male I_1 , Infected female I_2 , dormant Reservoir R_1 and active Reservoir R_2 . It follows that the matrices F and V for the new infective terms and remaining transfer terms respectively are given below:

$$F = \begin{bmatrix} 0 & \frac{px}{N_H} & 0 & \alpha_3 x \\ \frac{qz}{N_H} & 0 & 0 & \alpha_4 z \\ 0 & 0 & \beta_R & \beta_R \\ 0 & 0 & 0 & 0 \end{bmatrix} \quad V = \begin{bmatrix} A_1 & 0 & 0 & 0 \\ 0 & A_1 & 0 & 0 \\ 0 & 0 & A_2 & 0 \\ 0 & 0 & -\sigma & A_3 \end{bmatrix}$$

$$V^{-1} = \begin{bmatrix} \frac{1}{A_1} & 0 & 0 & 0 \\ 0 & \frac{1}{A_1} & 0 & 0 \\ 0 & 0 & \frac{1}{A_2} & 0 \\ 0 & 0 & \frac{\sigma}{A_2 A_3} & \frac{1}{A_3} \end{bmatrix}$$

$$FV^{-1} = \begin{bmatrix} 0 & \frac{px}{A_1 N_H} & \frac{x\sigma\alpha_3}{A_2 A_3} & \frac{x\alpha_3}{A_3} \\ \frac{qz}{A_1 N_H} & 0 & \frac{x\sigma\alpha_4}{A_2 A_3} & \frac{x\alpha_4}{A_3} \\ 0 & 0 & \frac{\beta_R(A_3 + \sigma)}{A_2 A_3} & \frac{\beta_R}{A_3} \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$$\rho(FV^{-1}) = \sqrt{\frac{px.qz}{(N_H A_1)^2}}$$

Substituting the values of x, z at equilibrium, the values of A_1, p and q gives

$$R_0 = \sqrt{\frac{(c_2 \alpha_1 (1 - \varepsilon \tau) \beta_H \theta) \times (c_1 \alpha_2 (1 - \varepsilon \tau) \beta_H (1 - \theta))}{\mu_1 ((\mu_1 + \delta_1 + \gamma))^2}} \quad (14)$$

Endemic Equilibrium

This is an equilibrium state where at least one of the infected compartments is non-zero. In order to find the Endemic equilibrium for our model equations (1) to (6), the following steps are taken. We let $E_e = (x^*, y^*, z^*, u^*, v^*, w^*)$ represent any arbitrary point of the Endemic Equilibrium of our model equations further,

$$\text{let; } \lambda_M^* = \frac{c_2 \alpha_1 (1 - \varepsilon \tau) u^* + \alpha_3 w^*}{N_H}, \lambda_F^* = \frac{c_1 \alpha_2 (1 - \varepsilon \tau) y^* + \alpha_4 w^*}{N_H} \quad (15)$$

Be the force of infection of susceptible male and susceptible female respectively. Solving our model equations (1) to (6) at steady state gives

$$\begin{aligned}
 u^* &= \frac{\beta_H(1-\theta)N_H\lambda_F}{(\lambda_F + \mu_1)(\mu_1 + \delta_1 + \gamma) - \gamma\lambda_F}, v^* = \frac{\beta_R N_R}{(\sigma + \mu_2 + \delta_2)}, w^* = \frac{\sigma\beta_R N_R}{(\mu_2 + \delta_2)(\sigma + \mu_2 + \delta_2)}, \\
 x^* &= \frac{(\mu_1 + \delta_1 + \gamma)\beta_H\theta N_H}{(\lambda_M + \mu_1)(\mu_1 + \delta_1 + \gamma) - \gamma\lambda_M}, z^* = \frac{(\mu_1 + \delta_1 + \gamma)\beta_H(1-\theta)N_H}{(\lambda_F + \mu_1)(\mu_1 + \delta_1 + \gamma) - \gamma\lambda_F}, \\
 y^* &= \frac{\beta_H\theta N_H\lambda_M}{(\lambda_M + \mu_1)(\mu_1 + \delta_1 + \gamma) - \gamma\lambda_M}
 \end{aligned} \quad (16)$$

Substituting (16) into (15) we have;

$$\lambda_F^* = \frac{k_1 q \beta_H \theta N_H \lambda_M^* + (\alpha_4 \sigma \beta_R N_R) [\lambda_M^* (\mu_1 + \delta_1) + k_2]}{[\lambda_M^* (\mu_1 + \delta_1) + k_2] k_1} \quad (17)$$

$$\lambda_F^* = \frac{k_3 \lambda_M^* + \lambda_M \alpha_4 \sigma \beta_R N_R (\mu_1 + \delta_1) + k_2 \alpha_4 \sigma \beta_R N_R}{\lambda_M^* (\mu_1 + \delta_1) k_1 + k_2 k_1} \quad (18)$$

$$\lambda_F^* = \frac{k_3 \lambda_M^* + k_4 \lambda_M^* + k_2 \alpha_4 \sigma \beta_R N_R}{k_5 \lambda_M^* + k_2 k_1} \quad (19)$$

and

$$\lambda_M^* = \frac{k_1 p \beta_H (1-\theta) N_H \lambda_F^* + (\alpha_3 \sigma \beta_R N_R) [(\mu_1 + \delta_1) \lambda_F^* + k_2]}{[(\mu_1 + \delta_1) \lambda_F^* + k_2] k_1} \quad (20)$$

$$\lambda_M^* = \frac{k_1 p \lambda_F^* + \alpha_3 \sigma \beta_R N_R (\mu_1 + \delta_1) \lambda_F^* + k_2 \alpha_3 \sigma \beta_R N_R}{k_1 (\mu_1 + \delta_1) \lambda_F^* + k_2 k_1} \quad (21)$$

$$\lambda_M^* = \frac{k_6 \lambda_F^* + k_7 \lambda_F^* + k_2 \alpha_3 \sigma \beta_R N_R}{k_8 \lambda_F^* + k_2 k_1} \quad (22)$$

$$\begin{aligned}
 P &= c_2 \alpha_1 (1 - \varepsilon \tau), q = c_1 \alpha_2 (1 - \varepsilon \tau), k_1 = (\mu_2 + \delta_2)(\sigma + \mu_2 + \delta_2), k_2 = \mu_1 (\mu_1 + \delta_1 + \gamma), \\
 \text{Where } k_3 &= k_1 q \beta_H \theta N_H, k_4 = \alpha_4 \beta_H \theta N_R (\mu_1 + \delta_1), k_5 = k_1 (\mu_1 + \delta_1), k_6 = p \beta_H (1 - \theta) N_H, \\
 k_7 &= \alpha_3 \beta_R \theta N_R (\mu_1 + \delta_1), k_8 = (\mu_1 + \delta) k_1
 \end{aligned} \quad (23)$$

Substituting λ_F^* (19) into λ_M^* (22) we have

$$\lambda_M^* = \frac{k_6 k_3 \lambda_M^* + 2k_4 \lambda_M^* + 2k_2 \alpha_4 \sigma \beta_R N_R + k_7 k_3 \lambda_M^* + k_2 \alpha_3 \sigma \beta_R N_R (k_5 \lambda_M^* + k_2 k_1)}{k_8 k_3 \lambda_M^* + k_4 \lambda_M^* + k_2 \alpha_4 \sigma \beta_R N_R + k_2 k_1} \quad (24)$$

$$\lambda_M^* = \frac{\lambda_M^* (k_6 k_3 + 2k_4 + k_7 k_3 + k_2 k_5 \alpha_3 \sigma \beta_R N_R) + \sigma \beta_R N_R (\alpha_3 k_2^2 k_1 + 2k_2 \alpha_4)}{\lambda_M^* (k_8 k_3 + k_4) + k_2 \alpha_4 \sigma \beta_R N_R + k_2 k_1} \quad (25)$$

$$\lambda_M^* (\lambda_M^* (k_8 k_3 + k_4) + k_2 \alpha_4 \sigma \beta_R N_R + k_2 k_1) = \lambda_M^* (k_6 k_3 + 2k_4 + k_7 k_3 + k_2 k_5 \alpha_3 \sigma \beta_R N_R) + \sigma \beta_R N_R (\alpha_3 k_2^2 k_1 + 2k_2 \alpha_4) \quad (26)$$

$$(\lambda_M^*)^2 (k_8 k_3 + k_4) + \lambda_M^* k_2 \alpha_4 \sigma \beta_R N_R + \lambda_M^* k_2 k_1 - \lambda_M^* (k_6 k_3 + 2k_4 + k_7 k_3 + k_2 k_5 \alpha_3 \sigma \beta_R N_R) - \sigma \beta_R N_R (\alpha_3 k_2^2 k_1 + 2k_2 \alpha_4) = 0 \quad (27)$$

$$(\lambda_M^*)^2 (k_8 k_3 + k_4) + \lambda_M^* [k_2 \alpha_4 \sigma \beta_R N_R + k_2 k_1 - (k_6 k_3 + 2k_4 + k_7 k_3 + k_2 k_5 \alpha_3 \sigma \beta_R N_R)] - \sigma \beta_R N_R (\alpha_3 k_2^2 k_1 + 2k_2 \alpha_4) = 0 \quad (28)$$

$$k_9 (\lambda_M^*)^2 + k_{10} \lambda_M^* + k_{11} = 0 \quad (29)$$

Where

$$\begin{aligned}
 k_9 &= (k_8 k_3 + k_4), \\
 k_{10} &= [k_2 \alpha_4 \sigma \beta_R N_R + k_2 k_1 - (k_6 k_3 + 2k_4 + k_7 k_3 + k_2 k_5 \alpha_3 \sigma \beta_R N_R)], \\
 k_{11} &= \sigma \beta_R N_R (\alpha_3 k_2^2 k_1 + 2k_2 \alpha_4
 \end{aligned} \tag{30}$$

Thus, the positive endemic equilibria of the basic model (1) to (6) are obtained by solving for λ_M^* from the quadratic (29) and substituting the results (positive values of λ_M^* into the expressions in (16). Clearly, the coefficient k_9 of (29), is always positive, and k_{11} is positive (negative) if R_0 is less than (greater than) unity, respectively.

Asymptotic Global Stability of Endemic Equilibrium

We used the Centre Manifold theorem as described in (Castillo- Chavez and Songs, 2004), for Bifurcation analysis to show that our model equations (1) to (6) is globally asymptotically stable (GAS).

In order to apply this theorem, we first make the following change of variables. Let

$$S_1 = x_1, I_1 = x_2, S_2 = x_3 = I_2 = x_4, R_1 = x_5, R_2 = x_6, \text{ so that } N_H = x_1 + x_2 + x_3 + x_4$$

and $N_R = x_5 + x_6$ further, using the vector notation, $X = (x_1, x_2, x_3, x_4, x_5, x_6)^T$.

Then our model equations (1) to (6) can be written in the form

$$\frac{dx}{dt} = (f_1, f_2, f_3, f_4, f_5, f_6)^T, \text{ such that:}$$

$$\frac{dx_1}{dt} = f_1 = \beta_H \theta N_H + \gamma x_2 - \frac{(px_4 + \alpha_3 x_6)x_1}{N_H} - \mu_1 x_1 \tag{31}$$

$$\frac{dx_2}{dt} = f_2 = \frac{(px_4 + \alpha_3 x_6)x_1}{N_H} - (\mu_1 + \delta_1 + \gamma)x_2 \tag{32}$$

$$\frac{dx_3}{dt} = f_3 = \beta_H (1 - \theta) N_H + \gamma x_4 - \frac{(qx_2 + \alpha_4 x_6)x_3}{N_h} - \mu_1 x_3 \tag{33}$$

$$\frac{dx_4}{dt} = f_4 = \frac{(qx_2 + \alpha_4 x_6)x_3}{N_h} - (\mu_1 + \delta_1 + \gamma)x_4 \tag{34}$$

$$\frac{dx_5}{dt} = f_5 = \beta_R N_R - (\sigma + \mu_2 + \delta_2)x_5 \tag{35}$$

$$\frac{dx_6}{dt} = f_6 = \sigma x_5 - (\mu_2 + \delta_2)x_6 \tag{36}$$

Now the Jacobian of the model equations (31) to (36) at disease free equilibrium which is;

$$J_{E_0} = \begin{bmatrix}
 -\mu_1 & \gamma & 0 & \frac{px_1}{N_H} & 0 & \frac{\alpha_3 x_1}{N_H} \\
 0 & -A_1 & 0 & \frac{px_1}{N_H} & 0 & \frac{\alpha_3 x_1}{N_H} \\
 0 & \frac{qx_3}{N_H} & -\mu_1 & 0 & 0 & \frac{\alpha_4 x_3}{N_H} \\
 0 & \frac{qx_3}{N_H} & 0 & -A_1 & 0 & \frac{\alpha_4 x_3}{N_H} \\
 0 & 0 & 0 & 0 & -A_{2v} & 0 \\
 0 & 0 & 0 & 0 & \sigma & -(\mu_2 + \delta_2)
 \end{bmatrix} \tag{37}$$

The basic reproductive number in terms of the new variables is $R_0 = \sqrt{\frac{px_1 \cdot qx_3}{(N_H A_1)^2}}$

Consider the case where $R_0 = 1$, suppose that p is chosen as the Bifurcation parameter, since R_0 is often not convenient to use directly as bifurcation parameter, solving for p gives $R_0 = 1$, where $p^* = p$. Eigen-vectors of $J_{(E_0)} / p^* = p$
 As in Garba et al (2008) we let v and w be the corresponding Right and Left eigen-vector associated with the zero eigen-value of the Jacobian (37) at $p^* = p$, denoted by J_{p^*} , chosen such that $vJ_{(E_0)} = 0$ and $J_{(E_0)}w = 0$, with $vw = 1$ where $v = (v_1, v_2, v_3, v_4, v_5, v_6)$, and $w = (w_1, w_2, w_3, w_4, w_5, w_6)$

$$J_{(E_0)}V = \begin{bmatrix} -\mu_1 & \gamma & 0 & \frac{px_1}{N_H} & 0 & \frac{\alpha_3 x_1}{N_H} \\ 0 & -A_1 & 0 & \frac{px_1}{N_H} & 0 & \frac{\alpha_3 x_1}{N_H} \\ 0 & \frac{qx_3}{N_H} & -\mu_1 & 0 & 0 & \frac{\alpha_4 x_3}{N_H} \\ 0 & \frac{qx_3}{N_H} & 0 & -A_1 & 0 & \frac{\alpha_4 x_3}{N_H} \\ 0 & 0 & 0 & 0 & -A_2 & 0 \\ 0 & 0 & 0 & 0 & \sigma & -(\mu_2 + \delta_2) \end{bmatrix} \cdot \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \\ v_5 \\ v_6 \end{bmatrix} = 0 \quad (38)$$

To solve for V we reduce $J_{(E_0)}$, to upper triangular matrix using elementary row operation to have

$$\begin{bmatrix} -\mu_1 & \gamma & 0 & \frac{px_1}{N_H} & 0 & \frac{\alpha_3 x_1}{N_H} \\ 0 & -A_1 & 0 & \frac{px_1}{N_H} & 0 & \frac{\alpha_3 x_1}{N_H} \\ 0 & 0 & -\mu_1 & A_3 & 0 & A_4 \\ 0 & 0 & 0 & -A_1 + A_3 & 0 & A_4 \\ 0 & 0 & 0 & 0 & -A_2 & 0 \\ 0 & 0 & 0 & 0 & 0 & -(\mu_2 + \delta_2) \end{bmatrix} \cdot \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \\ v_5 \\ v_6 \end{bmatrix} = 0 \quad (39)$$

where

$$A_1 = (\mu_1 + \delta_1 + \gamma), A_2 = (\sigma + \mu_2 + \delta_2), A_3 = \frac{px_3 px_1}{(N_H)^2 A_1}, A_4 = \frac{qx_3 \alpha_3 x_1}{(N_H)^2 A_1} + \frac{\alpha_4 x_3}{N_H} \quad (40)$$

Solving for v in equation (39) we have

$$v_1 = \frac{[(pA_4 + \alpha_1 x_1 (A_1 - A_2))\gamma + \alpha_3 A_4 + \alpha_3 (A_1 - A_3)]x_1}{N_H (A_1 - A_3)\mu_1} v_6 \quad (41)$$

$$v_2 = \frac{p_1 x_1 A_4 + \alpha_3 x_1 (A_1 - A_3)}{A_1 - A_3} v_6 \quad (42)$$

$$v_3 = \frac{A_3 A_4 - A_4 (A_1 - A_2)}{A_1 - A_3} v_6 \quad (43)$$

$$v_4 = \frac{A_4}{A_1 - A_3} v_6 \quad (44)$$

$$v_5 = 0 \quad (45)$$

$$v_6 = v_6 \quad (46)$$

Left eigenvalue $wJ_{(E_0)}$

The left eigenvalue of (J_{E_0}) are transposes of the right eigenvectors of the transposed matrix $(J_{E_0})^T$, since their defining equation is equivalent to

$$J_{(E_0)}^T w^T = \lambda w, \text{ thus, } wJ_{(E_0)} = \lambda w$$

that is

$$(J_{E_0})^T w^T = (w_1, w_2, w_3, w_4, w_5, w_6)^T = \begin{bmatrix} -\mu_1 & 0 & 0 & 0 & 0 & 0 \\ \gamma & -A_1 & \frac{qx_3}{N_H} & \frac{qx_3}{N_H} & 0 & 0 \\ 0 & 0 & -\mu_1 & 0 & 0 & 0 \\ \frac{px_1}{N_H} & \frac{px_1}{N_H} & 0 & -A_1 & 0 & 0 \\ 0 & 0 & 0 & 0 & -\mu_2 & 0 \\ \frac{\alpha_3 x_1}{N_H} & \frac{\alpha_3 x_1}{N_H} & \frac{\alpha_4 x_3}{N_H} & \frac{\alpha_4 x_3}{N_H} & 0 & -(\mu_2 + \delta_2) \end{bmatrix}.$$

$$\begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ w_4 \\ w_5 \\ w_6 \end{bmatrix} = 0 \quad (47)$$

To solve for W we reduce $J_{(E_0)}$, to lower triangular matrix using elementary row reduction to have

$$\begin{bmatrix} -\mu_1 & 0 & 0 & 0 & 0 & 0 \\ (A_5 + \gamma) & (-A_1 + A_3) & 0 & 0 & 0 & 0 \\ 0 & 0 & -\mu_1 & 0 & 0 & 0 \\ \frac{p_1 x_1^*}{N_h^*} & \frac{p_1 x_1^*}{N_h^*} & 0 & -A_1 & 0 & 0 \\ 0 & 0 & 0 & 0 & -\mu_2 & 0 \\ \frac{\alpha_3 x_1}{N_H} & \frac{\alpha_3 x_1}{N_H} & \frac{\alpha_4 x_3}{N_H} & \frac{\alpha_4 x_3}{N_H} & 0 & (\mu_2 + \delta_2) \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ w_4 \\ w_5 \\ w_6 \end{bmatrix} = 0. \quad (48)$$

where

$$A_5 = \frac{qx_3 R_3}{(N_H)^2 A_1} + R_2 \quad (49)$$

Solving for w in equation (48), we have

$$w_1 = w_1 \quad (50)$$

$$w_2 = \frac{A_5 + \gamma}{A_1 - A_3} w_1 \quad (51)$$

$$w_3 = 0 \quad (52)$$

$$w_4 = \frac{((A_2 - A_5) + (A_5 + \gamma))px_1}{A_1 N_H (A_1 - A_5)} w_1 \quad (53)$$

$$w_5 = 0 \quad (54)$$

$$w_6 = \left(\frac{(A_1 + \gamma)}{N_H (A_1 - A_5)} x_1 \left(\frac{\alpha_4 N_H A_1 + \alpha_4 x_3 p}{N_H A_1} \right) w_1 + \frac{\alpha_4 x_3}{N_H} \right) \frac{1}{\mu_2 - \delta_{2,1}} \quad (55)$$

Computation of a and b

$$a = \sum_{k,i,j=1}^n v_k w_i w_j \frac{\partial^2 f_k}{\partial x_i \partial x_j}(0,0) \quad (56)$$

For our model, we have $n = 6$, $k = 1, 2, 3, 4$ representing the susceptible compartments,

S_1, S_2 , the dormant and active reservoir compartments R_1, R_2 therefore,

$v_1 = v_3 = v_5 = v_6 = 0 \Rightarrow a_1 = a_3 = a_5 = a_6 = 0$. We therefore compute the associated non-zero partial derivatives of f at the DFE for $f_2 = f_4$

For f_2

$$f_2 = \frac{(px_4 + \alpha_3 x_6)x_1}{N_H} - (\mu_1 + \delta_1 + \gamma)x_2 \quad (57)$$

$$\begin{aligned} \frac{\partial^2 f_2}{\partial x_1 \partial x_j}(0,0) &= 0, \text{ for } j = 1, 2, 3, 5, & \frac{\partial^2 f_2}{\partial x_1 \partial x_4}(0,0) &= \frac{p}{N_H}, & \frac{\partial^2 f_2}{\partial x_1 \partial x_6}(0,0) &= \frac{\alpha_3}{N_H} \\ \frac{\partial^2 f_2}{\partial x_2 \partial x_1}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_2 \partial x_2}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_2 \partial x_3}(0,0) &= 0, \\ \frac{\partial^2 f_2}{\partial x_2 \partial x_4}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_2 \partial x_5}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_2 \partial x_6}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_3 \partial x_1}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_3 \partial x_2}(0,0) &= 0, \\ \frac{\partial^2 f_2}{\partial x_3 \partial x_3}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_3 \partial x_4}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_3 \partial x_5}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_3 \partial x_6}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_4 \partial x_1}(0,0) &= \frac{p}{N_H}, \\ \frac{\partial^2 f_2}{\partial x_4 \partial x_2}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_4 \partial x_3}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_4 \partial x_4}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_4 \partial x_5}(0,0) &= 0, \\ \frac{\partial^2 f_2}{\partial x_4 \partial x_6}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_5 \partial x_1}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_5 \partial x_2}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_5 \partial x_3}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_5 \partial x_4}(0,0) &= 0, \\ \frac{\partial^2 f_2}{\partial x_5 \partial x_5}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_5 \partial x_6}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_6 \partial x_1}(0,0) &= \frac{\alpha_3}{N_H}, & \frac{\partial^2 f_2}{\partial x_6 \partial x_2}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_6 \partial x_3}(0,0) &= 0, \\ \frac{\partial^2 f_2}{\partial x_6 \partial x_4}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_6 \partial x_5}(0,0) &= 0, & \frac{\partial^2 f_2}{\partial x_6 \partial x_6}(0,0) &= 0 \end{aligned}$$

For f_4

$$f_4 = \frac{(qx_2 + \alpha_4 x_6)x_3}{N_H} - (\mu_1 + \delta_1 + \gamma)x_4 \quad (58)$$

$$\begin{aligned}
 \frac{\partial^2 f_4}{\partial x_1 \partial x_1}(0,0) &= 0, \frac{\partial^2 f_4}{\partial x_1 \partial x_2}(0,0) = 0, \frac{\partial^2 f_4}{\partial x_1 \partial x_3}(0,0) = 0, \frac{\partial^2 f_4}{\partial x_1 \partial x_4}(0,0) = 0, \frac{\partial^2 f_4}{\partial x_1 \partial x_5}(0,0) = 0, \\
 \frac{\partial^2 f_4}{\partial x_1 \partial x_6}(0,0) &= 0, \frac{\partial^2 f_4}{\partial x_2 \partial x_1}(0,0) = 0, \frac{\partial^2 f_4}{\partial x_2 \partial x_2}(0,0) = 0, \frac{\partial^2 f_4}{\partial x_2 \partial x_3}(0,0) = \frac{q}{N_H}, \frac{\partial^2 f_4}{\partial x_2 \partial x_4}(0,0) = 0, \\
 \frac{\partial^2 f_4}{\partial x_2 \partial x_5}(0,0) &= 0, \frac{\partial^2 f_4}{\partial x_2 \partial x_6}(0,0) = 0, \frac{\partial^2 f_4}{\partial x_3 \partial x_1}(0,0) = 0, \frac{\partial^2 f_4}{\partial x_3 \partial x_2}(0,0) = \frac{q}{N_H}, \frac{\partial^2 f_4}{\partial x_3 \partial x_3}(0,0) = 0, \\
 \frac{\partial^2 f_4}{\partial x_3 \partial x_4}(0,0) &= 0, \frac{\partial^2 f_4}{\partial x_3 \partial x_5}(0,0) = 0, \frac{\partial^2 f_4}{\partial x_3 \partial x_6}(0,0) = \frac{\alpha_4}{N_H}, \frac{\partial^2 f_4}{\partial x_4 \partial x_1}(0,0) = 0, \frac{\partial^2 f_4}{\partial x_4 \partial x_2}(0,0) = 0, \\
 \frac{\partial^2 f_4}{\partial x_4 \partial x_3}(0,0) &= 0, \frac{\partial^2 f_4}{\partial x_4 \partial x_4}(0,0) = 0, \frac{\partial^2 f_4}{\partial x_4 \partial x_5}(0,0) = 0, \frac{\partial^2 f_4}{\partial x_4 \partial x_6}(0,0) = 0, \frac{\partial^2 f_4}{\partial x_5 \partial x_1}(0,0) = 0, \\
 \frac{\partial^2 f_4}{\partial x_5 \partial x_2}(0,0) &= 0, \frac{\partial^2 f_4}{\partial x_5 \partial x_3}(0,0) = 0, \frac{\partial^2 f_4}{\partial x_5 \partial x_4}(0,0) = 0, \frac{\partial^2 f_4}{\partial x_5 \partial x_5}(0,0) = 0, \frac{\partial^2 f_4}{\partial x_5 \partial x_6}(0,0) = 0, \\
 \frac{\partial^2 f_4}{\partial x_6 \partial x_1}(0,0) &= 0, \frac{\partial^2 f_4}{\partial x_6 \partial x_2}(0,0) = 0, \frac{\partial^2 f_4}{\partial x_6 \partial x_3}(0,0) = \frac{\alpha_4}{N_H}, \frac{\partial^2 f_4}{\partial x_6 \partial x_4}(0,0) = 0, \frac{\partial^2 f_4}{\partial x_6 \partial x_5}(0,0) = 0, \\
 \frac{\partial^2 f_4}{\partial x_6 \partial x_6}(0,0) &= 0.
 \end{aligned}$$

Therefore the associated non-zero partial derivative of f at DFE for the sign of a are given

$$\begin{aligned}
 \text{by; } \frac{\partial^2 f_2}{\partial x_1 \partial x_4}(0,0) &= \frac{p}{N_H}, \frac{\partial^2 f_2}{\partial x_1 \partial x_6}(0,0) = \frac{\alpha_3}{N_H}, \frac{\partial^2 f_2}{\partial x_4 \partial x_1}(0,0) = \frac{p}{N_H}, \frac{\partial^2 f_2}{\partial x_6 \partial x_1}(0,0) = \frac{\alpha_3}{N_H}, \\
 \frac{\partial^2 f_4}{\partial x_2 \partial x_3}(0,0) &= \frac{q}{N_H}, \frac{\partial^2 f_4}{\partial x_3 \partial x_2}(0,0) = \frac{q}{N_H}, \frac{\partial^2 f_4}{\partial x_3 \partial x_6}(0,0) = \frac{\alpha_4}{N_H}, \frac{\partial^2 f_4}{\partial x_6 \partial x_3}(0,0) = \frac{q}{N_H}
 \end{aligned} \quad (59)$$

Substituting (59) into (56), we have

$$a_2 = 2v_2 w_1 w_4 \frac{p}{N_H} + 2v_2 w_1 w_6 \frac{\alpha_3}{N_H} \quad (60)$$

$$a_4 = 2v_4 w_2 w_3 \frac{q}{N_H} + 2v_4 w_3 w_6 \frac{\alpha_4}{N_H} \quad (61)$$

Simplifying, we have;

$$a_2 = 2v_2 w_1 \left(w_4 \frac{p}{N_H} + w_6 \frac{\alpha_3}{N_H} \right) \quad a_4 = 2v_4 w_3 \left(w_2 \frac{q}{N_H} + w_6 \frac{\alpha_4}{N_H} \right)$$

$$a = a_1 + a_2 + a_3 + a_4 + a_5 + a_6, \text{ but } a_1 = a_3 = a_5 = a_6 = 0$$

$$\text{Therefore, } a = 2v_2 w_1 \left(w_4 \frac{p}{N_H} + w_6 \frac{\alpha_3}{N_H} \right) + 2v_4 w_3 \left(w_2 \frac{q}{N_H} + w_6 \frac{\alpha_4}{N_H} \right) \quad (62)$$

Clearly, if $w_1 > 0, w_2 > 0, w_3 > 0, w_4 > 0, w_5 > 0, w_6 > 0$, then, $a > 0$.

Otherwise, $w_1 < 0, w_2 < 0, w_3 < 0, w_4 < 0, w_5 < 0, w_6 < 0$ then, $a < 0$

$$\text{Similarly, } b = \sum_{k,i=1}^n v_k w_i \frac{\partial^2 f_k}{\partial x_i \partial x_\phi}(0,0) \quad (63)$$

For $k = 1, 3, 5, 6 \Rightarrow v_1 = v_3 = v_5 = v_6 = 0 \Rightarrow b_1 = b_3 = b_5 = b_6 = 0$. We therefore compute the associated non-zero partial derivatives of f at the DFE for $f_2 = f_4$

where $\phi = p^*$

$$f_2 = \frac{(px_4 + \alpha_3 x_6)x_1}{N_H} - (\mu_1 + \delta_1 + \gamma)x_2 \quad (64)$$

$$\frac{\partial^2 f_2}{\partial x_4 \partial x_\phi}(0,0) = \frac{x_1}{N_H}, \frac{\partial^2 f_2}{\partial x_1 \partial x_\phi}(0,0) = \frac{x_1}{N_H}, \frac{\partial^2 f_2}{\partial x_2 \partial x_\phi}(0,0) = 0, \frac{\partial^2 f_2}{\partial x_4 \partial x_\phi}(0,0) = 0,$$

$$\frac{\partial^2 f_2}{\partial x_5 \partial x_\phi}(0,0) = 0, \frac{\partial^2 f_2}{\partial x_6 \partial x_\phi}(0,0) = 0.$$

$$f_4 = \frac{(qx_2 + \alpha_4 x_6)x_3}{N_H} - (\mu_1 + \delta_1 + \gamma)x_4 \quad (65)$$

$$\frac{\partial^2 f_4}{\partial x_2 \partial x_\phi}(0,0) = , \frac{\partial^2 f_4}{\partial x_1 \partial x_\phi}(0,0) = 0, \frac{\partial^2 f_4}{\partial x_3 \partial x_\phi}(0,0) = 0, \frac{\partial^2 f_4}{\partial x_4 \partial x_\phi}(0,0) = 0, \frac{\partial^2 f_4}{\partial x_5 \partial x_\phi}(0,0) = 0,$$

$$\frac{\partial^2 f_4}{\partial x_6 \partial x_\phi}(0,0) = 0,$$

Substituting the derivative of (64) and (65) into (63) we have b as;

$$b_2 = v_2 w_4 \frac{x_1}{N_H} + v_2 w_1 \frac{x_4}{N_H}, \quad (67)$$

$$b_4 = 0$$

$$b = v_2 w_4 \frac{x_1}{N_H} + v_2 w_1 \frac{x_4}{N_H} \quad (68)$$

$$b = v_2 \left(\frac{w_4 x_1}{N_H} + \frac{w_1 x_4}{N_H} \right) \quad (69)$$

$x_1 > 0, x_4 > 0, w_4 > 0, w_1 > 0$. Hence, $b > 0$

Thus we claim the following

Corollary 1

If $R_0 > 1$

The endemic equilibrium points E_1 is locally asymptotically stable for R_0 close to 1

The bifurcation at $p^* = 0$ is subcritical when $a > 0, b < 0$

Conclusion

A Mathematical Model was developed for the spread and control of Lassa Fever. Key to our analysis is the basic reproductive number (R_0), which is an important threshold for disease control. The disease free equilibrium (DFE) and the endemic equilibrium were obtained. In analyzing the endemic equilibrium states for stability we also adopted the method of (Castillo- Chavez and Song, 2004), which entails finding the Right and Left eigenvalues. The

analysis shows that the endemic equilibrium points E_1 is locally asymptotically stable for R_0 close to 1, and the bifurcation at $p^* = 0$ is subcritical when $a > 0$

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MODELING AND ANALYTICAL SIMULATION OF MICROBIAL FATE AND TRANSPORT PHENOMENA IN POROUS MEDIA

I. B. S. MOHAMMED AND R. O. OLAYIWOLA

Department of Mathematics,

Federal University of Technology, Minna, Nigeria.

E-mail: olayiwola.rasaq@futminna.edu.ng babashabafu@gmail.com

Phone No: +234-805-254-8167

Abstract

Concern about pathogen contamination of groundwater and the use of microbial agents in the cleanup of groundwater has highlighted the need for an improved understanding of the fate and transport of microbes in the subsurface. This paper presents an analytical method to describe the physical, chemical and biological processes governing the simultaneous transport of microbes and nutrient in porous media. The governing equations account for the net flux of microbes by convection and dispersion, the decay and growth rates of microbes, the chemotaxis/chemotactic and the deposition of microbes on solid matrix. The decay of microbes is assumed to be a first-order reaction and the growth of microbes is assumed to follow the Monod equation. The existence and uniqueness of solution was examined. The coupled non-linear partial differential equations describing the phenomenon have been decoupled using parameter-expanding method and solved analytically using eigenfunction expansion technique. It is clear from all the results obtained that chemotaxis and sedimentation play a significant role in the transport of microbial cells through porous media.

Keywords: Microbes, microbial transport, chemotaxis, sedimentation, porous media, analytical solution.

Introduction

There has been a lot of interest in the study of fate and transport of microbes through porous media. The study is of practical nature since viruses and bacteria are responsible for some of the deadliest diseases in history, such as AIDS, the plague and flu, and yet bacteria perform the most important roles in maintaining life on this planet. Bacteria are the planet's recyclers, plant nurturer and undertakers (Christner, Morris, Foreman, Cai, Sands, 2008).

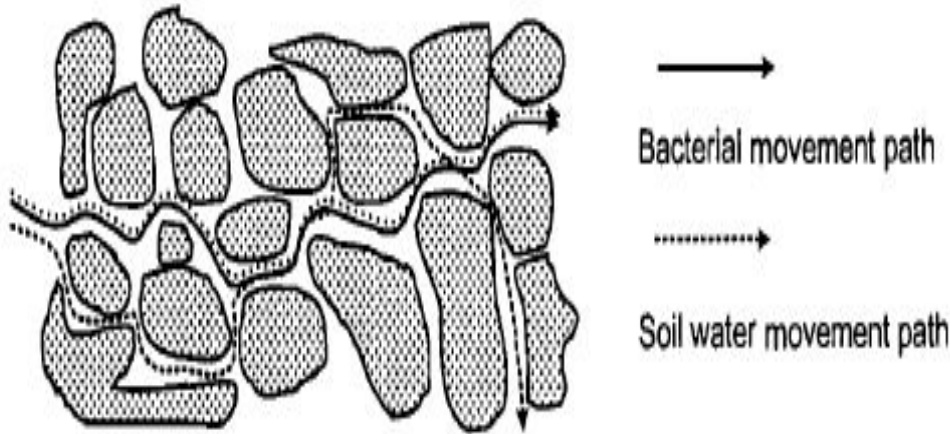
Corapcioglu and Haridas (1984) developed a model for both virus and bacteria considering the environments factors such as rainfall, soil moisture, temperature, oxygen, nutrients, etc. They found that these factors affect microbial transport. Ginn et al, (2002) in the review of physical, chemical and biological processes governing microbial transport in the saturated subsurface introduced novel conceptual models of the interactions between cell surface structures and other surfaces.

Tufenkji (2007) reviewed critically traditional approaches used to model microbial transport and fate in saturated porous media. Sen, Das, Khilar, and Suraishkumar, (2005) presented a comprehensive mathematical model for microbial transport and fate coupling with both physicochemical and biological phenomena as well as incorporation of chemotaxis/chemotactic in porous media but considered sedimentation of bacteria negligible. The numerical solution of the model was obtained using a fully implicit finite difference scheme.

Sedimentation is filtration due to gravity (Corapcioglu, & Haridas, 1984; McDowell-Boyer, Hunt & Sitar, 1986) and depends on particle buoyancy (Wan, Tokunaga & Tsang, 1995).

However, cultured microorganisms are typically larger and sometimes denser than their native counterparts (Harvey, 1997) and may involve sizeable buoyancy-driven filtration (Ginn, Wood, Nelson, Scheibe, Murphy & Clement, 2002). Thus the need for the present paper arises. Here, we incorporated sedimentation and obtained an analytical solution for describing the fate and transport of microbes in porous media. We determine the criteria for the existence of unique solution.

Model Formulation



Flow Diagram (Jiang, 2005)

Following sen et al. (2005), the transport of microbial in porous media is described by the following equations:

$$\varepsilon \frac{\partial C_b}{\partial t} = D_b \varepsilon \frac{\partial^2 C_b}{\partial x^2} - \varepsilon \left(v_p + \frac{(\rho_s - \rho)gd_s}{18\mu} + \frac{vs^2 R_t k_d}{(k_d + C_f)^2} \frac{\partial C_f}{\partial x} \right) \frac{\partial C_b}{\partial x} + \varepsilon \left(k_{g \max} \left(\frac{C_f}{k_s + C_f} \right) + k \right) C_b + k_1 \rho_b (\sigma - \sigma_0) - k_2 \varepsilon C_b \quad (1)$$

$$\frac{\partial(\rho_b \sigma)}{\partial t} = \rho_b \left(k_{g \max} \left(\frac{C_f}{k_s + C_f} \right) + k \right) \sigma - k_1 \rho_b (\sigma - \sigma_0) + k_2 \varepsilon C_b \quad (2)$$

The transport of nutrient is described by the following equation:

$$\varepsilon \frac{\partial C_f}{\partial t} + \frac{\partial(\rho_s k_f C_f)}{\partial t} = D_f \varepsilon \frac{\partial^2 C_f}{\partial x^2} - v_p \varepsilon \frac{\partial C_f}{\partial x} - \varepsilon \frac{k_{g \max}}{Y} \left(\frac{C_f}{k_s + C_f} \right) C_b - \rho_b \frac{k_{g \max}}{Y} \left(\frac{C_f}{k_s + C_f} \right) \sigma \quad (3)$$

For a packed column of length L , the initial and boundary conditions can be written as:

$$\left. \begin{aligned} C_b(x,0) &= 0, & C_b(0,t) &= C_{b0}, & \frac{\partial C_b}{\partial x} \Big|_{x=L} &= 0 \\ \sigma(x,0) &= 0 \\ C_f(x,0) &= 0, & C_f(0,t) &= C_{f0}, & \frac{\partial C_f}{\partial x} \Big|_{x=L} &= 0 \end{aligned} \right\} \quad (4)$$

where C_b is the microbial concentration (kg/m^3), ε is the porosity of the medium, v_c is the chemotactic velocity of microbes (m/s), v_p is the pore water velocity (m/s), v_g is the sedimentation velocity of microbes (m/s), D_b is the dispersion coefficient for microbes (m^2/s), r_r is the rate of release of captured or deposited microbes (kg/m^3s), r_c is the rate of capture of microbes (freely suspended microbes) (kg/m^3s), r_{gf} is the growth rate of microbes (freely suspended microbes) (kg/m^3s), r_{df} is the decay rate of microbes (freely suspended microbes) (kg/m^3s), σ is the volume of captured or deposited microbes per unit volume of porous medium (m^3/m^3), r_{gs} is the growth rate of capture or deposited microbes (kg/m^3s), r_{ds} is the decay rate of capture or deposited microbes (kg/m^3s), ρ_b is the density of microbes (kg/m^3), C_f is the nutrient (substrate) concentration (kg/m^3), S_f is the mass of adsorbed nutrient per unit mass of solid matrix (kg/kg), D_f is the dispersion coefficient for nutrient (m^2/s) and ρ_s is the bulk density of dry solid matrix (kg/m^3), s is the one-dimensional cell swimming speed (m/s), R_t is the number of receptors on the microbial cell surface, k_d is the dissociation constant for the receptor-attractant complex and ν is the differential tumbling frequency which represents the fractional change in cell run time per unit temporal change in receptor occupancy, v_g is the sedimentation velocity (acting vertically downward), ρ_s is the cell density, ρ is the solution density, g is the gravitational acceleration, μ is the dynamics viscosity and d_s is the cell diameter (treated as a sphere), k_1 is the release rate coefficient for captured cells (s^{-1}), k_2 is the capture rate coefficient for free cells and σ_0 is minimum captured cell concentration, k_{gf} and k_{gs} are specific growth rates for free and captured cells (s^{-1}), respectively, $k_{g\max}$ is the maximum specific growth rate (s^{-1}) and k_s is Monod constant for the essential nutrient (kg/m^3), k_{df} and k_{ds} are specific decay rates for free and captured cells (s^{-1}), Y is the yield coefficient, k_f is the partition coefficient (m^3/kg).

Method of Solution

Non-dimensionalization: Here, we non-dimensionalize equations (1) – (4), using the following dimensionless variables:

$$t' = \frac{v_p t}{L}, \quad x' = \frac{x}{L}, \quad C = \frac{C_b}{C_{b0}}, \quad \theta = \frac{\sigma}{\sigma_0}, \quad \phi = \frac{C_f}{C_{f0}} \quad (5)$$

and obtain

$$\frac{\partial C}{\partial t} = D_1 \frac{\partial^2 C}{\partial x^2} - \left(1 + \alpha_2 + \frac{\alpha}{(a + \phi)^2} \frac{\partial \phi}{\partial x}\right) \frac{\partial C}{\partial x} + \left(\gamma \left(\frac{\phi}{b + \phi}\right) + \delta\right) C + \beta(\theta - 1) - \lambda C \quad (6)$$

$$\frac{\partial \theta}{\partial t} = \left(\gamma \left(\frac{\phi}{b + \phi}\right) + \delta\right) \theta - \beta_1(\theta - 1) + \lambda_1 C \quad (7)$$

$$\frac{\partial \phi}{\partial t} + \alpha_1 \frac{\partial \phi}{\partial t} = D_2 \frac{\partial^2 \phi}{\partial x^2} - \frac{\partial \phi}{\partial x} - \gamma_1 \left(\frac{\phi}{b + \phi}\right) C - \gamma_2 \left(\frac{\phi}{b + \phi}\right) \theta \quad (8)$$

together with initial and boundary conditions:

$$\left. \begin{aligned} C(x, 0) = 0, \quad C(0, t) = 1, \quad \frac{\partial C}{\partial x} \Big|_{x=1} = 0 \\ \theta(x, 0) = 0 \\ \phi(x, 0) = 0, \quad \phi(0, t) = 1, \quad \frac{\partial \phi}{\partial x} \Big|_{x=1} = 0 \end{aligned} \right\}, \quad (9)$$

where

$$\begin{aligned} D_1 &= \frac{D_b}{Lv_p}, & \alpha &= \frac{vs^2 R_t k_d}{Lv_p C_{f0}}, & a &= \frac{k_d}{C_{b0}}, & b &= \frac{k_s}{C_{f0}}, & \gamma &= \frac{Lk_{g \max}}{v_p}, \\ \delta &= \frac{kL}{v_p}, & \beta &= \frac{Lk_1 \rho_b \sigma_0}{\varepsilon C_{b0} v_p}, & \lambda &= \frac{k_2 L}{v_p}, & \lambda_1 &= \frac{Lk_2 \varepsilon C_{b0}}{\rho_b \sigma_0 v_p}, & \beta_1 &= \frac{k_1 L}{v_p}, \\ \alpha_1 &= \frac{Lk_f \rho_s}{\varepsilon}, & D_2 &= \frac{D_f}{Lv_p}, & \gamma_1 &= \frac{Lk_{g \max} C_{b0}}{Y C_{f0} v_p}, & \gamma_2 &= \frac{Lk_{g \max} \rho_b \sigma_0}{Y \varepsilon C_{f0} v_p}, & \alpha_2 &= \frac{(\rho_s - \rho) g d_s}{18 \mu v_p} \end{aligned}$$

Existence and Uniqueness of Solution

Theorem 1: Let $D_1 = D_2 + D$, $\alpha = \alpha_1 = \alpha_2 = \gamma = \gamma_1 = \gamma_2 = 0$, $\lambda = \lambda_1 = \beta_1 = \delta$. Then the equations (6) – (8) with initial and boundary conditions (9) has a unique solution for all $t \geq 0$.

Proof: Let $D_1 = D_2 + D$, $\alpha = \alpha_1 = \alpha_2 = \gamma = \gamma_1 = \gamma_2 = 0$, $\lambda = \lambda_1 = \beta_1 = \delta$ and $\psi(x, t) = C(x, t) + \phi(x, t)$, we obtain

$$\frac{\partial \theta}{\partial t} = \delta(1 + C), \quad \theta(x, 0) = 0 \quad (10)$$

$$\frac{\partial \psi}{\partial t} = D \frac{\partial^2 \psi}{\partial x^2} - \frac{\partial \psi}{\partial x} + \beta(\theta - 1), \quad \psi(x, 0) = 0, \quad \psi(0, t) = 2, \quad \psi_x(1, t) = 0 \quad (11)$$

Using direct integration and eigenfunction expansion method, we obtain the solution of problem (10) as

$$\theta(x, t) = \delta(t + k(x, t)) \quad (12)$$

where

$$k(x, t) = \int C(x, t) dt$$

and the solution of problem (11) as

$$\psi(x, t) = 2 + \beta \sum_{n=1}^{\infty} V_n(t) \sin\left(\frac{2n-1}{2}\pi x\right) \quad (13)$$

where

$$V_n(t) = \int_0^t \exp\left(-D\left(\frac{(2n-1)\pi}{2}\right)^2(t-\tau)\right) F_n(\tau) d\tau$$

$$F_n(t) = 2\delta T_n(t) + \frac{4}{(2n-1)\pi}(\delta t - 1)$$

$$T_n(t) = \int_0^1 k(x, t) \sin\left(\frac{(2n-1)\pi x}{2}\right) \pi x dx$$

Then, we obtain

$$C(x, t) = \left(2 + \beta \sum_{n=1}^{\infty} V_n(t) \sin\left(\frac{(2n-1)\pi x}{2}\right)\right) - \phi(x, t) \quad (14)$$

$$\phi(x, t) = \left(2 + \beta \sum_{n=1}^{\infty} V_n(t) \sin\left(\frac{(2n-1)\pi x}{2}\right)\right) - C(x, t) \quad (15)$$

Hence, there exists a unique solution of problem (21) – (23). This completes the proof.

Analytical Solution

We let $m = 1 + \alpha_2$ in (6) and solve equations (6) – (9) using parameter-expanding method (where details can be found in [5]) and eigenfunctions expansion method (where details can be found in [8]).

We rewrite equations (6) - (8) in the form:

$$\frac{\partial C}{\partial t} = D_1 \frac{\partial^2 C}{\partial x^2} - \left(m + \frac{\alpha}{(a + \phi)^2} \frac{\partial \phi}{\partial x}\right) \frac{\partial C}{\partial x} + \left(\gamma \left(\frac{\phi}{b + \phi}\right) + \delta\right) C + \beta(\theta - 1) - \lambda C \quad (16)$$

$$\frac{\partial \theta}{\partial t} = \left(\gamma \left(\frac{\phi}{b + \phi}\right) + \delta\right) \theta - \beta_1(\theta - 1) + \lambda_1 C \quad (17)$$

$$\frac{\partial \phi}{\partial t} + \alpha_1 \frac{\partial \phi}{\partial t} = D_2 \frac{\partial^2 \phi}{\partial x^2} - f\alpha \frac{\partial \phi}{\partial x} - \gamma_1 \left(\frac{\phi}{b + \phi}\right) C - \gamma_2 \left(\frac{\phi}{b + \phi}\right) \theta, \quad (18)$$

where $f\alpha = 1$

We let

$$m = h\alpha, \quad \gamma = p\alpha, \quad \lambda_1 = q\alpha, \quad \gamma_1 = r\alpha, \quad \gamma_2 = s\alpha$$

Suppose that the solution of equations (16) – (18) can be expressed as:

$$\left. \begin{aligned} C(x, t) &= C_0(x, t) + \alpha C_1(x, t) + \dots \\ \theta(x, t) &= \theta_0(x, t) + \alpha \theta_1(x, t) + \dots \\ \phi(x, t) &= \phi_0(x, t) + \alpha \phi_1(x, t) + \dots \end{aligned} \right\} \quad (19)$$

Substituting (19) into (16) – (18) and processing, we obtain

$$\frac{\partial C_0}{\partial t} = D_1 \frac{\partial^2 C_0}{\partial x^2} + (\delta - \lambda)C_0 + \beta(\theta_0 - 1) \quad (20)$$

$$C_0(x, 0) = 0, \quad C_0(0, t) = 1, \quad \left. \frac{\partial C_0}{\partial x} \right|_{x=1} = 0$$

$$\frac{\partial \theta_0}{\partial t} = (\delta - \beta_1)\theta_0 + \beta_1 \quad (21)$$

$$\theta_0(x, 0) = 0$$

$$\frac{\partial \phi_0}{\partial t} + \alpha_1 \frac{\partial \phi_0}{\partial t} = D_2 \frac{\partial^2 \phi_0}{\partial x^2} \quad (22)$$

$$\phi_0(x,0)=0, \quad \phi_0(0,t)=1, \quad \left. \frac{\partial \phi_0}{\partial x} \right|_{x=1} = 0$$

$$\frac{\partial C_1}{\partial t} = D_1 \frac{\partial^2 C_1}{\partial x^2} + (\delta - \lambda)C_1 - h \frac{\partial C_0}{\partial x} - \frac{1}{(a + \phi_0)^2} \frac{\partial \phi_0}{\partial x} \frac{\partial C_0}{\partial x} + p \left(\frac{\phi_0}{b + \phi_0} \right) C_0 + \beta \theta_1 \quad (23)$$

$$C_1(x,0)=0, \quad C_1(0,t)=0, \quad \left. \frac{\partial C_1}{\partial x} \right|_{x=1} = 0$$

$$\frac{\partial \theta_1}{\partial t} = (\delta - \beta_1)\theta_1 + p \left(\frac{\phi_0}{b + \phi_0} \right) \theta_0 + q C_0 \quad (24)$$

$$\theta_1(x,0)=0$$

$$\frac{\partial \phi_1}{\partial t} + \alpha_1 \frac{\partial \phi_1}{\partial t} = D_2 \frac{\partial^2 \phi_1}{\partial x^2} - f \frac{\partial \phi_0}{\partial x} - r \left(\frac{\phi_0}{b + \phi_0} \right) C_0 - s \left(\frac{\phi_0}{b + \phi_0} \right) \theta_0 \quad (25)$$

$$\phi_1(x,0)=0, \quad \phi_1(0,t)=0, \quad \left. \frac{\partial \phi_1}{\partial x} \right|_{x=1} = 0$$

Using integrating factor method and eigenfunctions expansion method, we obtain the solution of equations (20) - (25) as

$$C_0(x,t) = 1 + \sum_{n=1}^{\infty} (q_1(e^{Bt} - e^{p_1t}) - q_2(1 - e^{p_1t})) \sin\left(\frac{2n-1}{2}\right) \pi x \quad (26)$$

$$\theta_0(x,t) = A(1 - e^{Bt}) \quad (27)$$

$$\phi_0(x,t) = 1 \quad (28)$$

$$C_1(x,t) = \sum_{n=1}^{\infty} \left(\beta \sum_{n=1}^{\infty} (q_3(e^{Bt} - e^{p_1t}) - q_4(e^{-Bt} - e^{p_1t}) - q_5(1 - e^{p_1t}) - m_4 t e^{p_1t}) + \right. \\ \left. m_8 \sum_{n=1}^{\infty} (q_6(e^{Bt} - e^{p_1t}) + q_7(1 - e^{p_1t}) - (q_2 + q_1) t e^{p_1t}) + \right. \\ \left. \frac{4\beta}{(2n-1)\pi} (-q_8(1 - e^{p_1t}) + q_9(e^{-Bt} - e^{p_1t}) - q_{10}(e^{Bt} - e^{p_1t})) - \right. \\ \left. h \sum_{n=1}^{\infty} \frac{(1 + (-1)^{2n})}{2} \left(q_6(e^{Bt} - e^{p_1t}) + q_7(1 - e^{p_1t}) + \right. \right. \\ \left. \left. (q_2 - q_1) t e^{p_1t} \right) \right) \sin\left(\frac{2n-1}{2}\right) \pi x \quad (29)$$

$$\theta_1(x,t) = \sum_{n=1}^{\infty} (m_2 e^{Bt} + m_3 e^{-Bt} - m_4 e^{p_1t} + m_5) \sin\left(\frac{2n-1}{2}\right) \pi x + m_6(1 - e^{-Bt}) + m_7(e^{Bt} - e^{-Bt}) \quad (30)$$

$$\phi_1(x,t) = \sum_{n=1}^{\infty} \left((p_3 + p_4)(1 - e^{p_2t}) + p_5(e^{Bt} - e^{p_2t}) - \right. \\ \left. \sum_{n=1}^{\infty} (p_6(e^{Bt} - e^{p_2t}) + p_7(e^{p_1t} - e^{p_2t}) + p_8(1 - e^{p_2t})) \right) \sin\left(\frac{2n-1}{2}\right) \pi x \quad (31)$$

where

$$\begin{aligned}
 A &= \frac{\beta_1}{\beta_1 - \delta}, \quad B = \beta_1 - \delta, \quad B_1 = \delta - \lambda, \quad p_1 = \left(B_1 - D_1 \left(\left(\frac{2n-1}{2} \right) \pi \right)^2 \right), \quad q_1 = \frac{4\beta A}{(2n-1)p_1\pi}, \\
 q_2 &= \frac{4(\beta(A-1) + B_1)}{(2n-1)p_1\pi}, \quad D_3 = \frac{D_2}{1+\alpha_1}, \quad m = \frac{pA}{b+1} + q, \quad m_1 = \frac{pA}{b+1}, \quad m_2 = \frac{qq_1}{2B}, \quad m_5 = \frac{qq_2}{B}, \\
 m_3 &= \frac{qq_1}{B+p_1} - \frac{qq_1}{2B} + \frac{qq_2}{B+p_1} - \frac{qq_2}{B}, \quad m_4 = \frac{q(q_1+q_2)}{B+p_1}, \quad m_6 = \frac{m}{B}, \quad m_7 = \frac{m_1}{2B}, \quad m_8 = \frac{p}{b+1}, \\
 q_3 &= \frac{m_2}{B-p_1}, \quad q_4 = \frac{m_3}{B+p_1}, \quad q_5 = \frac{m_5}{p_1}, \quad q_6 = \frac{q_1}{B-p_1}, \quad q_7 = \frac{q_2}{p_1}, \quad q_8 = \frac{m_6}{p_1}, \quad q_9 = \frac{m_6 - m_7}{B+p_1}, \\
 q_{10} &= \frac{m_7}{B-p_1}, \quad q_{12} = \frac{r}{(1+\alpha_1)(b+1)}, \quad q_{13} = \frac{sA}{(1+\alpha_1)(b+1)}, \quad p_2 = -D_3 \left(\left(\frac{2n-1}{2} \right) \pi \right)^2, \\
 p_3 &= \frac{4q_{12}}{(2n-1)p_2\pi}, \quad p_4 = \frac{4q_{13}}{(2n-1)p_2\pi}, \quad p_5 = \frac{4q_{13}}{(2n-1)(B-p_2)\pi}, \quad p_6 = \frac{q_1 q_{12}}{B-p_2}, \\
 p_7 &= \frac{q_{12}(q_2 - q_1)}{p_1 - p_2}, \quad p_8 = \frac{q_2 q_{12}}{p_2}
 \end{aligned}$$

The computations were done using computer symbolic algebraic package MAPLE.

Results and Discussion

The systems of partial differential equations describing the physical, chemical and biological processes governing the simultaneous transport of microbes and nutrient in the presence of filtration due to gravity are solved analytically using parameter-expanding method and eigenfunction expansion technique. Analytical solutions of equations (16) - (19) are computed for the values of $\alpha = 1$, $\alpha_2 = 0.4$, $D_1 = 0.4$, $D_2 = 0.3$, $\beta = 0.2$, $\beta_1 = 0.2$,

$$\lambda = 0.5, \quad \lambda_1 = 0.5, \quad \delta = 1, \quad \alpha_1 = 1, \quad a = 1, \quad b = 20, \quad \gamma = 1, \quad \gamma_1 = 1, \quad \gamma_2 = 1$$

The following figures explain the distribution of volume of captured microbes and microbial and nutrient concentration against different dimensionless parameters.

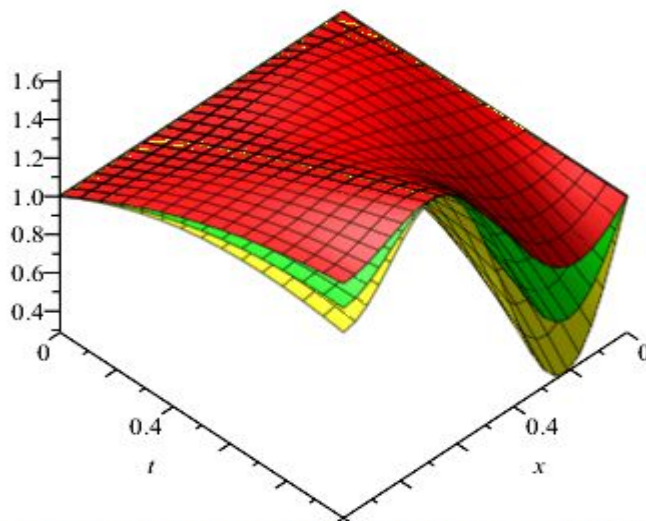


Figure 1: Variation of microbial concentration $C(x, t)$ with gravity number α_2

From Figure 1, we can conclude that with the increase of Gravity number (α_2), microbial concentration decreases along the temporal and spatial directions.

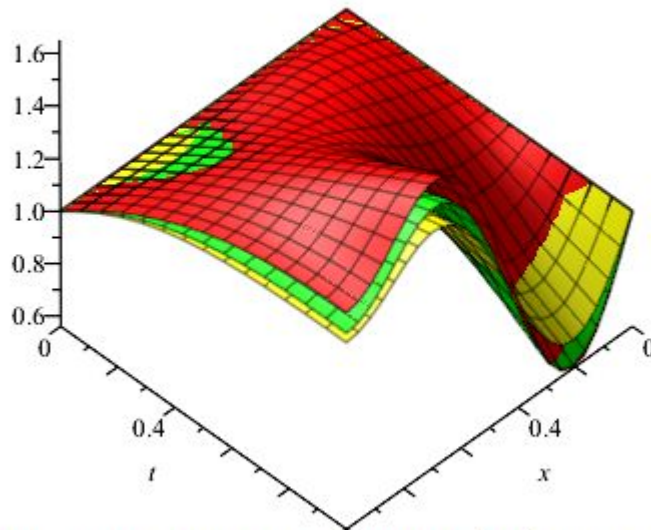


Figure 2: Variation of microbial concentration $C(x, t)$ with dispersion coefficient for microbes D_1

From Figure 2, we can conclude that with the increase of dispersion coefficient for microbes (D_1), microbial concentration decreases along the temporal and spatial directions.

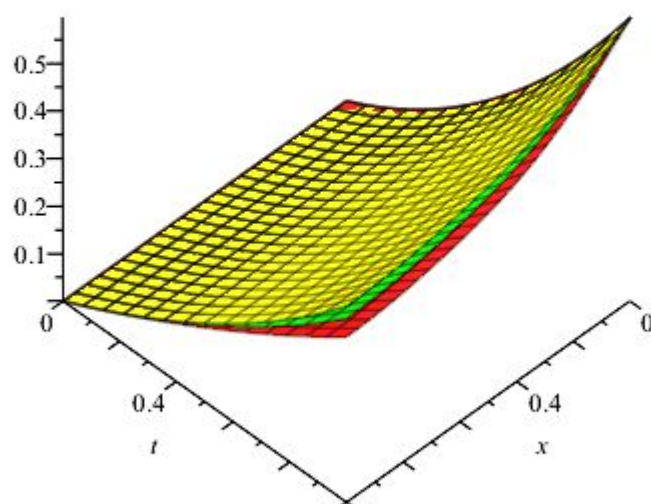


Figure 3: Variation of volume of captured microbes $\theta(x, t)$ with dispersion coefficient for microbes D_1

From Figure 3, we can conclude that with the increase of dispersion coefficient for microbes (D_1), the volume of captured microbes increases along the temporal and spatial directions.

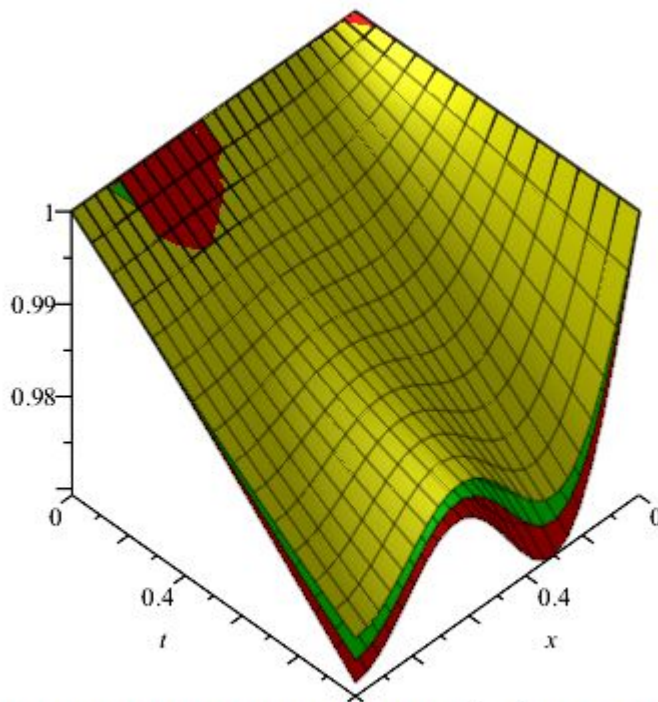


Figure 4: Variation of nutrient concentration $\phi(x, t)$ with dispersion coefficient for nutrient D_2

From Figure 4, we can conclude that with the increase of dispersion coefficient for nutrient (D_2), nutrient concentration increases along the temporal and spatial directions.

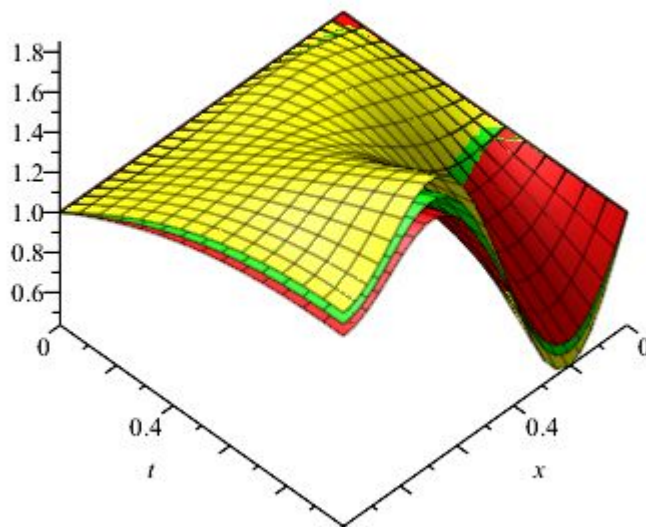


Figure 5: Variation of microbial concentration $C(x, t)$ with release rate coefficient for captured cells β

From Figure 5, we can conclude that with the increase of release rate coefficient for captured cells (β), microbial concentration increases along the temporal and spatial directions.

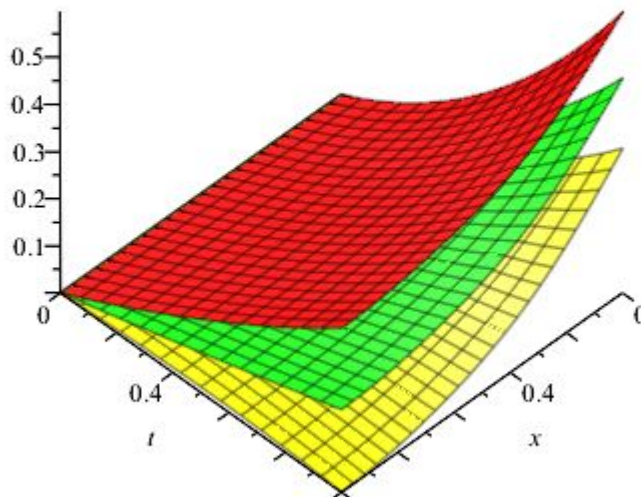


Figure 6: Variation of volume of captured microbes $\theta(x, t)$ with release rate coefficient for captured cells β

From Figure 6, we can conclude that with the increase of release rate coefficient for captured cells (β), the volume of captured microbes decreases along the temporal and spatial directions.

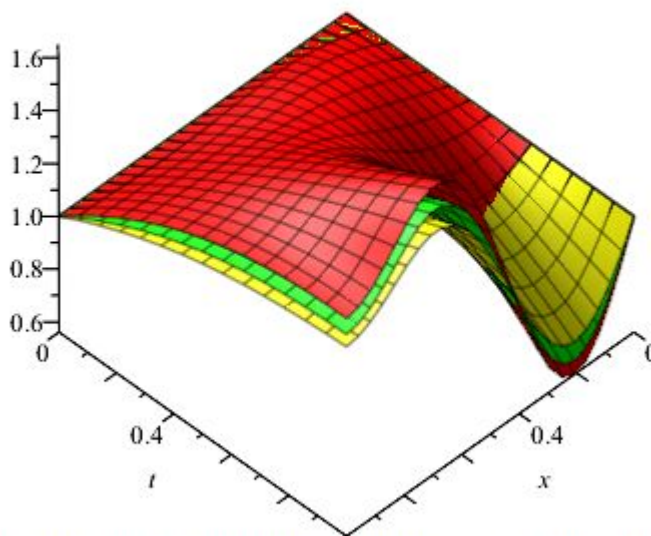


Figure 7: Variation of microbial concentration $C(x, t)$ with capture rate coefficient for free cells λ

From Figure 7, we can conclude that with the increase of capture rate coefficient for free cells (λ), microbial concentration decreases along the temporal and spatial directions.

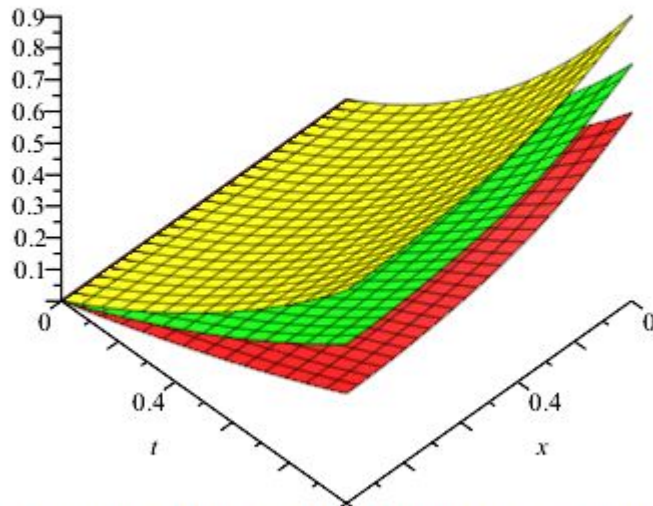


Figure 8: Variation of volume of captured microbes $\theta(x, t)$ with capture rate coefficient for free cells λ

From Figure 8, we can conclude that with the increase of capture rate coefficient for free cells (λ), volume of captured microbes increases along the temporal and spatial directions.

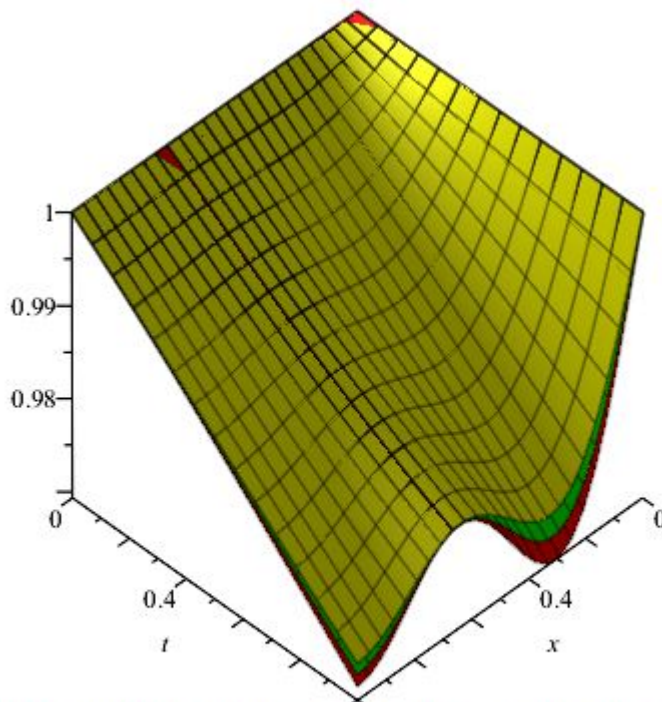


Figure 9: Variation of nutrient concentration $\phi(x, t)$ with capture rate coefficient for free cells λ

From Figure 9, we can conclude that with the increase of capture rate coefficient for free cells (λ), nutrient concentration increases along the temporal and spatial directions.

Conclusion

In this work, we studied the physical, chemical and biological processes governing the simultaneous transport of microbes and nutrients in porous media. The model used allows some essential insight of how chemotaxis and sedimentation can change the concentration of free and captured microbes. Based on our results, we state that:

- (i) Gravity number decreases the microbial concentration.
- (ii) Dispersion coefficient for microbes enhances the volume of captured microbes and decreases the microbial concentration.
- (iii) Dispersion coefficient for nutrient enhances the nutrient concentration.
- (iv) Release rate coefficient for captured cells enhances the microbial concentration and decreases the volume of captured microbes.
- (v) Capture rate coefficient for free cells decreases the microbial concentration and enhances the volume of captured microbes and nutrient concentration.

The main conclusion is that increase in weight or size of free microbes change significantly the concentration of free microbes, possibly many of them felled and were trapped in the pore matrix due to weight and size. This has negative implication on their survival when moving with soil water through the pore. Thus, it is crucial to prevent microbes from adding weight or size as it may affect their movement through porous media.

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STABILITY ANALYSIS OF THE DISEASE-FREE EQUILIBRIUM STATE OF A MATHEMATICAL MODEL OF TUBERCULOSIS DYNAMICS

NDAMAN ISAH

Department of mathematics, Niger State College of Education, Minna, Nigeria

Email: Isahgura@gmail.com

Abstract

A mathematical model for the transmission dynamics and control of tuberculosis incorporating treatment at both latent and active classes was developed. The disease-free equilibrium state was analyzed for stability and the result shows that the state is globally stable when the basic reproduction number, R_0 is less or equal to unity. Numerical simulation was used to verify the analytical result. It shows that the disease can be eradicated in 200 (years) if a high level of treatment is applied to both the active class and the latent class of the subpopulation.

Keywords: Tuberculosis, disease-free equilibrium state, basic reproduction number, stability.

Introduction

Tuberculosis (TB) remains one of the world's deadliest communicable disease. In 2013, an estimated 9.0 million people developed TB and 1.5 million died from the disease, 360000 of whom were HIV positive. TB is slowly declining each year and it is estimated that 37 million lives were saved between 2000 and 2013 through effective diagnosis and treatment (WHO, 2014). An estimated 480000 and 590000 were the cases reported for incidence and prevalence of TB in Nigeria for 2014 respectively, while about 91000 died from the disease (WHO, 2015). The high incidence of tuberculosis in the developing countries is as a result of poverty and underdevelopment, which lead to overcrowding, malnutrition, lack of access to good health care services which are contributory factors to the spread of the disease. The nature of population distribution is such that many people live in small areas, while others in larger areas have sparse concentration of people. This uneven pattern of population distribution, which results into massive concentration of people in a limited area, is a major factor which has helped to sustain some diseases, especially the airborne diseases of which tuberculosis is one.

In order to find an efficient way to control an infection, it is of great important to establish its transmission dynamics. Mathematical modeling and analysis is central to disease epidemiology. Numerous mathematical models were developed to study a disease transmission, to evaluate the spread of epidemics, and more importantly, to understand the mechanisms of epidemics in order to prevent them or minimize the transmission of disease via behavior change, vaccination, treatment, quarantine and other measures. During the last three decades Egbetade *et al.* (2012), James *et al.* (2012), Ibrahim *et al.* (2013), okuonghae *et al.* (2013), Bowong (2010) and Cagri *et al.* (20013) have designed mathematical models to evaluate the effects of tuberculosis in different population settings. Considering the works of the aforementioned authors, a new mathematical model is developed incorporating treatment at both latent and active classes of the population.

Materials and Methods

Model Development

Dividing the total population into three (3) compartments of Susceptible, Latent and Active individuals we assumed that:

- (a) There is homogeneous mixing of the population, where all people are equally likely to be infected by the active individuals in case of contact;
- (b) There is constant recruitment rate into the susceptible class;
- (c) New births are not infected at birth, i.e. the transmission is not vertical

The model variables and parameters are defined as follows:

$S(t)$ Susceptible individuals at time, t

$L(t)$ Latently infected individuals at time, t

$A(t)$ Active individuals at time, t

$N(t)$ Total population at time, t

Λ Recruitment rate

μ Natural death removal rate (or death due to other causes)

α Transmission probability per contact

τ_L Treatment rate of latently infected individuals

τ_A Treatment rate of active individuals

γ Progression rate from L class into A class due to lack of treatment or immunity

δ Tuberculosis induced death rate

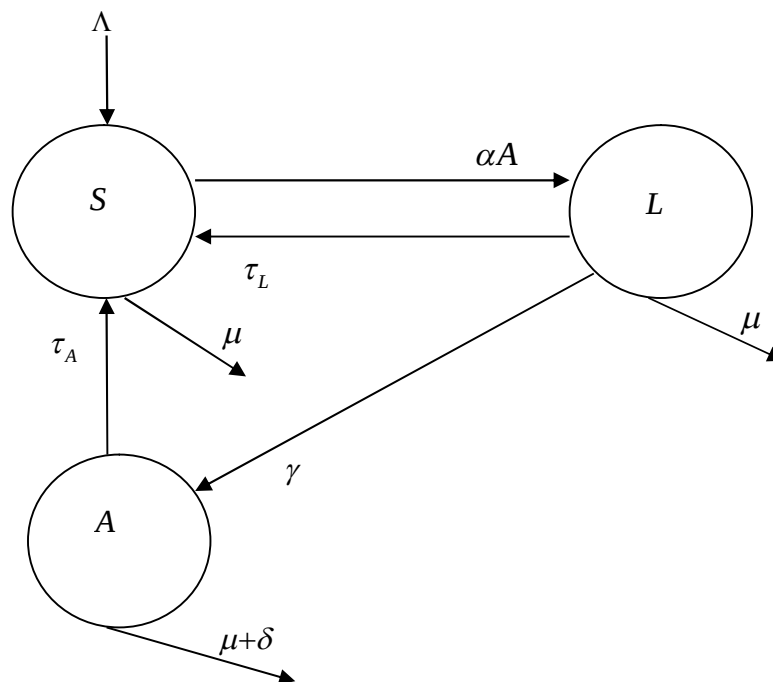


Figure 1: A schematic representation of the model

Schematic Diagram of Tuberculosis Transmission Dynamics

The susceptible subpopulation $S(t)$ is generated from constant recruitment of individuals at a rate Λ . They acquired infection via horizontal transfer from individuals in the active class (A) at a rate α and thus become latently infected. Individuals in the latent class recovered from the disease due to treatment at the rate τ_L and move back to the

susceptible class or progresses to the active class at the rate γ . The active individual's can also recover from the disease due to treatment at the rate τ_A and move back to the susceptible class or die due to the disease at the rate δ . Natural death occurs in all classes at a rate μ .

The proposed mathematical model of the dynamics is described by a system of ordinary differential equations given below from (3.1a) to (3.1c)

$$\frac{dS}{dt} = \Lambda - \alpha AS + \tau_L L + \tau_A A - \mu S \quad (3.1a)$$

$$\frac{dL}{dt} = \alpha AS - (\tau_L + \gamma + \mu)L \quad (3.1b)$$

$$\frac{dA}{dt} = \gamma L - (\tau_A + \mu + \delta)A \quad (3.1c)$$

Where

$$N = S + L + A \quad (3.2)$$

From the model system (3.1), let

$$K_1 = (\tau_L + \gamma + \mu) \quad (3.3)$$

$$K_2 = (\tau_A + \mu + \delta) \quad (3.4)$$

Equations (3.1a) to (3.1c) becomes

$$\frac{dS}{dt} = \Lambda - \alpha AS + \tau_L L + \tau_A A - \mu S \quad (3.5a)$$

$$\frac{dL}{dt} = \alpha AS - K_1 L \quad (3.5b)$$

$$\frac{dA}{dt} = \gamma L - K_2 A \quad (3.5c)$$

The total population size $N(t)$ can be determine by analysing (3.5a) to (3.5c) giving

$$\frac{dN}{dt} = \Lambda - \mu N - \delta A \quad (3.6)$$

The model (3.1) is epidemiologically and mathematically well-posed in the domain,

$$\Omega = \left\{ \begin{pmatrix} S \\ L \\ A \end{pmatrix} \in R_+^3 \mid \begin{array}{l} S \geq 0, \\ L \geq 0, \\ A \geq 0, \\ S + L + A \leq N \end{array} \right\} \quad (3.7)$$

This domain, Ω , is valid epidemiologically as the sub-populations S, L , and A are all non-negative and have sums less than or equal the total population, N .

Existence of Equilibria, E^*

At equilibrium state the rate of change of each variable is equal to zero. i.e.

$$\frac{dS}{dt} = \frac{dL}{dt} = \frac{dA}{dt} = 0 \quad (3.8)$$

Let

$$\begin{pmatrix} S \\ L \\ A \\ N \end{pmatrix} = \begin{pmatrix} S^* \\ L^* \\ A^* \\ N^* \end{pmatrix} \quad (3.9)$$

Thus, we have from system (3.5)

$$\Lambda - \alpha I^* S^* + \tau_L L^* + \tau_I I^* - \mu S^* = 0 \quad (3.10a)$$

$$\alpha A^* S^* - K_1 L^* = 0 \quad (3.10b)$$

$$\gamma L^* - K_2 A^* = 0 \quad (3.10c)$$

From (3.10c), we have

$$A^* = \frac{\gamma L^*}{K_2} \quad (3.11)$$

Substituting (3.11) into (3.10b), gives

$$\frac{\alpha \gamma L^* S^*}{K_2} - K_1 L^* = 0$$

i.e.

$$L^* (\alpha \gamma S^* - K_1 K_2) = 0$$

Thus

$$L^* = 0 \quad (3.12)$$

or

$$(\alpha \gamma S^* - K_1 K_2) = 0 \quad (3.13)$$

If (3.12) holds, then substituting it into (3.11) gives

$$A^* = 0 \quad (3.14)$$

Substituting (3.12) and (3.14) into system (3.10a) gives

$$S^* = \frac{\Lambda}{\mu} \quad (3.15)$$

Thus, the disease-free equilibrium state of the model is given by

$$(S^*, L^*, A^*) = \left(\frac{\Lambda}{\mu}, 0, 0 \right) \quad (3.16)$$

Similarly, if (3.13) holds, then

$$S^* = \frac{K_1 K_2}{\alpha \gamma} \quad (3.16)$$

Substituting (3.11) and (3.16) into system (3.10a) gives

$$\Lambda - K_1 L^* + \tau_L L^* + \frac{\tau_A \gamma L^*}{K_2} - \frac{\mu K_1 K_2}{\alpha \gamma} = 0$$

i.e.

$$L^* = \frac{(\Lambda \alpha \gamma - \mu K_1 K_2) K_2}{\alpha \gamma (K_1 K_2 - \tau_L K_2 - \tau_A \gamma)} \quad (3.17)$$

And substituting (3.17) into system (3.11) gives

$$A^* = \frac{(\Lambda \alpha \gamma - \mu K_1 K_2)}{\alpha (K_1 K_2 - \tau_L K_2 - \tau_A \gamma)} \quad (3.18)$$

Thus, an endemic equilibrium state of the model is given by

$$(S^*, L^*, A^*) = \left(\frac{K_1 K_2}{\alpha \gamma}, \frac{(\Lambda \alpha \gamma - \mu K_1 K_2) K_2}{\alpha \gamma (K_1 K_2 - \tau_L K_2 - \tau_A \gamma)}, \frac{(\Lambda \alpha \gamma - \mu K_1 K_2)}{\alpha (K_1 K_2 - \tau_L K_2 - \tau_A \gamma)} \right) \quad (3.19)$$

Basic Reproduction Number, R_0

Using the next generation operator technique described by Diekmann and Heesterbeek (2000) and subsequently analysed by Van den Driessche and Watmough (2002), we obtained the basic reproduction number, R_0 of the system model which is the spectral radius (ρ) of the next generation matrix, K .

i.e.

$$R_C = \rho K, \text{ where } K = FV^{-1}$$

Let

$$E^0 = (S^0, L^0, A^0) \quad (3.20)$$

denote the disease-free equilibrium state, then

$$F = \begin{pmatrix} 0 & \alpha S^0 \\ 0 & 0 \end{pmatrix} \quad (3.21)$$

and

$$V = \begin{pmatrix} K_1 & 0 \\ -\gamma & K_2 \end{pmatrix} \quad (3.22)$$

Thus,

$$R_0 = \frac{\alpha \gamma \frac{\Lambda}{\mu}}{K_1 K_2} \quad (3.23)$$

Local Stability Analysis of Disease-free Equilibrium State, E^0

We used the Jacobian stability approach to prove the local stability of the disease-free equilibrium state. Linearization of the system (3.10) at E^0 , gives the Jacobian matrix

$$J(E^0) = \begin{pmatrix} -\mu & \tau_L & -(\alpha S^0 - \tau_A) \\ 0 & -K_1 & \alpha S^0 \\ 0 & \gamma & -K_2 \end{pmatrix} \quad (3.24)$$

We now make the following elementary row-transformation:

Add $\frac{\gamma}{K_1}$ times the second row to the third row.

$$J(E^0) = \begin{pmatrix} -\mu & \tau_L & -(\alpha S^0 - \tau_A) \\ 0 & -K_1 & \alpha S^0 \\ 0 & 0 & -\left(\frac{K_1 K_2 - \gamma \alpha S^0}{K_1}\right) \end{pmatrix} \quad (3.25)$$

Thus, the eigenvalues are

$$\lambda_1 = -\mu < 0, \quad \lambda_2 = -K_1 < 0,$$

and

$$\lambda_3 = -\left(\frac{K_1 K_2 - \gamma \alpha S^0}{K_1}\right)$$

now, for λ_3 to be negative, we must have

$$-\left(\frac{K_1 K_2 - \gamma \alpha S^0}{K_1}\right) < 0$$

i.e

$$-K_1 K_2 + \gamma \alpha S^0 < 0$$

or

$$\frac{\alpha \gamma \frac{\Lambda}{\mu}}{K_1 K_2} < 1$$

Thus, $\lambda_3 < 0$ if $R_0 < 1$ implying all the eigenvalues have negative real parts, we therefore, established the following result.

Theorem 1: The disease-free equilibrium state, E^0 of the model is locally asymptotically stable (LAS) if $R_0 < 1$.

Global stability of disease-free equilibrium point, E^0

The epidemiological implication of theorem 1 is that tuberculosis can be eliminated (control) from the population when $R_0 < 1$, if the initial size of the sub-populations of the model are in the basin of attraction of the E^0 .

In order to ensure that tuberculosis is independent of the initial size of the sub-populations of the model, it is necessary to show that the E^0 is globally-asymptotically stable (GAS). One common approach in studying the global asymptotic stability of the DFE is to construct an appropriate Lyapunov function.

Theorem 3: The disease-free equilibrium E^0 of the model is globally asymptotically stable (GAS) in Ω if $R_0 \leq 1$.

Proof: Consider the Lyapunov function:

$$f = \gamma L + K_1 A \quad (2.26)$$

Its derivatives along the solutions of the model equations is

$$\begin{aligned} f' &= \gamma L' + K_1 A' \\ &= \gamma (\alpha AS - K_1 L) + K_1 (\gamma L - K_2 A) \\ &= \alpha \gamma AS - K_1 K_2 A \\ &= AK_1 K_2 \left(\frac{\alpha \gamma S}{K_1 K_2} - 1 \right) \end{aligned} \quad (2.27)$$

Now, since $S \leq S^0$, we have

$$f' \leq K_1 K_2 A \left(\frac{\alpha \gamma S^0}{K_1 K_2} - 1 \right)$$

i.e.

$$f' \leq K_1 K_2 A (R_0 - 1)$$

When $R_0 \leq 1$, $f' \leq 0$; the equality $f' = 0$ holds when $R_0 = 1$ and $A = 0$. Thus $A = 0$ is the largest invariant subsets in the set $f' = 0$. Thus, according to the asymptotical stability theorem of Lyapunov-LaSalle theorem E^0 is overall globally asymptotically stable in $\mathcal{R}_+^3$ and hence, the result is proved.

Numerical Simulation

Our numerical results were obtained and confirmed using different levels of treatment. At high levels of treatments (fig.1) the disease reduce drastically and vanishes at two hundred (200) years from the active class, while in the latent class the population of infective declines gradually and vanishes after 300 years. We examine treatment at low levels (fig.2) and the result show that the disease cannot be wipe out in the latent class but can be eradicated from the active class at about 270 years. Further, the impact of treatment leads to increase in population of the susceptibles (fig. 3).

The values of the parameters were obtained using data from Nigeria's central intelligence agency, on the population of Nigeria (177,155,754), life expectancy (52.64 years), birth rate 38.03/1000 population and natural death 13.16/1000 (CIA, 2014); other parameter values are from literature. The model parameters and their values are presented in Table 1

Table 1: Model Parameter and Values

Parameter	Description	Estimated value	Reference
Λ	Recruitment rate	9000	Estimated
$S(t)$	Susceptible class	162,000000	Estimated
$L(t)$	Latently infected	10,000000	Estimated
$A(t)$	Actively infected	5000000	Estimate
$N(t)$	Total Nigeria population	177000000	CIA
τ_L	Treatment for latent class	$0 < \tau_L < 1$	Estimate
τ_A	Treatment for active class	$0 < \tau_A < 1$	Estimate
μ	Natural death rate	0.01316	CIA
γ	Progression from latent to active class	0.000256	Cagri et al
δ	TB induced death rate	0.139	Cagri et al
α	Contact rate	0.0002	Estimate

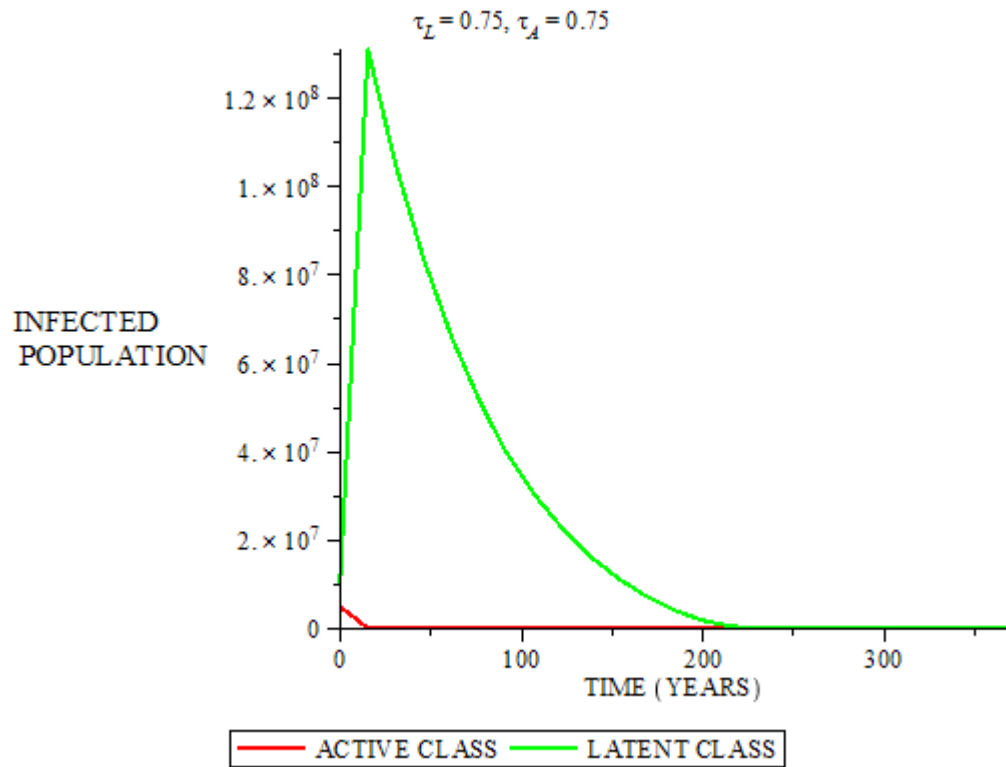


Figure 1: Shows the effect of high level treatment on the active and latent class

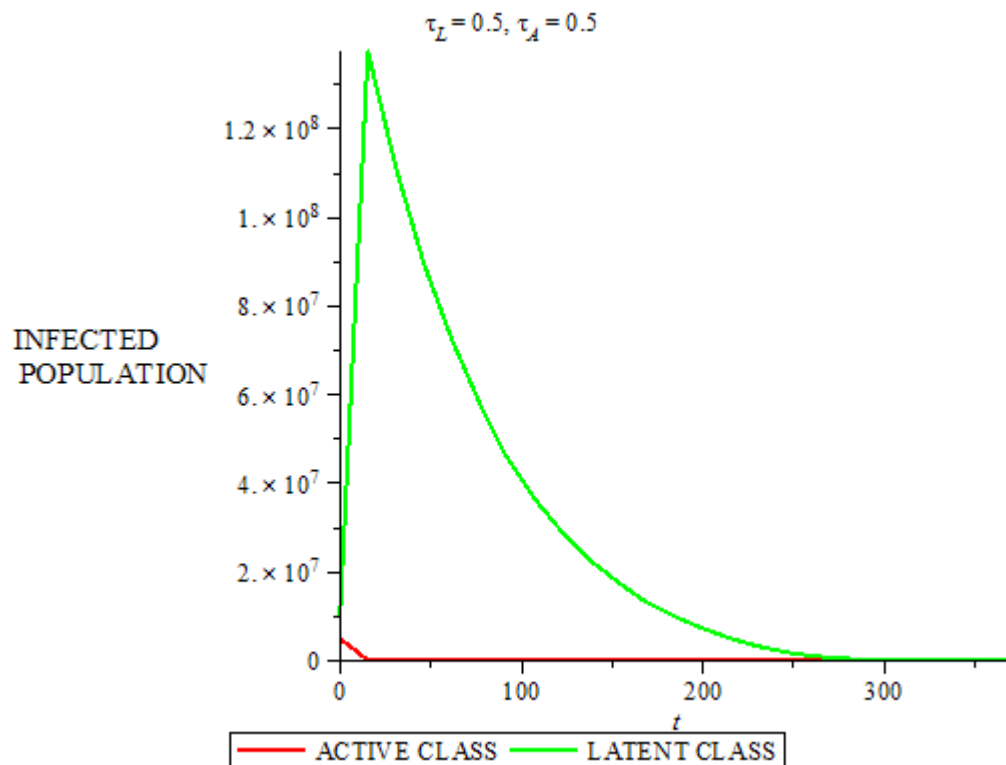


Figure 2: Shows the effect of low level of treatment on both Active and Latent class

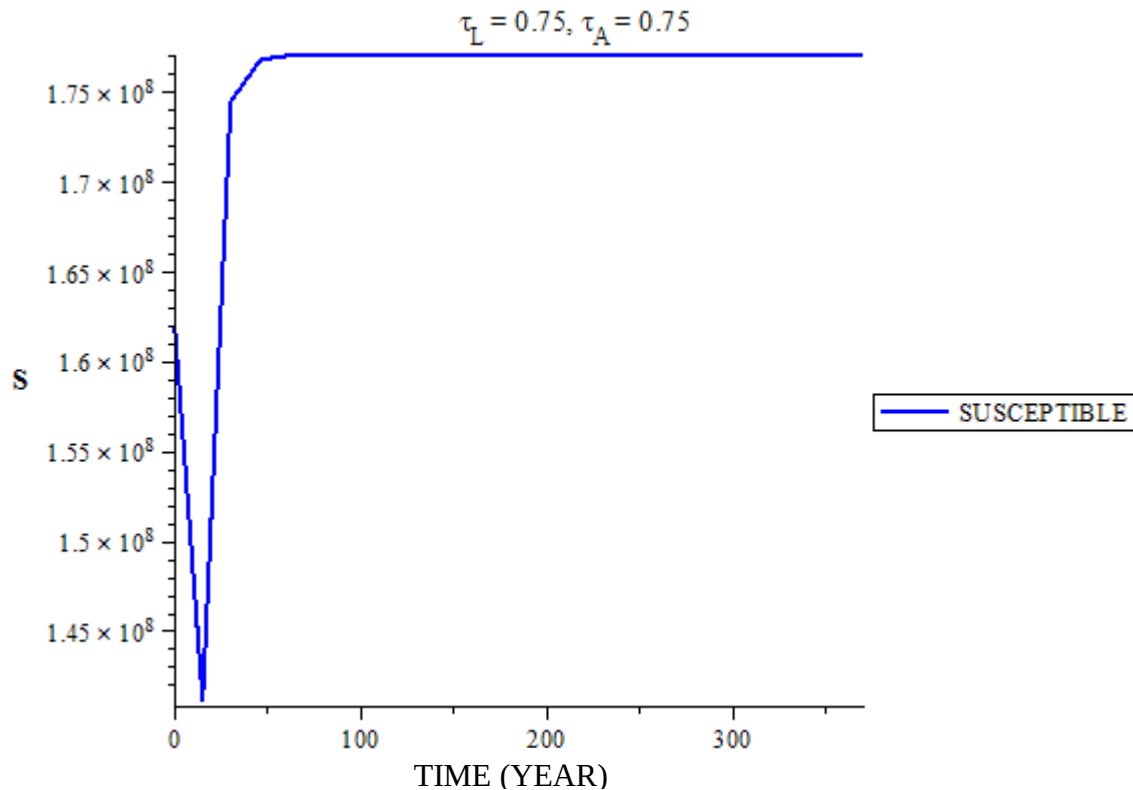


Figure 3: Shows the effect of treatment of active and latent class on susceptible class

Conclusion

A mathematical model of the dynamics and control of tuberculosis was developed and analysed for stability. The existences of disease-free and endemic equilibria states were obtained. The basic reproduction number R_0 was computed. The analysis revealed that for $R_0 \leq 1$, the disease-free equilibrium is globally asymptotically stable so that the disease always dies out. If $R_0 > 1$ the disease free equilibrium point is unstable and the endemic equilibrium emerges. Thus, $R_0 \leq 1$ when the effective contact rate (α) is very small and the treatment rates of latent individual (τ_L), and infectious individuals (τ_A) are high.

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COMPARISON OF NEURAL NETWORK, J48, AND RANDOM TREE BASED ALGORITHM FOR ANORMALY INTRUSION DETECTION

¹VICTOR ONOMZA WAZIRI, PHD, ²USMAN ABDULQAHAR OZOVEHE, &
³AUDU ISAH

^{1&2}Department of Cyber Security Science,
School of Information and Communication Technology,
Federal University of Technology, Minna, Niger State Nigeria

³School of Physical Sciences, Department of Statistics,
Federal University of Technology, Minna, Niger State Nigeria

E-mail: ¹victor.waziri@futminna.edu.ng ²abdulqaharusuman@gmail.com, &
³aisah@futminna.edu.ng

Phone No: +234-806-351-8931

Abstract

Currently, the number of computer users is growing exponentially, so are the number of network intrusions and cyber-attacks known variously as Hacking, Hacktivism, Distribution of Denial Attacks (DDoS)m cybercrime just any Internet Network attack for some nefarious reasons. Attacks whose signatures (commonly known as zero-day attack) that have not been identified have posed the biggest threat over the years. This situation has led to lots of research in intrusion detection aimed at curbing the threat. This work compares the strength of Neural Networks algorithms in network traffic classification with the ransom tree and J48 models for efficiency and performance accuracy. By using a portion of the NSL-KDD dataset and splitting it into three parts in the WEKA soft computing software environment, it is possible to determine the strength of the three models in classifying anomaly network intrusion detection systems. The classification rate so obtained (based on the trained numerical values as provided) all gave tests indication of very high correct classification values, high true positive rate and very low false positive rate. When the comparison was performed against Random Tree results to that of Bayesnet and J48 classifiers, Ramdom Tree performed better. However, from the experimental results given, it could be concluded that the use of Random Tree and Neural Network can be more effective in developing real world Intrusion Detection Systems.

Keywords: Neural Network, Naive Bayes, Decision Tree, Intrusion Dictation, Performance Evaluation

Introduction

The exponential growth in the use of computer network world wide has really created an issue of real apprehension and also an area in which further researches should really be carried out. Policies used by some companies are unable to cover some lapses coupled with some information security infrastructures are badly configured and some computer programs used in interfacing to the internet are having vulnerabilities that could be exploited. The process of monitoring events occurring in a computer system or network and analyzing them for sign of intrusion is known as intrusion detection (Abraham *et al.*, 2004). An intrusion detection system can be a piece of installed software or physical device that monitors network traffic in order to detect unwanted activities and events such as illegal and malicious traffic that violates the security policy, and traffic that goes against the acceptable use policy of the network (Wu, 2009). If an intrusion detection system is properly deployed, it would play an important role in determining if a system is under attack or identifying any breach in security.

Generally, intrusion detection can be grouped into two categories: (a) anomaly detection and (b) misuse detection. This classification is based on the method of analysis.

- (a) **Anomaly Detection:** In this method, normal system behavior is monitored and recorded. A proper knowledge base is created for normal behavior; anomaly based IDS identify action that deviates too far from normal activity or behavior, and alarms an administrator. This method is particularly resourceful in the detection of unwanted traffic that is not specifically known (Rohit, 2010)
- (b) **Misuse Detection:** In this method, the activities are documented and then compared with known attack signature database. If these activities come close to certain benchmarks or have values that are equal to those benchmarks, these events are flagged as intrusion. The IDS would then alarm the administrator of the possibility of a break-in; it then falls on the administrator to take action as he deems fit to address the situation (Rohit, 2010).

Classification based on the location of censor (a) Network based IDS (b) Host based IDS:

- (a) **Network Based IDS:** Network packets are the source of data in this method. Analysis and monitoring of the traffic are done in real time on the network adapter; various detection techniques are used to analyze and identify the attack type. Upon detection of the attack by the network administrator, appropriate actions are taken to mitigate the attack. Network based IDS include wireless network monitoring and network analysis (Rohit, 2010).
- (b) **Host Based IDS:** Host based IDS relies primarily on security logs and information gathered through a monitoring system, events and system logs. Intrusions are identified by analyzing these logs and frequent checks for unexpected deviations from what has been specified as normal system activities. An appropriate counteraction is taken, if an attack is identified, by either disconnecting the user login or disabling the account (Rohit, 2010).

Motivation

The use of machine learning algorithms and methods to analyze network traffic has always been a prosperous approach. With a firm believe that there is no information security infrastructure that can be perfectly secured, therefore, comparing algorithms that are employed in network traffic analysis lead to the authors undergoing this paper.

Related Works

A lot of research has been conducted in the field of intrusion detection with the aim at improving detection accuracy and reduce the false alarm rates; and defend against novel attacks.

Mrutyunjaya and Manas (2007) proposed a model using naïve Bayes classifiers over the KDD cup 99 dataset. The experiment was carried out on 10% of the KDD cup 99 dataset which contained approximately 65525 connections; with a full training set and 10 fold cross validation for the testing purpose. In the 10 fold cross validation the available data was randomly divided into 10 disjoint subsets of approximately equal sizes, with one subset being used as the test set and remaining 9 subsets used for building the classifier.

Bharti, Jain, and Shukla (2010) proposed an intrusion detection model that makes use of feature selection, fuzzy K-mean clustering and J48 algorithm. Their model eliminated hard assignment for assigning data-points to corresponding clusters, which is a major problem of k-mean clustering, fuzzy K-mean clustering was used to solve this problem. J48 was used to tackle class to cluster assignment.

Chandollikar and Nandavadekar, (2012) in their paper evaluated the performance of two data mining algorithms to ascertain their effectiveness in intrusion detection. BayesNet a Bayes based algorithm and J48 algorithm which is a decision tree algorithm.

Aziz, Salama, Hassanien, and Hanafi (2012) in their paper used the artificial immune system (AIS) inspired genetic algorithm approach to tackle anomaly network intrusion detection. The algorithm was implemented in the project WEKA. The NSL- KDD dataset was used as test data. The test was carried out using the Minowski and Euclidean distance function.

Tang and Cao (2009) proposed a new approach to detect network attacks; an illustration of the model is shown in figure 2.1 (Tang & Cao, 2009). The aim was to study the efficiency of Neural Networks and support vector machine methods in intrusion detection. The algorithms were applied to the KDD cup 99 dataset. The test was carried out on varying percentage of the test data. They observed that with increasing percentage of the test data, the accuracy was also increased, while the detection rate reduced with increased percentage of the test data. From their results, based on accuracy Neural Networks slightly outperform Support Vector Machines. However, for detection rate, support vector machines carried the day.

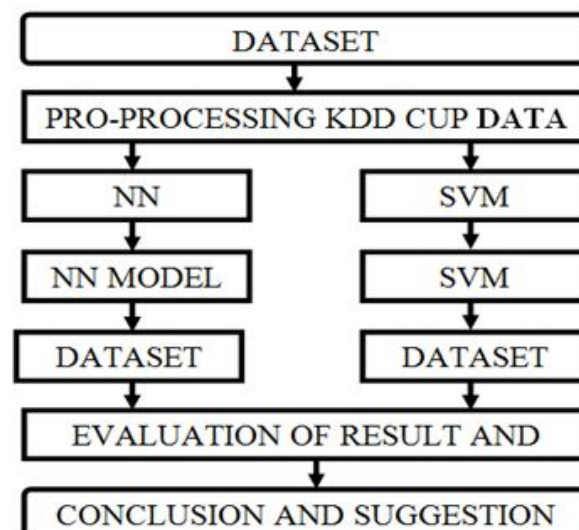


Figure 2.1: Proposed Intrusion Detection Model

Hoque, Mukit, and Bikas (2012) in their paper, proposed an IDS that was based on genetic algorithms (GA), their model was based on Darwin's principle of evolution and survival of the fittest. The system they used was divided into two phases; the pre-calculation phase and detection phase. In the pre-calculation phase, a set of chromosomes is created using the training data, these chromosomes are then used in the detection phase for comparison. In the detection phase, a population is created for the test data and then goes through an evaluation process which involves selection, cross-over and mutation, these determines the type of the test data.

Methodology

This section is on the presentation of the experiment and also discusses the parameters used in evaluating the algorithms used in this research.

Table 2.1: Experimental Design Setup tools

Operating System	Microsoft Windows 7 professional 64-bit.
Software	Weka Version 3.6.10
Neural Network Algorithms	BayesNet, J48, and Random Tree.
Data set	NSS-Kdd
Laptop	Dell D630, intel Duo Core 2,4Gig RAM, T7300 2.00GHz.

Parameters: Here we discuss the various indices used in building and evaluating a neural network.

Attributes: These make up the input nodes for the network:

Hidden Layer: These are intermediate nodes between the input and output layer, in our experiment, the hidden layer is set to 'a' which is, $(\text{attribs} + \text{classes})/2$. This enables greater processing power and system flexibility.

Mean Absolute Error (MAE): This is used to measure the closeness of a prediction to its eventual result.

Root Mean Squared Error (RMSE): This is used to measure how well the system learned the model, that is, it measures how close the predictions came to the actual class.

Relative Absolute Error (RAE): This evaluates the error relative to what might have been if a simpler predictor had been used.

Root Relative Squared Error (RRSE): This measures the error relative to what it would have been, had a simpler predictor been used (Note: for RAE and RRSE the simpler predictor is just an average of the actual value).

Confusion Matrix: This has details of the actual and predicted classes.

True positive (TP): This is when an anomaly is correctly classified as one; true positive rate (TPR) is a ratio of the identified normal data to that of the entire normal data.

False positive (FP): This is the anomaly that is incorrectly labeled as normal; false positive rate (FPR) is the ratio of incorrectly labeled anomaly to the entire malicious data, rate has to be very low.

True Negative: This occurs when there is no attack and no alarm. True negative rate (TNR) is the ratio of correctly classified anomaly to the entire malicious dataset.

False Negative: This is the normal data labeled as anomaly. False negative rate (FNR) is the ratio of incorrectly labeled normal data to that of the entire normal data.

Precision: It is the proportion of predicted positive instances that have been found to be correct.

Accuracy: This is the percentage of the correctly predicted instances

Kappa Statistics: It is a chance-corrected measure of agreement between the actual and predicted classes. It does not take cost into account. Where a value of 1 indicates complete agreement while 0 indicates no agreement at all. A value close to 1 is an indication of good performance for the classifier.

$$K = \frac{p(A) - P(E)}{1 - p(E)} \quad (3.1)$$

From equation (3.1) defines the parameters as follow:

P(A) is the proportion of times that the coders, it is the accuracy of the classifier;

P(E) is the proportion of times that we would expect them to agree by chance, which are calculated along the lines of the intuitive argument.

In analyzing the results obtained from the test on various samples of the data, the use of accuracy only would not be generally acceptable, as it is not sensitive to class distribution and therefore not chance corrected.

For this paper, the Bayesnet, J48, and the Random Tree neural network algorithms in Weka were used to analyze the network traffic NSS-kdd downloaded from <http://nsl.cs.unb.ca/NSL-KDD/> to carry out our test.

Experimental Layout

The test and training files are saved as arff formats in a folder on the desktop.

Description WEKA software is started:

Retrieve the training and test data from the desktop.

Choose the Classifier.

Set classifier parameters.

Run the experiment and document results.

Repeat step i to vi for the each data set.

Note:

The 42 attributes of the data are the input nodes at the input layer

The number of hidden layers is 22

The Experiment steps

Download the network traffic from <http://nsl.cs.unb.ca/NSL-KDD/>

Process the dataset; divide it into three parts named NSL-kdd_4000, NSL-kdd_3500 and NSL-kdd_3000, representing 4000, 3500 and 3000 connections respectively.

Start WEKA and load the dataset from the folder it is located on the disk, figure 3.1 shows the screenshot of the loaded dataset.



Figure 3.1: Screenshot Showing Weka Startup On Windows

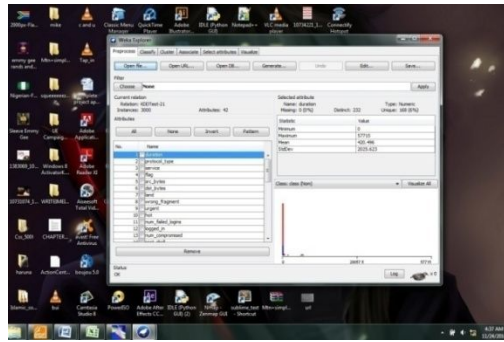


Figure 3.2: Screenshot Showing Loaded Dataset

Start the training and testing process using 10-fold cross validation.

After the learning rate and momentum has been varied, result of the BayesNet for the three set of data would be compared with that of J48, and Random Tree neural network algorithms.

Retrieve and evaluate the results gotten

Experimental Results

This section discusses the experimental results that show some simple graphical analysis as presented in normalized Table 4.1.

The results for the experiments on the 3 datasets and varying Kappa statistics, root mean square error (RMSE), correctly classified instances (CCI), True positive (TP), and the false negative performance accuracy are compared for the analysis by applying the three algorithms (BayesNet, J48, and Random Tree algorithms) as summarized in table 4. The results as shown in the graphical histograms clearly show the difference in terms of performance between the algorithms. The comprehensive results of the tables summarized is obtained in Table 4.1 The experiment was carried out on Dataset NSS-kdd_4000

Table 4.1: Result from the iteration of NN1 Model.

Training Parameters	NN1 Train	1 st Retrain	2 nd Retrain	3 rd Retrain	4 th retrain	5 th retrain	6 th retrain	7 th retrain
Iterations	13	9	15	8	12	14	15	13
Training MSE	0.00618566	0.00735707	0.00583144	0.00787549	0.00662532	0.00551117	0.00657987	0.00553799
Validation MSE	0.00944252	0.00698658	0.00793371	0.00603267	0.00744463	0.00833006	0.00862000	0.00816243
Testing MSE	0.00788424	0.00681670	0.00954940	0.00520126	0.01047210	0.00934746	0.00962382	0.00838818
Regression	0.48749	0.47795	0.53002	0.50716	0.50484	0.5807	0.49665	0.59163
Duration	1sec	3secs	7secs	3secs	4secs	0sec	4secs	41secs
Mu	0.00100	0.00100	0.00001	0.00100	0.00010	0.00010	0.00100	0.00100

Table 4.2: Result for Dataset NSSkdd4000

Dataset	CLASSIFIER	KAPPA	RMSE	CCI	TPR	FPR
NSSkdd_4000	Bayesnet	0.6898	0.2923	3587 (89.675%)	0.888	0.161
	J48	0.863	0.1993	3840 (96 %)	0.955	0.121
	Random Tree	0.8788	0.1867	3857 (96.42%)	0.958	0.108

Kappa Characteristics: The kappa statistics for the data set NSSkdd_4000 analyzed is 0.6898, 0.863, and 0.8788 representing the BayesNet, J48, and the Random Tree classifier algorithm respectively. The Random tree classifier algorithm show the highest and the better result, followed by the J48 algorithm with a value of 0.863, then the Bayesian algorithm produced the lowest of all with a value of 0.6898.

Root Mean Square Error: In Table 4.1 above, the RMSE field shows that the BayesNet gave the highest value of 0.2923. The Random Tree gave a value of 0.1867 and the J48 show the value of 0.1993. The Random Tree algorithm had the lowest value.

Correctly Classified Instances: Under the correctly classified instance in the table above, the result clearly shows that Random Tree algorithm out scored the other algorithms used with a value of 3857 (96.42%). Followed by the J48 and the Bayes algorithms with values of 3840 (96%) and 3587 (89.675%) respectively.

True Positive Rate: This value has to be high because it is a ratio of the identified normal data to that of the entire normal data. The BayesNet had the highest value of 0.888, followed by the J48 with a value of 0.955. In this case also, the Random Tree algorithm showed a promising value of 0.958 which is the highest value.

False Positive Rate: This value has to be low because it is used measure ratio of incorrectly labeled anomaly to the entire malicious data. The Bayes Network had the highest value of 0.161, followed by the J48 with a value of 0.121. In this case also, the Random Tree algorithm showed a promising value of 0.108 which is the lowest value.

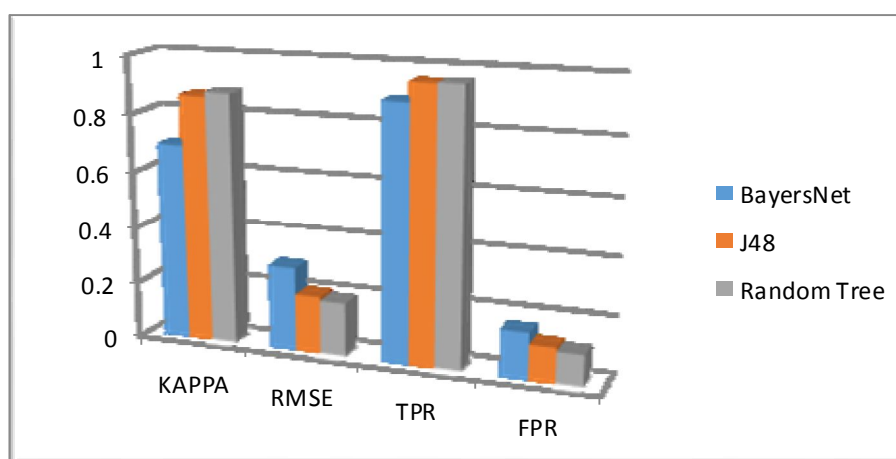


Figure 4.1: Comparison of the three algorithms on NSS-Kdd_4000 dataset

Result Discussion for the Dataset NSS-kdd_3500

In Table 4.1, we present features of our experimental results; Table 4.3 shows further values of the various data attributes experimented upon as stated above.

Table 4.3 Result for Dataset NSS-kdd_3500

SAMPLE	CLASSIFIER	KAPPA	RMSE	CCI	TPR	FPR
NSSkdd3500	BayesNet	0.6538	0.3145	3098 (88.514%)	0.885	0.150
	J48	0.8621	0.1844	3361(96.028%)	0.960	0.119
	Random Tree	0.8723	0.1824	3370 (96.28%)	0.963	0.104

Kappa Characteristics: The Kappa statistics as shown above was 0.6538, 0.8621, and 0.8723 for BayesNet, J48, and Random Tree algorithms classifier respective. The highest score recorded was 0.8723 from the Random tree algorithm classifier. The Kappa characteristics indicates the agreement between the classifications and the true classes, the resulting value for our results most give very high but must not be greater than one (1). With the result obtained, the Random Tree algorithm classifier is having the highest value of 0.8723 while the lowest score recorded was from the BayesNet algorithm classifier.

Root Mean Square Error: In Table 4.2 above, the RMSE field shows that the BayesNet gave the highest value of 0.3145. The Random Tree got a value of 0.1824 and the J48 show the value of 0.1844. The Random Tree algorithm had the lowest value.

Correctly Classified Instances: Under the correctly classified instance in the table above, the result clearly shows that Random Tree algorithm out scored the other algorithms used with a value of 3370 (96.28%). Followed by the J48 and the BayesNet algorithms with values of 3361(96.028%) and 3098 (88.514%) respectively.

True Positive Rate: This value has to be high because it is a ratio of the identified normal data to that of the entire normal data. The BayesNet had the highest value of 0.885, followed by the J48 with a value of 0.960. In this case also, the Random Tree algorithm also showed a promising value of 0.963 which is the lowest value.

False Positive Rate: This value has to be low because it is used to measure the ratio of incorrectly labeled anomaly to the entire malicious data. The BayesNet has the highest value of 0.150, followed by the J48 with a value of 0.119. In this case also, the Random Tree algorithm showed a promising value of 0.104 which is the lowest value. Figure 4.2 depicts the graphical features of the three experimental algorithms

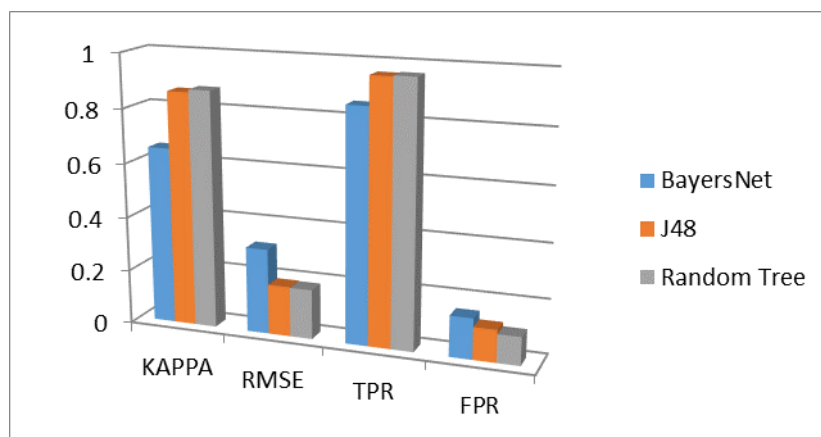


Figure 4.2 comparison of the three algorithms on NSS-kdd_3500 dataset

4.3 Result Discussion for the Dataset NSS-kdd_3000

This subsection depicts details of the experiment carried out on the Dataset NSS_KDD_3000

Table 4.4: Result for Dataset NSS - KDD_3000

Sample	Classifier	KAPPA	RMSE	CCI	TPR	FPR
NSSkdd3000	BayesNet	0.656	0.306	2664 (88.8%)	0.888	0.161
	J48	0.8439	0.1915	2864 (95.46%)	0.960	0.115
	Random Tree	0.8561	0.2047	2874 (95.8 %)	0.964	0.095

Kappa Characteristics: The kappa statistics values for the data set NSSkdd_3000 analyzed are 0.656, 0.8439, and 0.8561 representing the BayesNet, J48, and the Random Tree classifier algorithm respectively. The Random Tree classifier algorithm show the highest and the better result, followed by the J48 algorithm with a value of 0.863, and the Bayesian algorithm produced the lowest of all with a value of 0.6898.

Root Mean Square Error: In Table 4.3, the RMSE field shows that the BayesNet gave the highest value of 0.306. The Random Tree gave a value of 0.2047 and the J48 show a value of 0.1915. The J48 algorithm had the lowest value.

Correctly Classified Instances: Under the correctly classified instance in the Table 4.4, the result clearly shows that Random Tree algorithm out scored the other algorithms used with a value of 2874 (95.8 %). Followed by the J48 and the Bayes algorithms with values of 2664 (88.8%) and 2864 (95.46%).

True Positive Rate: This value has to be high because it is a ratio of the identified normal data to that of the entire normal data. The BayesNet had the lowest value of 0.888, followed by the J48 with a value of 0.960. In this case also, the Random Tree algorithm showed a promising value of 0.964 which is the highest recorded value.

False Positive Rate: This value has to be low because it is used to measure the ratio of incorrectly labeled anomaly to the entire malicious data. The BayesNet had the highest value of 0.161, followed by the J48 with a value of 0.115. In this case also, the Random Tree algorithm showed a promising value of 0.095 which is the lowest value.

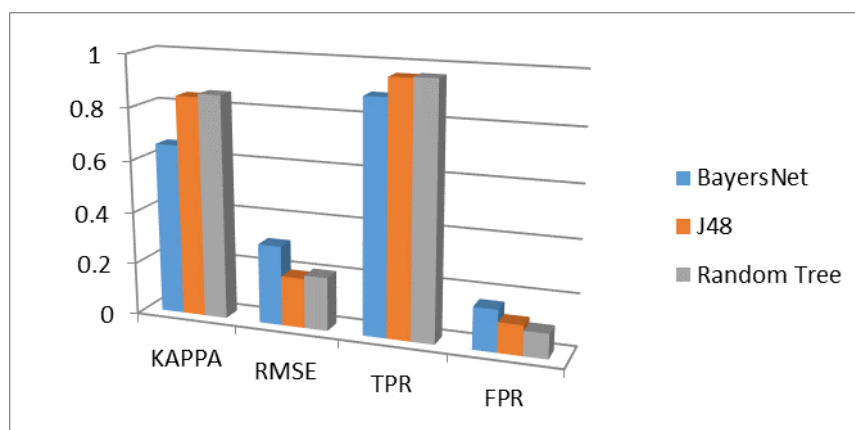


Figure 4.3: Comparison of the three algorithms on NSS-kdd_3000 dataset

Receiver Operating Characteristics ROC

The Receiver Operating Characteristics was developed in the 1950's to help set the operating point of a communication system and has also been used to set the parameters

(before learning) or thresholds (after learning) of many learning algorithms for any two classes. In figure 4.4, we can see that the Random Tree has the smallest area coverage. J48 curves shows the area runs exponentially up while the BayesNet curve has more area coverage. Thus, under this ROC construct the BayesNet is more efficient. ROC is calculated using the existing Dataset processed from NSS-kdd_3000 Dataset

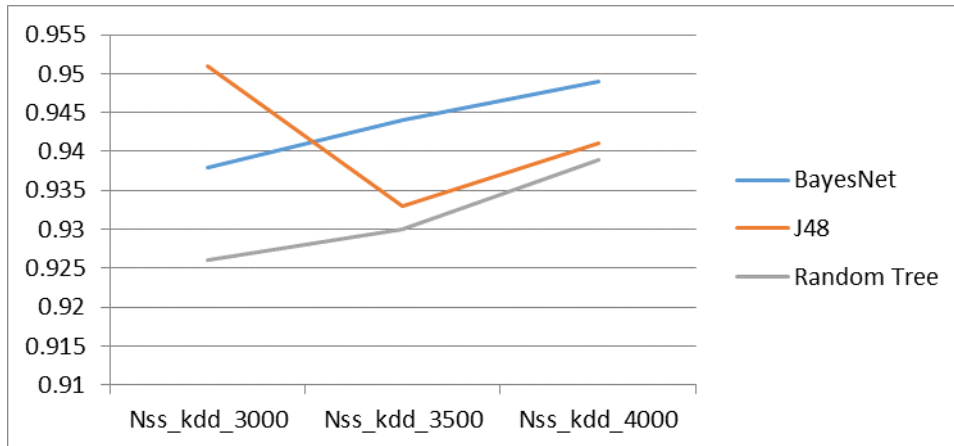


Figure 4.4: Depicts the ROC curve showing performance of the three Algorithms

Conclusion and Future Works

From the above tables and figures, we can say that the Random Tree Neural Network performs relatively well. When the Random Tree Neural network result is compared with that of other classifiers namely, BayesNet and J48; the Random Tree Neural Network outperforms all the other classifiers, except for the Root Mean Square Error in Table 4.3 where the J48 smartly edges past the Random Tree with 0.1915 Root Mean Square Error (RMSE) for the Random Tree Neural Network was 0.2047.

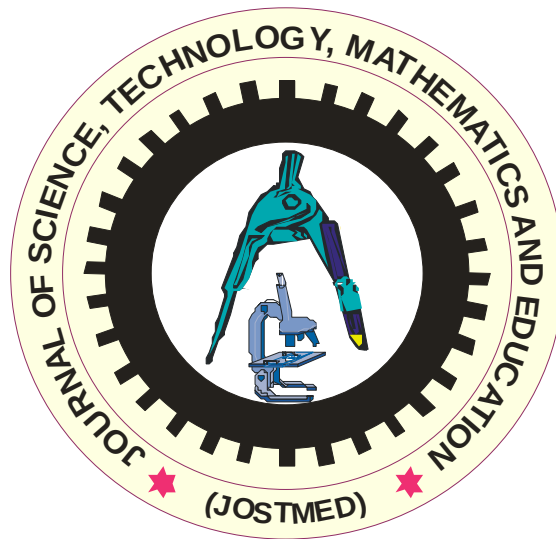
On the basis if the experiment carried out and the result obtained, the Random Tree algorithm did show the potential of being more efficient when compared with other two. The Random Tree Neural Network algorithm has really shown that there is a bright future for having an algorithm for analyzing network traffic with low False Positive Rate (FP), a high True Positive Rate (TP) and a very low Root Mean Square Error (RMSE) which clearly defines how reliable information technology security infrastructures are. Future works could be done with the comparison of the efficiencies of WEKA, Matlab and Java software.

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ASSESSMENT SKILLS AND COMPETENCIES IN PRACTICE BY IMO STATE SCHOOL COUNSELORS

ANGELA O. DARA & LAW-Obi FIDELIA N.

Dept of Educational Psychology / Guidance and Counseling,
Science and Technology Unit, Dept of primary education,
Alvan Ikoku Federal College of Education, Owerri, Nigeria

E-mail: daraangela2011@gmail.com Phone No: +234-803-841-3888

Abstract

This Research study focused on the assessment skills and competencies in practice by counselors in Imo state school system. The purpose of this study is to explore school counselors' extent of using the various assessment techniques, assessment program logistics and utilization of assessment information in their counseling work. A sample size of 72 out of a total of 362 school counselors in Imo State was used for the study. The instrument for data collection is a questionnaire made up of 4 point modified likert-type scale. Item face and content validity was determined. The result showed that the school counselors were using non-standardized assessment techniques most frequently and standardized testing least of all. In the area of program logistics, they were rarely involved in selecting school achievement tests or career inventories nor coordinating either of those testing programs. The result also showed that Imo state school counselors were not sufficiently involved in the utilization of assessment information. The researchers among others, recommend that counselors in the schools should be encouraged to update their knowledge in the use of assessment in counseling by attending conferences and workshops, in service training, and other continuing education opportunities.

Keywords: Assessment skills, Competencies, Practice, School Counselors

Introduction

In the practice of assessment skills and competencies acquired by counselors during their training, they are expected to assess, measure and evaluate their clients to enable them make effective decisions, resolve their problems, have positive mental and healthy behaviors. These processes require sound knowledge in assessment and evaluation. Assessment is the gathering of information for decision making about individuals, groups, programs or processes. Assessment skills include certain skills related to assessment while competencies describe skills or understanding that a school counselor should possess to perform evaluation activities effectively.

Counseling, according to Uwazie, Ifegbo, Ukegbu and Uwazurike (2008: 147) is "a relationship between a professionally trained, competent counselor and individual seeking help in gaining greater self-understanding and improved decision making and behaviour-changing skills for problem resolution and developmental growth". Schmidt (1995) pointed out that the purpose of counseling in schools is to assist students with their educational, career, personal and social development. In carrying out this goal, school counselors serve students directly and indirectly through counseling with their parents, teachers, and other educators. The National Association of College Admissions Counselors believes that elementary through post-secondary school counselors must be competent in developing, collecting, analyzing, and interpreting data (Drummond, 1992). Although it is true that student information may be gathered through individual and / or group counseling, observations, and a review of school records, standardized and structured

assessment procedures are also important data collection tools. Additional assessment tools at school counselors' disposal are qualitative techniques such as observation protocols and open-ended rating scales, students' behavior rating scales, self-reports, anecdotal reports, questionnaires, structured interviews, and sociometric techniques (Gibson & Mitchel, 1995). Goldman (1992) has suggested that few school counselors other than career counselors make use of tests. Findings in a survey by Engen, Lamb, and Prediger (1981) reported by Zytowski (1982), says that 93% of secondary school counselors administered at least one test to students; 76% administered achievement test batteries; 66% administered academic aptitude or intelligent tests; and 16% administered inventories of schools or social adjustment or personality tests. Goldman (1992) has suggested that few school counselors other than career counselors make use of tests.

In assessment program logistics, school counselors are supposed to be involved in: selecting school achievement tests and career inventories; coordinating achievement tests and career testing programs.

In addition to gathering information, school counselors have an important role to play in dissemination of information. In performing this work, they are involved in identifying students' career aptitude and interests, academic achievement levels, level of social skills and interpreting assessments to students, parents and other educators. Educational professionals, including secondary school teachers rely on school counselors to provide them with assessment information and to answer their questions about testing (Impara and Plake 1995, Stiggins, 1995). Focusing on this role of test interpreter, Goldman (1982) found little research evidence that tests as they are being used by counselors have made much impact to the people they service.

Although there is considerable research about the assessment competencies school counselors need (Anastasi, 1992; Impara & Plake, 1995), there is less evidence to suggest that school counselors actually are using those skills and the training they receive is insufficient.

Drummond (1992), Tymofirich and Leroux (2000) put in that because assisting students to make effective decisions about their educational plans and future careers requires a sound foundation of accurate data, school counselors need to be skilled in information gathering and dissemination. This is why graduate program in school counseling routinely include at least one course in assessment (Council for Accreditation of Counseling and Related Program (CACREP), 1994; Elmore, Ekstram & Diamond, 1993; Goldman, 1992; National Association of State Directors of Teacher Education and Certification (NASDTEC); National Association of State Directors of Teacher Education and Certification (NASDTEC). National school counselor certificate examination and state credentialing standard require knowledge and skill development in assessment. California Commission on Teacher Credentialing (CCTC), (2001); National Board for Certified Counselors (NBCC), (1998); and professional associations have specified assessment competencies (American School Counselor Association (ASCA), 1998).

In the study of skills needed by school counselors, Schafer and Mufson (1993) found a natural division of the job role expectations of school counselors which they grouped into six areas: counseling (individual / or group), pupils' assessment, consultation, information officer, school program facilitator, and research and evaluation. There is assessment-intensive aspects of each of these roles. These roles that have been identified imply that school counselors should have certain skills related to assessment. They concluded that

these CACREP skills consciously presented in a counselor education program, would in most areas constitute an adequate preparation for a beginning-level school counselors. Because effectiveness in assessment and evaluation is critical to effective counseling, these competencies are important for school counselors.

Tymofievich and Leroux (2000) described good assessment practice as including test selection, administration and interpretation. The ASCA national model (2003) outlined for school counselors the ethical standards to be used in selecting, administering and interpreting assessment measures. This model reflects a comprehensive approach to program foundation delivery, management and accountability.

Despite the assessment trainings that the school counselors received in their preparation programs and the links between educational assessment and counseling, it is not certain whether counselors in Imo State schools are sufficiently and frequently practicing these assessment skills and competencies in their counseling work. It is based on this that the present study focus on the investigation of assessment skills and competencies of school counselors in Imo state.

Research Questions

The following four research questions guided the study

- (i) To what extent do Imo State school counselors involved in the use of various assessment techniques?
- (ii) What is the level of usage of assessment program logistics by Imo State school counselors?
- (iii) To what extent do Imo State school counselors utilize assessment information?

Population of the Study

There are a total of three hundred and sixty-two (362) practicing school counselors in Imo State school system. (Source: Counselor Association of Nigeria (CASSON), 2013).

Sample and Sampling Technique

A sample size of seventy-two (72) school counselors was used for the study (20% of the total population). The seventy-two school counselors were randomly selected using balloting. The Instrument for data collection was a questionnaire made up of four likert type scales. Item validation was determined by consultation with two practicing school counselors, two counselors' educators, two experts in measurement and evaluation. Researchers personally visited Imo State school counselors during their annual meeting at Owerri, and administered the questionnaire items and retrieved on the spot their responses.

Method of Data Analysis

Mean served as statistical tool for data analysis. A mean rating of 2.5 and above was considered as positive responses (sufficient involvement) while a mean rating below 2.5 was considered as negative responses (insufficient involvement).

Results

Table 1: Analysis concerning the extent of usage of various assessment techniques by Imo State School Counselors

To what extent do Imo State school counselors involved in the use of the following assessment techniques?	No and score	GE	SE	LE	NE	Obtained mean scores
Observation of students	N	25	32	4	10	3.01
	Nx	100	99	8	10	
Achievement test	N	1	25	43	3	2.33
	Nx	4	75	86	3	
Structured students interviews	N	20	4	11	10	2.91
	Nx	80	8	11	10	
Student-completed rating scale	N	2	20	46	4	2.27
	nx	8	60	92	4	
Teachers/counselors-completed rating scales	N	3	26	40	3	2.40
	nx	12	78	80	3	
Career inventory study habit	N	2	22	44	4	2.02
	nx	8	66	88	4	
Pooled mean						2.49

From table 1 above, among the six domains of assessment techniques, school counselors reported sufficiently involved in the observation of students individually/or in group and structured students interview with means above 2.5 school counselors reported that they are less involved in the use of standardized achievement tests, student-completed rating scales, teacher/counselor-rating scales, and career inventories with means below 2.5. A grand total mean of 2.49 showed that Imo State school counselors do not make sufficient use of various assessment techniques in assessing their students.

Answering research question 2: To what extent do Imo State School counselors involved in program logistics?

Table 2: Analysis concerning the extent of involvement of Imo State School Counselors in program logistics

What is the level of your involvement in these assessment program logistics?	No and score	GE	SE	LE	NE	Obtained mean scores
Selecting school achievement tests	N	2	15	46	9	2.13
	nx	8	45	92	9	
Selecting school career inventories	N	0	10	44	18	1.88
	nx	0	20	88	18	
Coordinating achievement testing	N	1	24	43	4	2.30
	nx	4	72	86	4	
Coordinating career testing	N	2	20	46	4	2.27
	nx	8	60	92	4	
Pooled mean						2.06

Table 2 above shows that Imo State school counselors were not sufficiently involved in assessment program logistics with means below 2.5 and pooled mean of 2.06.

Table 3: Analysis concerning the extent Imo State School Counselors utilize assessment information

What is the extent of your utilization of the following assessment information?	No and score	GE	SE	LE	NE	Obtained mean scores
Identifying students career aptitudes and interests	n nx	2 8	20 60	42 84	8 8	2.22
Identifying students academic achievement level	n nx	1 4	23 69	43 86	5 5	2.27
Identifying students level of social skills	n nx	2 8	17 51	43 86	10 10	2.15
Interpreting assessments to students, parents and other educators	n nx	15 60	47 141	5 14	5 5	3.02
Grand total mean						9.64 2.41

On utilizing assessment information, table 3 above shows that school counselors were only sufficiently involved on interpreting assessments to students, parents and other educators. They were not sufficiently involved in identifying students career aptitude and interests, academic achievement levels and levels of social skills. The pooled mean of 2.41 showed insufficient utilization of assessment information.

The result generally showed that there is insignificant use of assessment skills and competencies by Imo State school counselors in their counseling work with pooled means of 2.49, 2.06 and 2.41 which are below 2.50.

Discussion

The finding of the study shows that there is no significant level of use of assessment skills and competencies by Imo State school counselors in their counseling work. This is in line with that of Goldman (1992) who attested that few school counselors other than career counselors make use of tests. Although there is considerable research about the assessment competencies school counselors need, (Anastasi 1992; Impara and Plake 1995), there is less evidence to suggest that school counselors actually are using those skills.

Outcomes of this study suggest that school counselors use non-standardized assessment techniques most frequently with those of student observation and structured student interview being the most. This is not surprising because training in these techniques, both of which call for inter-personal and observation skills, typically occurs throughout counseling preparation programs in a multiplicity of counseling courses (CCTC, 2001). Less frequently used was indicated for teacher- or school counselor-completed rating scales, which is somewhat puzzling because these formats are likely to provide school counselors with a rich source of information. For example, teachers' day-to-day observation of students in their classrooms coupled with school counselors' ratings could provide important cross-validation between measures of behavior. However, it is not surprising that student-completed ratings and standardized tests are seldom used, because these techniques are more likely to be taught in only the one or two tests and measurement courses that are typical of school counselor preparation programs (CCCT, 2001). It is unfortunate that the school counselors are making so little use of career inventories in identifying students career aptitude and interests. This is because the major part of school counselor's role is assisting students to acquire the necessary academic skills, knowledge and strategies required for future career planning (Dahir, Sheldon, & Valiga, 1998).

It is not surprising that school counselors were frequently involved in the area of interpreting assessment data to students' parents and other educators because communication and consultation skills are major part of course work in school counselors' preparation programs (CCTC, 2001). This finding could suggest that school counselors feel competent in conferring with and relaying information to others.

Implication

Based on this study, since these school counselors did not seem to be involved in using standardized assessment technique, conducting and coordinating the school's testing program implies that the results produced by Imo state schools have questionable quality. Since school counselors in this study seem not involved in selecting school achievement tests, career inventories and coordinating school testing programs, it is therefore recommended that school counselors should update their knowledge in the use of the above assessment techniques in counseling by attending conferences and workshops, develop themselves in further studies and in-service training and continuing education. They could gather more information from the internet.

Further implications show that either our educational institutions do not have enough content in assessment coursework in counselor training programs and as a result of that, counselor educators emphasized on the assessment content which school counselors acquired the knowledge and use them in their counseling work. Also standardized tests are used by government organizations like WAEC, NECO and foreign firms in Nigeria and not made available for counselor's use. Achievement tests are in the possession of teachers and head teachers not counselors. This implies that counselors in Imo State do not administer achievement tests rather they make use of their results in counseling students/pupils. It is therefore recommended that Imo State school counselors should be involved in selecting, administering and utilizing of achievement tests/results.

Conclusion

The finding of the study showed that there is no significant level of use of assessment skills and competences by Imo State school counselors in their counseling work. There is considerable research about the assessment skills and competences school counselors need but there is less evidence to suggest that they are actually using those skills.

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ASSESSING TEACHERS' PERSPECTIVE OF CHALLENGES MILITATING AGAINST IMPLEMENTATION OF SCHOOL BASED ASSESSMENT IN SOUTH WEST, NIGERIA

OLUTOLA, ADEKUNLE T. (Ph. D.)¹, DARAMOLA, DORCAS S. (Ph.D.)²
& SHEU, ADARAMAJA L. (Ph.D.)¹

¹Department of Educational Foundations, Faculty of Education,
Federal University Dutsin-Ma, Katsina State, Nigeria.

²Department of Educational Psychology/G &C, Faculty of Education,
Federal College of Education, Owerri, Imo State, Nigeria.

E-mail: aolutola@fudutsunma.edu.ng, immaculatetabitha@yahoo.com,
adaramaja4real@yahoo.com

Phone No: +234-806-029-7940, +234-809-785-0451

Abstract

The study assessed the teachers' perspective of challenges militating against implementation of School Based Assessment (SBA) in South West, Nigeria. The study examines teachers' assessment skills, supervision, in-service training and laxity on the implementation of school based assessment in Nigerian secondary schools. The Survey design was adopted for this study. The population of the study consists of all the secondary school teachers in Nigeria while the target population comprised of all the secondary school teachers in South - Western State of Nigeria. Five hundred and seventy-six teachers were randomly drawn from secondary school teachers in South - Western State of Nigeria. A total number of thirty-two secondary schools were involved in the study. From each of the schools, eighteen teachers were randomly selected to take part in the study. A rating scale titled "Teachers Implementation of School Based Assessment Questionnaire" (TISBAQ) was used to collect data. A Cronbach's Alpha reliability coefficient of 0.78 was obtained for the instrument. Analysis of data was carried out using mean, t-test and ANOVA statistics at 0.05 alpha level. The result revealed that the main challenge faced by teachers in South Western States in implementing SBA is assessment skills with highest mean, followed by in-service training and supervision while the least challenge was recorded in teachers' laxity. In addition, significant difference exists in the challenges faced by secondary school teachers' in South Western Nigeria on the basis of gender, school location, teaching experienced and qualifications in implementing SBA. Based on these findings, it was recommended that the governments at all level should periodically organize in-service training programme for secondary school teachers on regular basis to broaden their knowledge in assessment skills and qualified teachers should be recruited, supervised, motivated and improved their welfare to get the best result in Nigerian secondary schools.

Keywords: *Assessing, Challenges, Implementation, School Based Assessment*

Introduction

Assessment is an important aspect in teaching and learning process. Quality and effective teaching cannot exist without good students' assessment. Assessment refers to activities undertaken by teachers, which provide information to be used as feedback to modify the teaching and learning activities (Black & William, 1998). It involves the collection of information about an individual's knowledge, skills, attitudes, judgment, interpretation and using the data for taking relevant decisions about the individual instructional process, curriculum or programme (Ugodulunwa, 2008). The onset of 6-3-3-4 educational system in Nigeria also heralded continuous assessment into the school system. The School-Based Assessment is one of the reforms introduced at the basic education level in Nigeria as a reflection of the paradigm shift in the field of educational evaluation.

The paradigm shift from “Assessment of Learning” to “Assessment for Learning” is to ensure that assessment serves its basic purpose in the educational system. According to Black, Harrison, Lee, Marshall and William (2003), Assessment of Learning refers to formal tests carried out after a certain learning period or at the end of a course, the results of which are used mainly for comparison, selection, or accountability purposes. This type of assessment is often summative in nature. Assessment for Learning on the other hand, refers to assessment activities that are embedded in normal teaching and learning processes with the purpose of providing feedback for both teachers and students to plan the next step of teaching and learning (Black, et al, 2003). This type of assessment is formative in nature and is synonymous with School –Based Assessment (SBA). With the shift in teacher’s roles to that of a facilitator in formative assessment, students change from passive recipients of information and knowledge to active participants in the classroom (Black, et al 2003).

Following from this orientation, Federal Republic of Nigeria (2004) recommended the introduction of School–Based Assessment (SBA) at the basic and secondary school levels (Adediwura, 2012). According to Yusuf (1994), SBA provides a cumulative teacher judgment about the performance of individual students’ work by a systematic collection of grades or scores. Appropriate use of information gathered through SBA by teachers serves the purpose of monitoring their students’ performance. The feedback obtained from the students assist them to adjust their teaching methods.

The main purposes of SBA are to enhance students’ learning, provide feedback to parents and students, contribute to scores used for the award of senior secondary school qualifications, monitor nationwide educational standards, and identify learning needs to effectively allocate resources (Crooks, 2002). Specifically, the objectives of formative assessment as a form of SBA are to:

- (i) provide feedback for teachers to modify subsequent learning activities and experiences;
- (ii) identify and remediate group or individual deficiencies;
- (iii) move focus away from achieving grades onto learning processes in order to increase self efficacy and reduce the negative impact of extrinsic motivation;
- (iv) Improve students’ meta-cognitive awareness of how they learn; and
- (v) Give room for fine-tuning of instruction by teachers with a focus on learner progress (Huhta, 2010; Shepard, 2005 & Cauley & McMillan, 2010).

Feedback is the central function of SBA and formative assessment. Nicol and Macfarlane-Dick (2005) synthesized literature and listed the following seven principles of good feedback practice:

- (i) clarification of what good performance is (goals, criteria, expected standards) ,
- (ii) facilitation of the development of self-assessment in learning,
- (iii) provision of information to students about their learning,
- (iv) encouragement of teacher and peer dialogues around learning,
- (v) encouragement of positive motivational beliefs and self-esteem,
- (vi) provision of opportunities to close the gap between current and desired performance,
- (vii) provision of information to teachers to reform teaching (Nicol & Macfarlane-Dick, 2005 & 2006).

The effects of SBA or assessment for learning have also been found to lead to achievement gains in external examinations (Assessment Reform Group, 1999). School Based Assessment is expected to expand the form, mode, means and scope of assessment in schools to facilitate and enhance learning (Osunde, 2008). Continuous assessment was introduced to

Nigerian schools in 1981 and replaced in 1999 with school based assessment. In spite of these changes, students' performances in both internal and external examinations are neither encouraging nor stable. For instance, no fewer than one million Nigerian students fail the 2014 May/June West African Senior School Certificate Examination (WASSCE), the poorest result recorded in the last three years. Only 529, 425 candidates (31.28 %) out of the 1.7million candidates who wrote the exam obtained credits in five subjects and above, including English Language and Mathematics (Garbriel, 2014). In addition, the percentage failure rate of students sat for Biology WASSCE were 22.86%, 29.34% and 33.77% in 2010, 2011 and 2012 respectively which had been poor and discouraging (WAEC 2012). Moreover, the overall average performance of students in science subjects, English and Mathematics from 2008-2012 is 46.5% (WAEC, 2012 & Sakiyo & Badau, 2015). The students' performance in 2008-2012 is below average and is a great concern to educationists in Nigeria. It is not clear whether the teachers' knowledge of and readiness to implement school based assessment fall within acceptable limits to make for learners' success since a lot of weaknesses is noticed in the learning and performance levels of students.

It is therefore necessary to assess the teachers' perspective of challenges militating against implementation of School Based Assessment (SBA) in Nigeria. Specifically, the study aimed at assessing the teachers' perspective of challenges militating against implementation of School Based Assessment (SBA) in South West, Nigeria. The aspects of SBA focused on by this study include assessment skills, supervision, in-service training and commitment of teachers to the implementation of SBA.

Research Questions

The following research questions were addressed by the study:

- (i) What are the challenges faced by teachers in South Western States in implementing SBA?
- (ii) Is there gender difference in the challenges faced in the implementation of SBA by teachers in south western Nigeria?
- (iii) Does teaching experience account for differences in challenges faced in the implementation of SBA by teachers in south western Nigeria?
- (iv) Does qualification of teachers account for differences in the challenges faced in the implementation of SBA by teachers in south western Nigeria?

Research Hypotheses

- (i) There is no significant difference in the challenges faced by male and female teachers in implementing SBA.
- (ii) There is no significant difference in challenges faced by teachers in South Western States in implementing SBA on the basis of teaching experience.
- (iii) There is no significant difference in the challenges faced by teachers in South Western States in implementing SBA on the basis of teaching qualification

Methodology

Survey design was adopted for this study because collection of valid and reliable data is possible and inferences concerning the population drawn from the representative sample selected. The population of the study consists of all the secondary school teachers in Nigeria while the target population comprised of all the secondary school teachers in South - Western Nigeria comprised of six State governments. Five hundred and seventeen-six teachers were randomly selected from thirty-two secondary schools from South - Western Nigeria. Eighteen teachers were randomly selected from each of the sampled schools to take part in the study.

A questionnaire titled “Teachers Implementation of School Based Assessment Questionnaire” (TISBAQ) was used to collect data. It was divided into five sections. Section A contained teachers’ biographic information such as gender, school type, teachers experience and qualifications. Section B contained six items on teachers’ assessment skills and implementation of school based assessment (SBA), section C consists of five items on teachers’ supervision and implementation of SBA, section D contained five items on teachers’ in-service training and implementation of SBA and section E consists of five items on teachers’ commitment and implementation of SBA.

A 4-point scale of strongly agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD) was used. Expert judgment was used in validating the instrument. A Cronbach's Alpha reliability coefficient of 0.78 was obtained. Analysis of data was carried out using mean, standard deviation, t-test and ANOVA statistics at 0.05 alpha level.

Results

Research Question One: What are the challenges faced by South Western State teachers in implementing SBA?

Teachers’ response on the questionnaire was subjected to mean analysis.

Table1: Details of the mean analysis on implementation challenges of school-based assessment of the respondents

SBA Implementation Challenges	Mean	Standard Deviation	Rank
Assessment Skills	12.4583	3.19538	1 st
Supervision	9.5278	1.64267	3 rd
In-Service training	10.4028	2.79955	2 nd
Commitment	9.0972	2.40093	4 th

From table 1 the main challenge faced by teachers in South Western States in implementing SBA is assessment skills with highest mean (12.4583) followed by In-service training and supervision with mean of 10.4028 and 9.5278 respectively while the least challenge was recorded in teachers’ laxity with a least mean score of 9.0972.

Hypotheses Testing

Hypothesis One: There is no significant difference in challenges faced by male and female teachers in implementing SBA.

The sampled teachers’ responses on all the items on implementation challenges of school-based assessment were summed up and compared on the basis of gender using t-test statistics.

Table 2: t-test Analysis on difference in challenges faced by male and female teachers in implementing SBA

Variables	N	Mean	SD	Df	t-value	P-value	Decision
Male	174	39.5460	8.12871	574	4.04	.000	Rejected
Female	402	42.3259	7.33358				

Table 2 revealed the t-test calculated value of 4.04 while its P- value is 0.000 at alpha level of 0.05. The null hypothesis one is rejected since the P-value .000 is less than 0.05 alpha level ($.000 < 0.05$). Thus, there is significant difference in the challenges faced by male and

female teachers in implementing SBA. Female teachers are significantly different in challenges faced in implementing SBA with higher mean of 42.3259.

Hypothesis Two: There is no significant difference in challenges faced by teachers South Western State in implementing SBA on the basis of teaching experience.

The sampled teachers' responses on all the items on implementation challenges of school-based assessment were summed and compared using ANOVA statistics.

Table 3: Details of the ANOVA statistics on respondents' implementation challenges of school-based assessment on the basis of teaching experience

Sources	SS	df	Mean Square	F-ratio	P-value	Decision
Between Group	28772.145	3	9590.715			
Within Group	5163.744	572	9.028	1.062	.000	Rejected
Total	33935.889	575				

Table 3 reveals an F-value of 1.062, which is significant at 0.05 alpha level. Thus, the null hypothesis of no significant difference in challenges faced by teachers in South Western State in implementing SBA on the basis of teaching experience is rejected. This implies that there is a significant difference in challenges faced by teachers in South Western States in implementing SBA on the basis of teaching experience. Scheffe's Post Hoc was carried out to find the sources of the differences.

Table 4: Scheffe's Post -hoc test on respondents' implementation challenges of school-based assessment on the basis of teaching experience

Years of Teaching Experience	Subset for alpha = 0.05			
	1	2	3	4
18year & above	25.0000			
1-5years		35.0769		
11-15years			38.1176	
6-10years				50.0714

The table 4 shows the Scheffe's post hoc on Respondents' implementation challenges of school-based assessment on the basis of teaching experience and a significant difference was revealed. Teachers with 6-10years teaching experience faced more implementation challenges of SBA with highest mean of 50.0714, followed by teachers with teaching experience of 11-15years and 1-5years with the mean of 38.1176 and 35.0769 respectively. Teachers with teaching experienced of 18 years and above are faced with least challenges in implementing SBA because they have the least mean of 25.0000.

Hypothesis Three: There is no significant difference in challenges faced by teachers in South Western State in implementing SBA on the basis of teaching qualification

The sampled teachers' responses on all the items on implementation challenges of school-based assessment were summed and compared using ANOVA statistics.

Table 5: ANOVA statistics on respondents' implementation challenges of school-based assessment on the basis of teaching qualification

Sources	SS	df	Mean Square	F-ratio	P-value	Decision
Between Group	23604.289	6	3934.048			
Within Group	10331.600	569	18.157	216.663	.000	Rejected
Total	33935.889	575				

Table 5 reveals an F-value of 216.663 which is significant at 0.05 alpha level. Thus, the null hypothesis four is rejected. Therefore, there is a significant difference in challenges faced by teachers in South Western State in implementing SBA on the basis of teaching experience. Scheffe's Post Hoc test was carried out to find the sources of the differences.

Table 6: Scheffe's Post-hoc test on respondents' implementation challenges of school-based assessment on the basis of teaching qualification

Teaching Qualification	Subset 1	for 2	alpha 3	=	0.05
M.Ed.	32.0000				
B.Sc. (Ed.)/B.Ed.	34.5000				
NCE	35.0000				
B.A		37.0000			
B.Sc		37.8750			
OND		39.6000			
HND			51.0000		

The table 6 shows the Scheffe's post hoc test on Respondents' implementation challenges of school-based assessment on the basis of teaching qualification and a significant difference was recorded. South Western State teachers with HND certificate have greatest challenges in implementing SBA with highest mean of 51.0000, followed by teachers with OND, B.Sc. and B.A certificates with means of 39.6000, 37.8750 and 37.0000 respectively. The means in the same subset implies that the respondents significantly have the same challenges in implementing SBA. The respondents with NCE, B.Sc.(Ed.)/B.Ed. and M.Ed. certificates have the least mean of 35.0000, 34.5000 and 32.0000 respectively and are significantly different in SBA implementation challenges.

Discussion

Based on the data collected and work done on the analysis of result, the findings of the study revealed that the main challenge faced by teachers in South Western States in implementing SBA is assessment skills with highest mean (12.4583) followed by in-service training and supervision with mean of 10.4028. It was followed by supervision with mean score of 9.5278 while the least challenge was recorded in teachers' laxity with a mean score of 9.0972. This study is supported by Bassey, Akpama, Ayang & Obeten (2012) study which revealed that the observed level of best assessment practices exhibited by the basic education teachers was not significantly higher than expected, except in assessment administration and scoring but assessment practices were significantly poor in construction, interpretation, communication, analysis and trial implications. SBA skills are the main challenge faced by teachers in South Western States in implementing SBA.

In addition, there is a significant difference in the challenges faced by male and female teachers in implementing SBA. Female teachers are significantly different in challenges faced in implementing SBA with higher mean of 42.3259. This finding disagree with a study by Hamzah and Pamasivam (2009) on SBA Oral English assessment revealed that SBA is not

implemented according to the guidelines provided partly due to teachers (both male and female) lacking knowledge and skills in the area. In addition, Talib, Kamsah, Naim and Latif (2014) also supported this study, their finding shows that in SBA which is based on assessment for learning(AFL) practices, female teachers are above the mean of male teachers except for active involvement of students in their own learning. This shows that, there is a statistical significant difference in the practices of AfL principles in relation to gender.

The null hypothesis of no significant difference in challenges faced by teachers in South Western States in implementing SBA on the basis of teaching experience is rejected. It therefore means that there is a significant difference in challenges faced by teachers in South Western States in implementing SBA on the basis of teaching experience. Scheffe's Post Hoc was carried out to find the sources of the differences and it was revealed that teachers with 6-10years teaching experienced face more implementation challenges of SBA with highest mean of 50.0714, followed by teachers with teaching experience of 11-15years and 1-5years with the mean of 38.1176 and 35.0769 respectively. Teachers with teaching experience of 18 years and above are faced with least challenges in implementing SBA because they have the least mean of 25.0000. This study supports the findings of Dosunmu (2002) which observed that the more experienced a teacher is, the more he begins to understand and appreciate some important of assessment and test construction skills. Moreover, Silker (2003) made a similar observation and concluded that teacher year of experience was a significant factor that affects the validity of teacher-made tests. The finding of this study is against the study of Talib, et. al. (2014) which revealed that SBA practices were not significantly dependent on teaching experience of the teachers.

In addition, the null hypothesis of no significant difference in challenges faced by teachers in South Western States in implementing SBA on the basis of teaching qualification is rejected. It therefore means that there is a significant difference in challenges faced by teachers in South Western State in implementing SBA on the basis of teaching experience. Scheffe's Post Hoc was carried out to find the sources of the differences and it was revealed that South Western State teachers with HND certificate have the greatest challenges in implementing SBA with highest mean of 51.0000, followed by teachers with OND, B.Sc. and B.A certificates with means of 39.6000, 37.8750 and 37.0000 respectively. The means in the same subset implies that the respondents significantly have the same challenges in implementing SBA. The respondents with NCE, B.Sc. (Ed.)/B.Ed. and M.Ed. certificates have the least means of 35.0000, 34.5000 and 32.0000 respectively and are significantly different in SBA implementation challenges. This study is against the study of Bassey, Akpama, Ayang & Ifeji-Obeten (2013) who found that teacher qualifications do not significantly influence their best assessment practice.

Conclusion and Recommendations

It can be concluded from this study that significant difference exist in challenges faced in the implementation of SBA on the basis of gender, school location, teaching experience and teaching qualification. Based on the findings of this study, the following recommendations are made to educational authorities and other stakeholders in education.

1. Governments at all level, should periodically organize in-service training programme for secondary school teachers on regular basis to broaden their knowledge in assessment skills,
2. Qualified teachers should be recruited, supervised, motivated and improved their welfare to get the best result in Nigerian secondary schools.

3. Government should stop employing people without teaching qualifications to teach and assess students in our schools because they lack teaching methods and assessment skills,
4. There must be a proper monitoring and supervision of teachers' during continuous assessments and
5. Parents should monitor the continuous assessment or SBA records of their children in order to know the progress or improvement of their children in the school.

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EFFECTS OF COMPUTER MEDIATED POWER POINT PRESENTATIONS ON SECONDARY STUDENTS' LEARNING OUTCOMES IN BASIC SCIENCE IN OYO STATE, NIGERIA

SUNMAILA OYETUNJI RAIMI, OLUFEMI AKINLOYE BOLAJI,
& ABIODUN EZEKIEL ADESINA

General Studies Education, School of Education

Emmanuel Alayande College of Education

P.M.B. 1010, Oyo, Oyo State, Nigeria

E-mail: raimitunji@yahoo.com, akinik1@yahoo.com, aeadesina2010@gmail.com

Phone No: +234703-029-2283, +234-703-265-6077, +234-803-074-5843

Abstract

This study determined the impact of computer mediated power point presentations on students' achievement in and attitude to Basic science in Oyo State, Nigeria. A pre-test, posttest, control group quazi-experimental design was adopted for the study. Two hundred and five (205; M= 83, F=122) junior secondary two students selected using stratified random sampling technique participated in the study. Three research questions and three hypotheses guided the study. Two instruments – Students' Basic Science Attitudes Scale (SBSAS, $r = 0.91$); Students' Knowledge of Basic Science Test (SKBST, $r = 0.82$) were used for data collection. Descriptive statistics of mean, standard deviation and inferential statistics of ANCOVA, scheffe post-hoc test were used to analyse the data. The results indicated significant main effect of treatment on students cognitive ($F_{(1,200)} = 171.680$; $p < 0.05$; $\eta^2 = .239$) and attitudinal ($F_{(1,200)} = 34.466$; $p < 0.05$; $\eta^2 = .086$) achievement in Basic science with the experimental group having higher mean gain than the control group. Gender has significant main effect ($F_{(1,200)} = 23.382$; $p < 0.05$; $\eta^2 = .0816$) on students cognitive outcomes but not significant for attitudinal achievement in Basic science. The study therefore recommended among others that computer mediated power point presentations should be incorporated into curriculum methodology of Basic science in secondary schools.

Keywords: Basic Science, Computer mediated Power Point Presentations, Gender, Students' Achievement

Introduction

Basic science under Universal Basic Education (UBE) requires the availability of qualified Science teachers with requisite teaching method to succeed. Quality science teaching methods are undoubtedly the pillars on which the scientific and technological development of any nation depends. Iwuozor (2000) in Ogbu (2012) observed that science is an area of learning which enhances a nation's development especially in the area of automation by virtue of its numerous values to humanity. Apart from the government's efforts, other agencies like the Science Teacher's Association of Nigeria (STAN), Comparative Education and Study Adaptive Centre (CESAC), United Nations Educational, Scientific and Cultural Organization (UNESCO) and others are not left out in the race of promoting science based education in Nigeria. All branches of science have important contributions to make in Nigeria's technological advancement. One of such background to solid scientific understanding is Basic science. Basic science combines the topics in fragmented sciences and integrates these in a thematic approach to expose the students and pupils in upper and lower Basic schools to phenomena in Science.

The implementation of Basic Science Programme has been on for a couple of decades at the junior secondary school levels in Nigeria. Research reports (Odubunmi, 1991; Ozoji, 1998; Adejoh, 2006; Adejoh and Sambo, 2012; Olagunju, 2010; Obanya, 2010; Okebukola, 2013;

Babayemi, 2014; Ogundare, 2014) indicate that there are a number of problems that confront its effectiveness at that level. These problems range from dearth of qualified teachers, ineffective teaching methods, inadequate materials resources to poor attitude to implementation work by teachers. This invariably led to poor performance of the students in the subject.

Table 1.0: Basic Science Results 2005 – 2011

Years	Total Students	No with A & C	% with A & C
2005	89,826	45,138	50.25%
2006	112,182	56,316	50.20%
2007	123,894	62,172	50.18%
2008	132,560	61,505	40.40%
2009	96,050	48,250	50.23%
2010	141,291	68,947	48.80%
2011	138,693	61,859	44.60%
Total	834496	404187	48.43%

Source: Oyo State Ministry of Education (2012)

Table 1.0 shows that the students' performance in Basic Science in Junior secondary examination in Oyo State is below average. One of the constraints to effective basic science teaching and learning is poor teaching method.

Poor teaching methods have been predominantly in use for a long time in the teaching of science (Ezeudu, 1995; Okebukola, 2007, 2013; Okpala, 2011; Babayemi, 2014) which is traditionally based and expository in nature. Such methods as demonstration, guided inquiry, discovery method could be result oriented but they have been reported to have made students fail to see the inter-dependent relationship that exist between academic contents of science subjects offered in schools and their real life applications (Njoku, 2009 in Ogbu, 2012). Consequently, Nzewi (2011), Ogar and Upula (2013) propose the need for a search for better instructional methods for the attainment of improved learning outcome. Notable among such innovative approaches is the computer mediated power point presentations.

Rationally, this is a clarion call for the supports of the teacher in the teaching – learning process. The clarion call is in hegemony with the Constructivists and Behaviourists Instructional theories. To the constructivists, the human learning is constructed, that learners build knowledge upon the foundation of a prior or previous knowledge. The view of teaching – learning process paradigm shift from the passive transmission of information from one individual (teacher) to another (learner) into a participatory situation in which no stereotype of status as teacher and learners; everybody becomes active.

The constructivists like Glaserfeld, Vygotsky, Gagne, Piaget, Bruner, and many others believe that instructors or teachers or lecturers act as facilitator and not as teachers (Patel, 2013). Where a teacher gives a didactic lecture that covers the subject matter, a facilitator helps the learners to get to his or her own understanding of the content. Learners play an active role in learning process. Brownstein (2001) affirmed a dramatic role a facilitator needs to display which are totally different from that of a teacher or lecturer. A teacher tells, a facilitator asks; some teacher lecturers from the front, a facilitator supports from the back; a teacher gives answers according to a set of curriculum, a facilitator provides guidelines and

creates the environment for the learner to arrive at his or her own conclusions, a teacher mostly gives a monologue, a facilitator is a continuous dialogue with the learners.

This follows the psychological theory of “reinforcement” and “behavioral modification” as presented by Thorndike (1931) and Skinner (1954) among others also bears relevance to use of computer in teacher education. Naturally, when didactic lecture method is used to instruct the learners, they are unconditionally unresponsive, unstirred and passive to learning but whenever computer is utilized, the message structure into the brain stimulated and conditioned the attitudes to learning and the achievement of the instructional objectives (Patel, 2013; Abimbade, 2006, 2011; Mangat and Mangal, 2009; Chaung and Slavin, 2011; Erhan and Okan, 2011; Afolabi, 2006; Oduwaye, 2009). Nigeria as a developing nation needs her youths – the future generation to be prepared and equipped for the 21st century challenges. This calls for the need to integrate ICT into her educational system since education is concerned with the acquisition of knowledge, skills and attitudes (Ojo, 2008).

Incorporating media technology into the classroom has become a global trend and in recent years, schools and institution of higher learning in Nigeria and the world-over are integrating multi-media into their educational curriculum methodology to enhance the teaching learning process. Such a multi-medium is Computer-mediated power-point presentations (Ogar and Upula, 2013; Anulobi, 2012; Abraham, 2012; Abimbade, 2011; Erdermir, 2011; Susckind, 2007; Blalock and Montgomery, 2005; Bartsch and Cober, 2003).

PowerPoint is a software tool that has become a presentation staple in lecture halls, conference rooms, and through the application of computer-based training. It is used in over 30 million presentations a day, and its software is on 250 million computers world-wide (Alley & Neeley, 2005; Erdimir, 2011). Initially, PowerPoint was developed to improve learning by providing the means to develop presentations that are more structured and interesting to audiences (Amare, 2006). Researchers have examined the benefit that these types of presentations bring to various audiences. Overall, research indicates that students prefer PowerPoint-type Presentations (PPPs) to traditional lectures (Susskind, 2005; Gok & Silay, 2008; Anulobi, 2012; Abraham, 2012; Ogar & Upula, 2013).

Some lecturers state that PowerPoint inhibits the presenter-audience interaction (Driessnack, 2005), limits the amount of detail that can be presented (Tufte, 2003), and reduces a presentation's analytical quality (Stein, 2006). On the other hand, supporters claim that PowerPoint improves learning, invokes audience interest and aids explanations of complex illustrations (Apperson, Laws, & Scepansky, 2006). In short, all software has advantages and disadvantages, and this debate highlights the fact that PowerPoint is no exception.

Numerous studies have been conducted to determine whether or not PPPs affect the students' success in science instruction. Studies have revealed that the reason for success in science education have been associated with students' motivation, interest, and the use of PPPs in the classroom setting (e.g. Craker, 2006; Normah & Salleh, 2006). Furthermore, studies have consistently indicated that students generally believed that the use of PowerPoint facilitated their learning and retention (Apperson, Laws, & Scepansky, 2008; Mantei, 2000; Rankin & Hoaas, 2001; Szaba & Hastings, 2000). Therefore, the use of the PPPs to increase student teachers' achievements should be considered as an important step in science education.

Students who were exposed to teaching methods with PPPs emphasized that the interest and achievements were improved and said that PPPs enhanced learning and success (Frey &

Birnbaum, 2002; Apperson, Laws, & Scepansky, 2008) because they were able to see the notes (e.g., slides and texts) on the screen and easily follow the subject. Moreover, research has indicated that the sole use of traditional teaching methods has negative effects on students learning or comprehension of science concepts (Araujo, Veit, & Moreira, 2004; Susskind, 2005). So, it can be concluded that we need to implement contemporary teaching methods, tools, and technology (e.g., PPPs and computerized teaching) into science education in order to increase the level of students' academic success.

Educators hypothesize that the use of PPPs in science courses aims to encourage students' active involvement in science teaching and learning (Blas & Fernández, 2009; Gay, 2009). It enables students to learn, interpret the information, and retain the knowledge for a long time. Further, it attracts the students' attention to the subject, makes the lesson easy to learn, and helps to memorize abstract and concrete information (Erdemir, 2009; Savoy, Proctor & Salvendy, 2009; Wofford, 2009). Students appreciate the details, distinctive features, and critical points in the figures on the slides when graphic presentations are used. Hand-drawn figures cannot be copied onto the board. The impact on the success of this type of drawing is not as great as PPPs within the classroom setting (Bartsch & Cobern, 2003; Yucel, 2007).

In fact, students perceive lectures accompanied by computer-mediated PowerPoint presentations as more organized (Susskind, 2005) and better at emphasizing key points (Frey & Birnbaum, 2002; Susskind, 2005; Szabo & Hastings, 2000) than traditional lectures. When college instructors accompany lectures with computer-mediated PowerPoint presentations, there are positive effects on students' attitudes toward the course and self-efficacy beliefs (Frey & Birnbaum, 2002; Kask, 2000; Susskind, 2005; Szabo & Hastings, 2000).

Students claimed that PowerPoint presentations made it easier to attend to and understand the lectures. Students felt they took better notes and believed their notes were more organized, easier to understand, and useful for studying for exams when PowerPoint was employed (Szabo & Hastings, 2000; Frey & Birnbaum, 2002; Frey & Birnbaum, 2002; Susskind, 2005; Apperson, Laws, & Scepansky, 2006).

The purpose of education is to produce wholesome, pleasant and understanding individual who will interact wisely and purposefully within and outside the environment. Studies have demonstrated that students prefer power point and respond favourably to classes when it is used.

Anulobi (2012) experimented the effectiveness of power point slides and chalkboard instructional delivery methods on academic performance of Junior Secondary School Fine arts students in Owerri, Nigeria. A quazi-experimental design was adopted for the study. The subjects were randomly placed in control and experimental groups. Two research instruments were used to collect data from the subjects, t-test and ANOVA statistical tools were used to analyse the data. The results revealed that the students taught with power point slides (experimental group) performed better than those taught without power point slides (conventional group).

Abraham (2012) examined learners' perception about power point presentations in English Classroom, fifty arts and humanities male learners were exposed to power point slides presentation in one semester of their course of study. The data collected and analysed revealed that learners preferred power point presentation over traditional lecture methods and had positive attitudes towards PPPs and lectures who use them in their lessons.

Erdemir (2011) determined the effect of power point on students' achievement in Physics over the traditional lectures, using pretest-posttest control group quazi – experimental research design and 90 science student-teachers (Pre–service teachers) in physics education in a University in Turkey. T–test was used to analyse the data collected. The results indicated that PPPs group had higher grades than the control group and that intelligent use of power point presentations in Physics instruction is capable of increasing the students' success.

Susskind (2007) determined the limits and effects of power point's power: Enhancing students' self – efficacy and attitude but not their behaviour. Quazi – experimental design was adopted with two groups composed of 42 students in experimental group and 38 students in the control group. Descriptive statistical of mean and standard deviation were used to describe the results as well as a non – parametric statistics of ANOVA to determine any significant difference in the two groups. The results showed that power point presentations have significant influence on students' self – efficacy, attitude and academic achievement in University than the traditional method.

Nouri and Shahid (2005) conducted an experiment on the effect of power point presentations on students learning and attitudes using control-treatment design on seventy-four Accounting students, the regression analysis and Analysis of Covariance showed that power point presentation improved students' attitudes as well as short-term memory of the students.

Blalock and Montgomery (2005) determined the effect of PowerPoint on student performance in principles of economics in an exploratory study, twenty-four students were selected for chalk classroom and thirty-three students in the class receiving the multimedia presentation. The subjects were measured on four exams with 185 questions. Descriptive statistics of mean and standard deviation and Z-score was used to standardized the performance on the exams. The results indicated that power point presentations can improve test scores significantly and that students who are above-average academic performer students receive more benefits from multimedia presentations than students of below-average academic performance.

Bartsch and Cobern (2003) investigated effectiveness of power point presentations in lectures over overhead transparencies. Quazi – experimental design was adopted for the study with thirty – nine students in social psychology class at the University of Texas and Analysis of variance as a method of data analysis, the result showed that students preferred power point presentations to over head transparencies and traditional method of lecture.

Also, evidence in the related literatures (Ogbu, 2012; Egbo, 2005; Okebukola, 2007, 2013) shows that some factors have been shown to either singly or in combination with instructional methods influence students' academic outcome in sciences, among them is the student's gender. Therefore, this present study was carried out to determine the relative efficacy of computer mediated power point presentations and its interaction effect with gender on upper Basic Two students' outcome in Basic Science in Oyo East Local Government Area of Oyo State, Nigeria.

Purpose of the Study

The main purpose of this study is to determine the relative efficacy of computer mediated power point presentations on students' academic and attitudinal achievement in Basic Science in Oyo East Local Government Area of Oyo state, Nigeria.

The study equally examined the influence of the innovative strategy on the students' cognitive and affective outcomes based on gender.

Statement of the Problem

Baseline data revealed that students have low level of achievement in Basic Science in Oyo State, Nigeria. This poor achievement in Basic Science might engender negative attitude to the subject, delimit the rate of use of scientific concepts and ideas in their respective field of study which invariably produces low scientific and technological manpower and a resultant effect on dwindling social and economic development in the state and the nation at large. Studies have indicated the effectiveness of Computer-mediated Power Points Presentations (CMPPPs) on students learning. Therefore, this study determined the effects of CMPPPs on students' achievement and attitude to Basic Science in Oyo State, Nigeria.

Research Questions

The following research question's guided the study:

- (i) What is the cognitive mean score of Junior Secondary Two students in Basic Science when taught with computer mediated power point presentation and students taught conventional method?
- (ii) What is the cognitive mean score of male and female students in Basic Science when taught with computer mediated power point presentations?
- (iii) What is the attitudinal difference in senior secondary two students when taught with computer mediated power point presentations and students taught with conventional method?

Hypotheses

- Ho₁: There is no significant main effect of computer mediated power point presentations on students:
- a. Cognitive outcome;
 - b. Attitudinal outcome in Basic Science.
- Ho₂: There is no significant main effect of gender on students:
- a. Cognitive outcome;
 - b. Attitudinal outcome in Basic Science.
- Ho₃: There is no significant interaction effect of computer mediated power point presentations and gender on students:
- a. Cognitive outcome;
 - b. Attitudinal outcome in Basic Science.

Methodology

Research Design: A pre-test-post-test control group quazi experimental design was adopted for the study.

Population and Sample: The population for this study is the junior secondary school two students in Oyo East Local Government Area of Oyo State, Nigeria. Four schools were selected for the study using stratified random sampling method. Two of the selected schools were randomly assigned to the experimental group while the other two were assigned to the control for replication. A total of 205 students constituted the sample size.

Research Instrumentation: Two evaluative research instruments and two instructional guides were used for the study.

The two evaluative instruments are:

- (i) Students' Basic Science Attitudes Scale (SBSAS);
- (ii) Students' Knowledge of Basic Science Test (SKBST).

The two instructional guides are:

- (a) Computer Mediated PowerPoint Presentations Guide (CMPPPsG);
- (b) Conventional Teaching Method Guide (CTMG).

SBSAS is a 20 items instrument adapted from Zubair and Nasir (2011) Attitudes towards Science Learning (ATSL) Scale. With sections A and B. The instruments were validated for face, content and construct validity by experts in guidance and counseling. SKBST was a 20 item multiple choice instrument with 5 options, one correct option (stem) and four plausible distracters for each item. The research tool was constructed based on selected topics using table of specification. Thirty items were initially generated from Junior Class Two Basic Science Curriculum, consisting of work, energy, power, renewable and non-renewable resources and machines, given to experts in Basic Science and Science Education for contents and face validity.

SASAS was subjected to Cronbach's Alpha measure for reliability and a value of 0.91 showed the tool to be valid and reliable. SKBST was subjected to Kuder-Richardson formula 20 (KR-20) to determine the internal consistency, reliability values of 0.82 was gotten for the instrument.

Procedure for Data Collection

The treatment comprised of the two instrumentation strategies (computer mediated PowerPoint presentations and conventional teaching method). The Basic Science teachers in the respective schools of study were trained for a week on how to administer the treatment. The treatment process lasted eight weeks. The two response research instruments – SBSAS and SKBST were administered as pretests before the treatments commence and immediately after the treatment, the instruments were administered again on the same students as posttest.

Method of Data Analysis: The data obtained was analysed using mean, standard deviation and Analysis of Covariance (ANCOVA).

Results

Table 2.0: Summary of Students Achievement with Treatments and Gender

Students Learning Outcome	N	Treatments		Gender	
		CMPPPs	CTM	Male	Female
Cognitive		101	104	83	122
	Pretest				
	X	8.02	9.89	9.25	8.43
	SD	2.37	2.18	3.71	3.99
	Posttest				
	X	16.31	14.72	14.83	16.29
Attitude	SD	4.52	7.36	5.76	3.11
	Mean Gain	8.29	4.83	5.58	7.86
	Pretest				
	X	53.61	55.09	51.86	56.73
	SD	8.22	10.32	11.27	9.56
	Posttest				
	X	62.12	60.91	59.22	63.81
	SD	7.25	5.68	8.04	6.62
	Mean Gain	8.51	5.82	7.36	7.08

From table 1, the students' cognitive achievement in Basic Science mean gain for computer mediated power point presentation (CMPPPs) is 8.29 while that of the Conventional Teaching Method (CTM) is 4.83. Also, female students have a mean gain of 7.86 which was higher than mean gain of 5.58 of male students.

On attitude, the mean gain of 8.51 for CMPPPs is higher than the mean gain of 5.82 for CTM. The mean gain of 7.08 for female students was less than the mean gain of 7.36 for male students.

Table 3.0: Summary of 2 x 2 Analysis of Covariance (ANCOVA) of Students Basic Science Cognitive Achievement by Treatment and Gender

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.
Covariates (Pretest)	381.522	1	381.522	65.095	0.000*
Main Effects (combined)	1295.337	2	647.669	110.505	0.001*
Treatment	1006.216	1	1006.216	171.680	0.011*
Gender	137.042	1	137.042	23.382	0.002*
2-way Interaction	8.929	2	4.465	0.762	0.649
Treatment * Gender	8.929	2	4.465	0.762	0.649
Model	715.266	4	143.053	24.408	0.001
Residual	1172.201	200	5.861		
Total	1887.467	204	8.779		

*significant @ $p < 0.05$

From table 3.0, there is a significant effect of treatment on students Basic Science cognitive achievement ($F_{(1,200)} = 171.680$; $p < 0.05$; $\eta^2 = .239$). this means that the student agricultural science cognitive achievement is significantly different across the treatment. based on this result, H_{01} (a) was rejected. Also, from table 3.0, there is significant main effect of gender on students cognitive achievement in agricultural science ($F_{(1,200)} = 23.382$; $p < 0.05$; $\eta^2 = .0816$), therefore, H_{02} (a) was not accepted. However, there is no significant interaction effect of treatment and gender on students' cognitive achievement in Basic Science. This means that the students' response to the treatment was not influenced by their sex whether male or female. Therefore, the H_{03} (a) was accepted.

Table 4.0: Summary of 2x2 Analysis of Covariance (ANCOVA) of students Basic Science Attitudinal Achievement by Treatment and Gender

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.
Covariates (Pretest)	929.113	1	929.113	15.892	0.000*
Main Effects (combined)	5722.692	2	2861.346	48.942	0.001*
Treatment	2015.005	1	2015.005	34.466	0.000*
Gender	13.879	1	13.879	0.237	0.071
2-way Interaction	19.052	2	9.526	0.163	0.119
Treatment * Gender	19.052	2	9.526	0.163	0.119
Model	13071.725	4	2614.345	44.717	0.001
Residual	11692.833	200	58.464		
Total	24764.558	204	120.803		

*significant @ $p < 0.05$

From table 4.0, there was a significant effect of treatment on students Basic Science attitudinal achievement ($F_{(1,200)} = 34.466$; $p < 0.05$; $\eta^2 = .086$), therefore, H_{01} (b) was rejected. Also, from table 4.0, there is no significant attitudinal difference in Basic Science

based on gender ($F_{(1,200)} = 0.237$; $p > 0.05$; $\eta^2 = .001$). Therefore, H_{02} (b) was accepted. Likewise, there was no significant interaction effect of treatment and gender on students attitudinal outcome in Basic Science ($F_{(1,200)} = 0.163$; $p > 0.05$; $\eta^2 = .003$). Therefore, H_{03} (b) was accepted.

Discussion

From the research question answered and the tested hypotheses in the results, it was realized that the computer mediated power point presentations (CMPPPs) have a significant effect on the cognitive outcome of the junior secondary two students in Basic Science. The observed significant effect of the treatment on the cognitive outcome of the participants could be explained on the facilitative effects of CMPPPs on the participants. This finding is in corroboration of the earlier findings of Ogar and Upula (2013); Anulobi (2012); Abraham (2012); Erdermir (2011) Erhan and Okan (2011); Susskind (2007); Nour and Shahid (2005); Blalock and Montgomery (2005); Batsch and cobem (2003) that computer mediated power point presentations has the strength of raising learners' cognitive outcome than the conventional teaching methods.

The innovative teaching strategy (CMPPPs) was also significant in raising the students' attitudinal outcome than the conventional strategy. This observed significant effect of treatment on the participants' attitudinal outcome could be explained on the traits associated with PPPs that is self-stimulating, interest arousing, instructional delivery enhancement, enrichment, enablement and empowerment of teaching and learning. These findings find supports in Abraham (2012); Susskind (2007); Bartsch and cobem (2003) that reported positive significant influence of power point presentations on students' attitudes.

Furthermore, the results of this study indicated a significant main effect of students' gender on their cognitive outcomes in Basic science but not on their attitudinal outcome. The female students out-performed their male counterparts in academic achievement in Basic Science. This is a positive trend in the right direction as women takes their rightful position in national development. This result is supported by Babayemi (2014), Ogundare (2014), Okebukola (2013), Ogbu (2012), Egbo (2005) that female students, at present, are achieving better than the male students in science.

Conclusion

The following conclusions were reached from the results of the study:

- (i) Innovative strategies like computer mediated power point presentations can enhance students' cognitive and attitudinal outcomes in Basic science.
- (ii) Students' gender can make or mar students' cognitive outcomes in Basic Science and not their attitudinal outcomes.

Recommendations

On the basis of the findings of this study, the following recommendations were made:

- (i) The secondary school Basic science curriculum should be reviewed with a view to integrate computer mediated power point presentations as one of the plausible teaching methodology.
- (ii) Secondary school teachers and students should be motivated by using computer mediated power point presentations to facilitate teaching-learning process.
- (iii) The Nigerian Government at National, State and Local level should collaborate to provide computer and other necessary gadgets as well as subject softwares to facilitate the use of computer mediated power point presentation in schools.
- (iv) Need for professional development of secondary school teachers in the country to be computer literate and twenty-first century compliance.

- (v) There is urgent need for Public Private Partnership (PPP) in sourcing and accessing electronic instructional materials like computer and other gadgets to ensure the procurement of appropriate equipment for schools at reasonable cost.

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DEVELOPMENT AND VALIDATION OF A COMPUTER- ASSISTED INSTRUCTIONAL PACKAGE FOR LEARNING BASIC SCIENCE IN NIGERIA

LALEYE ADEMIOTAN MORIYIKE (Ph.D.)

Department of Science Education, Faculty of Education, Adekunle Ajasin University,
Akungba-Akoko, Ondo State, Nigeria

E-mail: dammylaleye@yahoo.com Phone No: +234-806-618-6034

Abstract

The emergence of Information and Communication Technology (ICT) revolution in the nation generally calls for update in teaching strategies. This study therefore developed and validated a Computer- Assisted Instructional Package (CAIP) for teaching a physics concept in Basic Science in Nigeria. The package was based on the Ina-Fourier (1994) instructional design model. Validation was done in line with the Dick, Carey and Carey's (2005) validation model. Seven students from target population participated in one-one validation with the total positive response of 85.7%, 12 students were engaged for the small group validation with the total positive response of 94.6% (on agree and disagree scale) while 30 students were engaged for the field trial evaluation with total positive response of 80.3% (on agree and disagree scale). Two physics experts and five (5) Basic Science teachers participated in the validation of the content area while two Senior Computer Programmers and two specialists in Educational Technology were also involved in the validation. Two instruments were employed: the evaluation questionnaire and the CAIP. All the instruments were face and content validated. Test-retest method was used to find the reliability coefficient of the instrument. The scores were correlated and analyzed using Pearson Product Moment Correlation. The result obtained was 0.78 at 0.5 level of significance. The overall reaction from the validating team was that the developed package (CAIP) is valuable for learning physics concept in Basic science. It is therefore recommended that CAIP should be produced to teach physics concepts in Basic Science on large scale.

Keywords: Development, Validation, Media package, CAIP, Evaluation Questionnaire, BSAT

Introduction

Every country desires and aspires to be among those that have been rated as advanced. Information and Communication Technology (ICT) is indispensable for any country that wants to belong to the global village. Integration of ICT into the teaching-learning process is adopted through the use of computers and other technological materials in delivering curriculum contents. Teaching and learning strategies can be strengthened by the use of computers. Computer technology can be used to complete school work more efficiently, either through the use of dedicated educational software or by simplifying basic tasks such as written assignment, checking of results, registration, among others. According to Abba (2003), to benefit from the opportunities derivable from the use of technology in learning, effective strategies should be provided for acquiring and using knowledge. He explained that science education in general and Basic Science in particular today, demand for teachers that are capable of handling the new technology and helping students interpret, re-package information and provide information - rich environment for communication. Technological revolution has placed a lot of demand on teaching and learning.

Computer-Assisted Instruction was defined by Sanni and Osungbemi (2004) as programmed instructional material presented by means of computer or computer systems. They are of the opinion that the problem of lack of interest shown in scientific studies could be minimized by the adoption of a more innovative approach based on information

technology. The innovative approach mentioned by these researchers is the use of Computer-Assisted Instructional Packages or Computer-Aided Learning.

Computer-Assisted Instructional Package is a technology-based method of instruction which can be used effectively to teach. To facilitate the use of computer and packages in teaching and learning, acquisition of basic ICT skills and capabilities has recently been made mandatory as part of the national minimum standard for teacher education and first degree education. Also, all universities in Nigeria have made ICT skills a requirement for all students in form of general studies that must be passed before graduation. Thus, the teacher education colleges have also been impacted by the current ICT revolution. (Ekireghwo, 2001).

Development of software occurs in three phases. They are design, develop and evaluation (validation) (Brandie et al 2000). To develop a package, models are selected (adopt) or combined/modify (adapt) to bring out the desired results. Several models have been developed for managing software development. One model developed by Ina Fourie model developed 1994 on the design of multimedia packages for distant teaching which consisted of seven phases. They are (1) determination of the need and situation analysis; (2) Determination of aims and performance objectives and development of items for evaluation; (3) Design of study material, including development of a teaching strategy and media selection and integration (e.g. the inclusion of sound and video); (4) Development and preparation (this includes story boarding and programming); (5) Implementation and use; (6) Assessment of student progress; and (7) Formative and summative evaluation on a continuous basis throughout all phases. (Fourier, 1994:220)

Several researchers have developed and validated packages on Science subjects. Among them were Philip and Moss (1993) on Biology, Afolabi (2006) on Biology, Oyelekan (2008) on Chemistry and Mahmud et al (2009) on Mathematics. All the developed packages were validated and field-tested. None of them has the same premise with the present study as this research work considers the foundation of learners in science and the developed package is meant for Junior Secondary Students for learning Basic Science and not Science as a single subject. The package centered on Physics-related concepts of Basic Science which had been identified and considered difficult to comprehend by teachers and students due to its abstractness.

Before 1999, Basic Science was taught as Integrated Science but in 1999 Universal Basic Education (UBE) Programme was initiated which changed integrated science to Basic science in the first 9 years of the education system, i.e., primary school and the junior secondary school. The curriculum for Basic Science is designed to allow curriculum planners and implementers to adequately target pupils' needs and interests in a rapidly changing society like Nigeria. Since science is an indispensable phenomenon, it is imperative to look for better ways of teaching it. According to Agusiobo (2000), Basic Science curriculum planners stress three basic strategies in teaching the subject. They are the use of discovery teaching method, the inclusion of problem-solving activities; and the involvement of students in open-ended laboratory exercise.

The problems facing the teaching and learning of Basic Science emanated from the curriculum planners. The syllabus drawn for the three years was so voluminous that teachers could hardly cover them within the duration given, i.e., three periods of 40 minutes each per week. As a result of this, teachers rushed to finish the syllabus but not to achieve the set goals and objectives (Afolabi, 2006). Difficult concepts, especially those that are abstract in nature, could not be taught effectively using conventional method which

consumed more time and teachers needed time to gather materials for demonstration at different intervals.

Odetoyinbo (2004) recommends that Basic Science teachers be exposed to various teaching techniques, such as inquiry, problem- solving, co-operative learning and concept mapping among others to carry out hands-on tasks and activities in order to maximize the gains of Science. NERDC (2006) outlined the following as the problems facing the implementation of the Basic Science curriculum include inability to meaningfully interpret the performance objectives; skipping unfamiliar content areas; inability to organize activities for children; skipping activities where materials are not readily available; inability to identify sources of teaching aids; lack of assessment skills; and rushing the pupils to finish the scheme of work.

Well-developed packages can solve all the identified problems and simplify the teacher's work. This makes learning easier and faster. There is an urgent need to improve the performance of students in Basic Science as most of them have already created the impression that science is a difficult subject. They believe they can pass other subjects easily without stress. If learning of the subject is made interesting and technology- based, it is hoped that students of different ability levels irrespective of their gender will strive to improve in their academic performance in any instructional setting they find themselves.

In a new millennium when science and technology are expected to be integral part of the world culture, the focus should be on how to obtain and sustain effective strategies for teaching Basic Science, which is supposed to be the bedrock in the teaching and learning of pure and applied sciences at the higher level of education (Daramola, 2000).

Statement of the Problem

Basic science is meant to arouse students' interest, provide good foundational knowledge and encourage their enrolment in science -related courses at the Senior Secondary School level and to improve performance in the subjects. Presently, the margin in enrolment between science and non-science students is very wide (Oyediran, Agoro & Fabiyi, 2004). The margin is in favour of the latter, both at the senior secondary level and at the tertiary level of education. This is a problem because the teaching and learning of Basic science, which is the foundation for the study of the sciences at higher levels is at the lowest ebb. When the foundation is good, the build-up will be strong. Also, the emergence of Information and Communication Technology (ICT) revolution in the nation generally calls for update in teaching strategies; hence, there is a need to experiment the use of Computer Assisted Instructional Package for effectiveness and comprehension.

Purpose of the study

This study developed a package on selected topics in Basic Science to find out if learning could be enhanced through CAIP than using conventional method. Also, the study set to find out if the developed CAIP covered all the required areas of the selected topics in the Basic Science curriculum using step-by-step approach; and if the package is well validated.

Research Questions

In order to address the problem better, the following research questions were raised:

- (i) What are the steps involved in the development stage of a Computer-Assisted Instructional Package?
- (ii) How was the developed Computer-Assisted Instructional Package validated?
- (iii) To what extent has the developed package CAIP covered all the required areas of the selected topic in the curriculum using step by step approach?

Research Design

The study develops and validated a courseware titled Computer-Assisted Instructional Package (CAIP) based on Ina Fourie (1994) model. The model addressed the background of students, age and instructional setting and the differences by providing significant experiences for each individual learner.

Sample and Sampling Technique

The selected topics for the content of the package cut across JSS 1-3 in the Basic science curriculum. Therefore, the target population for evaluation of the developed package was all JSS 3 students in Ondo State. The sample comprised of 120 JSS3 students selected from three private Secondary Schools. A purposive sampling technique was used in selecting the samples. The criteria set for this study required that the research samples are selected from schools where students and their teachers were computer literate and there are enough set of computers to serve the study groups.

Research Instruments

The instruments for the research were (1) Treatment instrument which is the Computer-Assisted Instructional Package (CAIP) and Evaluation Questionnaire.

This study adopted the design model provided by Ina, Fourie (1994) and the social constructivist learning theory to develop the package. The design model put into consideration the age of the subjects that are meant to use the package, aims and objectives of teaching the selected topics. The researcher developed the package with the assistance of four professional computer programmers. The teachers were expected to use the CAIP to deliver their Basic science lessons on the selected topics. Although, the contents for CAIP could be selected from any of the teaching subjects and topics, the researcher made consultations with five secondary school teachers teaching Basic science to identify difficult concepts used for dummies before concluding with the selected topic. Evaluation Questionnaires were designed for students, teachers and experts. They are the Content Expert Questionnaire, questionnaire for programmers and specialists in Educational Technology (Expert Evaluation Questionnaire), Students Validation Questionnaire (SVQ), Individual Validation Questionnaire (IVQ) and Group Validation Questionnaire (GVQ).

Validity of the Instrument

Manuscript of CAIP was given face, content and constructs validity by specialists in Physics and Integrated Science in two Universities. Corrections and suggestions were effected before given to programmers for package production. The same group went through the package after production. Students outside the research Zone but within the population of study also validated the package for comprehension. Three sets of questionnaire were designed to validate CAIP after production. Observations were recorded and corrections effected. Questionnaires were validated by five specialists from two universities. Experts that validated the instruments included individuals who have expertise in instructional design and test construction.

Reliability of the Instruments

A test-retest method was used to find the reliability of the test instrument. An equivalent school outside the research zone was used for the pilot study. Questionnaires were administered to the group of 30 students in JSS3. After a period of two weeks, the same set of questionnaires was re-administered to the same group of students. Two sets of scores were correlated and analyzed using Pearson Product Moment Correlation (PPMC). The results were 0.78, 0.75 and 0.76 at 0.05 level of significance.

Results

All the data were analyzed descriptively using simple percentage.

Research question one: What are the steps involved in the developmental stage of CAIP?
Development of CAIP

The study adopted the design model provided by Ina, Fourie in (1994) and the social constructivist learning theory. This is a traditionally designed model which is linear and sequential in nature. It emphasized the role of the designer as the expert. The design model put into consideration the age of the subjects that are meant to use the package, aims and objectives of teaching the selected topics as recommended by the National Education Research and Development Council (NERDC) Curriculum on Basic Science. The adopted model allowed development of the package to take less time and effort as it starts with specific set of prescribed objectives.

The team named the planned topic and its content as Scheme for Computer Assisted Instructional package (SCAIP). This was typed out from the curricula and developed, using viable teaching strategy including selection and integration of media, and copies were made for Basic Science teachers in five different schools for verification and validation. This is to ensure that nothing important has been left out and that there was no misinterpretation of concept. Useful ideas raised by the teachers were given consideration on the SCAIP before the final scripts were made for the production. The SCAIP was divided into 5 scripts with each of the scripts lasting 30 minutes for an average student. Script one dealt with meaning and concepts of energy. It considered the sources of energy, forms of energy and how the different forms could be converted from one form to another. Script two was on “work, energy and power” and its concepts. Script three was made up of Heat transfer and methods by which heat could be transferred. Script four treated electrical energy, conductors and insulators; while script five, also on Electrical Energy explained the concept of electron flow, types of circuit, some materials in the house circuit with their functions and how the students could read the electric meter in their various homes for billing.

At the production stage, the scripts were coded into computer readable language by the professional computer programmers that worked with the researcher for the development of CAIP which made it suitable for classroom instruction. The basic markup language used in describing the fonts, colour, graphics and texts in the package is called Hypertexts Mark-up Language (HTML). HTML gives users a way to identify the structural part of a document. The Editor used, where the source codes are typed before further processing was the macromedia dream weaver 8. Macromedia firework 8, Macromedia flash 8, Corel draw and Swishmax applications were used for the graphic and animation works in the package. Hypertext processor (Php) was the server-side language used for processing and validating the questions after each of the scripts in the package. The local host (server) which serves as the internet base on the system used for this package is called the Apache wamp server. The simplicity save Cascading Style Sheet (CSS) was used to enhance the html codes in the production. Microsoft word 2003 was used for the texts while CorelDraw was used for the graphics. Digital camera was used for snapping some of the images in the package while image scanner was used to scan some images got from websites into the work. Laptops, desktops and notebook systems, headphone and empty CD-ROMs were also used for the production. CD-ROM was the tool that houses the developed package for its availability, accessibility and efficiency.

To access information on the software product (the prepared package); insert the CAIP software (CD-ROM) into the system, five files will be displayed. The files are: CAIP, Answers, install_flash_play_ax, Installation guide of CAIP and Wampserver2.0b. User clicks on

installation guide of CAIP which presents the steps to be followed for successful installation, nine steps to be followed will be displayed on the monitor. The work is made so flexible that it can be launched and used on any platform of operating system. It is interactive in nature. However, to use the developed package, users do not need any prior knowledge of the languages used to develop the package. The package is just like any other software products and need to be handled with care. It should not be scratched or rubbed on any rough surface and needs to be kept in a dust-free shelf. The course content of the old JSS3 curriculum in Integrated Science on Energy conversion and transfer but cut across the new JSS 1-3 curricula in the Basic Science formed the Intended Learning Outcome (ILO) contained in the program. It is a self-instructional interactive package which lasts for 2 hours 30 minutes for the average student. This means that it contains 5 scripts, which lasts for 30 minutes each. It is structured in the following ways:

A folder, two short texts on installation guide and answers with the set-up of wamp-server and adobe flash player appears on the screen as the disc is inserted. The user clicks on the installation guide. This directs the user on how to access the content of the CAIP. After this, the guide instructs user to install the wamp-server. From the Wamp-server, users will right-click on the www directory, where the CAIP folder will be copied. User returns to the wamp-server from where he/she will click on the local-host. A page will be displayed on which the user searches for the CAIP project on which he/she will click. The main menu appears with the content of the CAIP. The main menu or homepage is the entry point to the content CAIP presents. Main menu implies some type of top-level index. It is the starting point to begin the program. It also presents the sequential order for content presentation. User clicks on "instruction". The student reads this for about three minutes. The five scripts are arranged consecutively after the short text. At the end of each script, there are questions based on the preceding text in the scripts followed with options (a) to (e) out of which the student picks one. A feedback of "correct" or wrong will be given by the computer.

Students can go back to the text and the diagrammatic illustrations to re-study them if any of the supplied answers are wrong. He then makes another attempt. The sequence of text display, question, answer options, feedback continues until all the contents of the package have been covered. The student cannot proceed to the next script unless he understands the previous script and get all the questions that followed correctly.

Research question Two: How was the developed package CAIP validated?

Association for Educational Communication and Technology (AECT) 2007 recommended that for any instructional media designed and developed to be selected and approved for use, experts that are relevant to the work and the intended end-users must be involved in the validation processes. As a result of this, Validation of the developed package (CAIP) was done in line with Dick, Carey and Carey (2005)'s recommendation. According to them, validation of developed packages took the following forms:

- (i) Expert validation;
- (ii) One to one validation with students (the validation model recommended minimum of three students);
- (iii) Small group validation with students (minimum of eight students); and
- (iv) Field-trial evaluation with students (thirty students at least).

This method of validation was considered appropriate because it corresponds to the AECT's recommendation that the process must involve experts and students who are the end-users. Manuscript prepared by the researcher and five selected Basic science teachers was validated by specialists (lecturers) in physics and Basic science in two Universities - Adekunle Ajasin University, Akungba-Akoko and University of Ilorin, Ilorin. The manuscript was given

to the experts for face and content validity. Corrections and suggestions were made and effected before it was given to the programmers for production. After production, the same group of experts in science education and another programmer went through it and necessary corrections were made.

Input and feedback from students and experts which include the teachers are important components of the developmental-process. Students that validated CAIP include JSS 3 students within the target population of study. Those in the expert group include individuals who are experts in physics, Science education, instructional design, instructional technology and qualitative research.

Three (3) questionnaires were designed to validate the CAIP after production. At the end of each of the questionnaires, there was room for comments where observations could be written apart from the ones mentioned in the questionnaire. The questionnaires were made up of statements unto which options of strongly agree, agree, disagree and strongly disagree responses were given. The questionnaires are:

- (i) Student Validation Questionnaire (SVQ) for individual and group of students. Seven (7) students were selected for individual validation within the target population and twelve (12) students for group validation. This questionnaire is made up of eleven (11) statements.
- (ii) Content Expert Questionnaire (CEQ). This is made up of eight (8) statements and was given to five (5) Basic Science teachers in the Junior Secondary Schools within the target population, two physics lecturers and two science education lecturers in Adekunle Ajasin University, Akungba – Akoko; and University of Ilorin. The questionnaire was given to them to ascertain the adequacy of the developed CAIP in line with the recommendation of the NERDC in the UBE scheme of the Basic Science curriculum for Nigerian Junior Secondary Schools, they considered the content in terms of tense and grammar used, teaching methodology, legibility and clarity, nature of the questions after each of the scripts etc.
- (iii) Programmers and specialists in Educational Technology Questionnaire (PETQ). This consists of eight (8) statements and was given to two (2) senior computer programmers and two (2) specialists in Educational Technology.

Research question three: Did the developed package cover all the required areas of the selected topics in the curriculum using step by step approach?

Topics used for preparing dummy for the developed package were decided upon by stakeholders and conclusion was made. Basic science teachers in the development team brought the NERDC (2007) recommended curriculum for Basic Science. This curriculum is divided into seven columns to guide the user. They are: topic, performance objectives contents, activities (teachers and students), teaching and learning material to be used and the evaluation guide. The curriculum was prepared using step by step approach, that is, from simple to complex. This was typed out the way it was arranged in the curriculum and given to five Basic science teachers for vetting to ensure nothing important was left out and no misinterpretation of concept. This was named Scheme for Computer Assisted Instructional Package (SCAIP). Textbooks recommended by the Universal Basic Education for Basic science and the Teacher's guide were used in planning the contents of the SCAIP. Content experts in the team verified and validated the SCAIP before the final production of the manuscript given to the programmers for coding. They all agreed that the content of CAIP covered every aspect of the selected concept- Energy conversion and transfer in the Basic science curriculum designed and recommended for junior secondary schools in Nigeria.

Results of the validation findings are given below:

Content Expert Validation: the subject content expert validation of the computer Assisted Instructional Package was done using the subject content expert validation questionnaire. The result obtained after administering the questionnaire revealed that the 8 validates strongly agreed with every statement in the questionnaire. From their comments, some were able to identify typographical error and graphical errors. All these were corrected before the final production. Some of the contents experts believed that the package could be useful in learning some topics successfully in SS 1 physics. This implies that the target class (JSS 3) may not be the only class that may benefit from the developed package going by the Nigerian curriculum design.

Expert Validation (programmers and specialists in Educational Technology): Two programmers and two specialists in Educational Technology used the expert evaluation questionnaire to validate Computer Assisted Instructional Program (CAIP) after production. These validations were based on the following criterion: legibility, typography, animation, simulation, navigation, accessibility, functionality, packaging and durability. Two senior programmers and two specialists in Educational Technology were involved in the validation. Reports from the programmers suggested that the main-menu bar should appear on every page to provide the user the options of viewing any aspect of the work at will. According to them, making the main-menu bar to appear on every page will make the package more flexible and interactive. The developing team did not affect this during correction as it was considered that lazy students can easily abandon or skip areas that they are not interested in and proceed to the net stage. As the instruction was programmed, students must pass all the questions after a script before proceeding to the next script. The computer instructs the user to go back to the script to find out why the question was missed, after which the user is expected to proceed to the questions again and re-answer. This requires endurance on the part of the user. Apart from this, they recommended the use of colour in some diagrams to make them fascinating. They commented on the colour used for the texts as not good enough as it may affect the sight of readers (white texts over black background were originally used. This was changed to black text over white background). They agreed that the font size was okay and navigation good enough. They applauded the production for the inclusion of User Instructional manual or guides as it will enable any novice to install with ease and access the package. In terms of legibility, packaging, functionality and durability they considered CAIP superb.

Specialists in Educational Technology considered the concept of the content good enough as it simplifies the topic. Both of them suggested the use of Audio explanations especially in the area of introducing the package when attempting the questions and at the completion of the package to reinforce users. They strongly agreed that the method of teaching matched the students' need and that the content will not confuse students. They agreed that the content of the package will match the level of students in terms of legibility, interpretation and comprehension. They strongly agreed that the graphics used served the appropriate level of students and that correct answers and appropriate feedback were supplied in the package. All the corrections made were effected on the package before the final production was made. Based on their comments and suggestions, colourful pictures were used except for few, background colour was changed and Audio added.

One to One Validation with Students: The questionnaire designed for individual students were given to seven students among the target population. They were to comment on the clarity of the package, simplicity and the aesthetic value of the content if it would hold or sustained the attention of students. From their response, it was gathered that the

vocabulary used for the package could be easily comprehended, clear enough, and strongly agreed that the arrangement of the scripts is sequential in nature and it's arranged from simple to complex. The students agreed that they were able to understand the concept of the package better as examples used are more or less what they encounter in their day to day life. They confessed that they enjoyed learning through the package and wish to continue learning through the package since they have sets of computer in their schools with standby generators.

Despite the fact that the students finished the package at different times, the last person still finished within the pace of time i.e. 30 min per script. Students that worked on systems with multi-media speakers and in-built speaker were able to enjoy the audio aspect of the package, though everybody had access to the contents of the scripts and animation. The participants were optimistic that the developed package CAIP could be used successfully to learn physics-related concepts of Basic Science in Nigeria especially for Remediation purpose. Students were not able to identify any error in the package. The summary table of the response and the percentage response of students to each of the items is on shown in table 1:

Table 1: Summary of the one to one students' validation questionnaire and % response

S/N	Statement	Response					
		SA	A	D	SD	% Agree	% Disagree
1	The content of the software attracted and held my attention more than the other methods my teacher uses to teach me	5	1	1	-	86	14
2	I gained more from the package than teacher standing in class to teach me	4	3	-	-	100	-
3	I understand easily the lesson scripts in the package	3	2	2	-	71	29
4	The scripts are arranged from simple to complex	5	1	1	-	86	14
5	Diagrams in the script are clear and self – explanatory	6	1	-	-	100	-
6	Most of the explanations given are related to things in my environment	4	2	1	-	86	14
7	Examples given in the contents of the script are on our day to day activities	5	2	-	-	100	-
8	The animation and the audio make the package more interesting	4	1	1	1	71	29
9	Questions asked after each of the scripts measures skill and knowledge acquisition	5	-	2	-	71	29
10	The test given before and after exposition to the package covered the content of the package	5	1	1	-	86	14
11	I will like to continue learning on the computer	4	2	1	-	86	14
Total		50	16	10	1	943	

Key: SA = Strongly Agree; A = Agree; D = Disagree; SD = Strongly Disagree

The one to one validation result of students shows that students are willing to learn through the use of Computer Assisted Instructional Package. To analyze the responses on the questionnaires, strongly agree and agree were merged as one while strongly disagree and disagree was merged as one; this allowed the use of simple percentage for statistical analysis. From the questionnaire given to the seven students selected for this purpose, Six (6) 86% of the students agreed that the content of the software attracted and held their attention than other methods used by their teacher. All the students (100%) agreed that they gained more from the package than teacher standing in class to teach them. On comprehension of the scripts in the package, they all agreed that they understood the scripts with ease. Although (6) 86% of them agreed that the scripts were arranged from simple to complex, (1) 14% of them disagreed. Despite this, all of them (100%) agreed that the diagram and illustrations in the scripts is clear and self-explanatory. This was confirmed when all except one of them (14%) agreed that the examples used in the content of the scripts are on their day to day activities, hence, no foreign idea or example was used. Though they all complained that the audio of the package was bad they applauded the use of animation that is thought provoking to make the package more interesting. The total positive response from students for the one to one validation was 85.7%.

After each of the scripts, questions were asked (formative evaluation). They all agreed (100%) that the questions were straight forward, and treated all the domains of learning i.e. affective, cognitive, and psychomotor they agreed that the question measure skills and knowledge acquisition. They agreed that the test treated the content of the package.

Finally they all pleaded to continue learning on the computer and recommended that more topics should be prepared on packages.

Table 2: Summary of the Students' questionnaire for group of students used for the validation of Computer-Assisted Instructional Package (CAIP).

S/N	Statement	SA	A	D	SA	% Agree	% Disagree
1	The contents of the software attracted and held my attention more than the other methods my teacher uses to teach me	11	1	-	-	100	-
2	I gained more from the package than teacher standing in class to teach me	9	3	-	-	100	-
3	I understand easily the lesson scripts in the package	10	2	-	-	100	-
4	The scripts are arranged from simple to complex	8	2	2	-	83	17
5	Diagrams in the script are clear and self-explanatory	8	2	2	-	83	17
6	Most of the explanations given are related to things in my environment	9	2	1	-	92	8
7	Examples given in the content of the script are on our day to day activities	10	2	-	-	100	-
8	The animation and the audio make the package more interesting	11	1	-	-	100	-
9	Questions asked after each of the scripts measure skill and knowledge acquisition	10	2	-	-	100	-
10	The tests given before and after exposition to	8	3	1	-	92	8

	the package treated the content of the						
11	I will like to continue learning on the computer	11	1	-	-	100	-
12	I prefer working alone on computer than in group	9	3	-	-	100	-
13	I enjoyed working with my peers to learn on computer	8	2	2	-	83	17
14	Every member of my group participated actively in the work	8	3	1	-	92	8
Total		130	29	9		1325	75
Key: SA = Strongly Agree; A = Agree; D = Disagree; SD = Strongly Disagree							

Most of the response of the students in group tallied with that of students in one-to-one validation results which reflected positive attitude towards the use of Computer Assisted Instruction in learning the selected topics. All the students that participated in group validation agreed that they like working alone but 83% of them still which to learn with peers to learn on the computer. This implies that they are ready to learn in any of the two instructional settings i.e. group or individual. 92% agreed that every member of the group participated actively in the work. This gives room for low ability level students to ask questions from their peers to explain areas that are not clear to them in simple and clear language that could be best understood. Though this may slow down and waste the time of high ability level students as the bulk of the work most of the time will be on them. Hence, rather than teacher dominating class, students feel empowered and less afraid to contact others. They believe they learn faster and better with CAIP. Shy students can feel free in their own students'-centered learning environment. This can improve the level of knowledge acquisition. CAIP test students' ability and mark their progress. It gives to the active participation of the learner. Their overall positive response to the questionnaire was 94.64 %. Since the developed package is meant to be used in teaching Basic Science in Nigeria, the report and candid approval by the teachers and students in Nigeria schools are very vital.

Field-trial Validation with Group of Students: The questionnaire designed for field-trial was given to 30 students selected for that purpose within target population. They were to comment on the clarity of the package, content of the package, its simplicity and its aesthetic value. The response gathered was not different from the ones gathered from one to one and group validation. They all agreed that vocabulary used for the package was clear, easy to be comprehended and are sequential on nature. The arrangement of the package to them was satisfactory, as they were arranged from simple to complex. They were able to finish the given task within the given period of 30 minutes per script. The summary of the response of students to the questionnaire during the field-trial validation is shown in table 3:

Table 3: Summary of the field-trial validation questionnaire and percentage response with a larger group of students

S/N	Statement	Response				% Agree	% Disagree
		SA	A	D	SD		
1	The content of the software attracted and held my attention more than the other methods my teacher uses to teach me	20	4	5	1	80.00	20.00
2	I gained more from the package than	25	2	2	1	90.00	10.00

	teacher standing in class to teach me						
3	I understand easily the lesson scripts in the package	18	2	8	2	66.67	33.33
4	The scripts are arranged from simple to complex	20	6	4	-	86.67	13.33
5	Diagrams in the script are clear and self-explanatory	20	4	4	2	80.00	20.00
6	Most of the explanations given are related to things in my environment	20	3	4	3	76.67	23.33
7	Examples given in the contents of the script are on our day to day activities	20	6	2	2	86.67	13.33
8	The animation and the audio make the package more interesting	20	2	6	2	73.33	26.67
9	Questions asked after each of the scripts measures skill and knowledge acquisition	24	4	2	-	93.33	6.67
10	The test given before and after exposition to the package covered the content of the package	20	5	5	-	83.33	16.67
11	I will like to continue learning on the computer	18	2	8	2	66.67	33.33
	Total 80.30%	215	40	50	15	888.34	216.66

Key: SA = Strongly Agree; A = Agree; D = Disagree; SD = Strongly Disagree

Reaction from the students in this group tallied with that of their colleagues with general positive response of 80.30% which was considered good enough by the stakeholders. From their comments, they all confessed to like learning the selected topics using the developed package.

Discussion

Three research questions were raised to guide this study. The development of CAIP was based on Ina Fourie (1994), design and the behaviorist learning theory. The model provided the opportunity of mastering the script step by step. The model prescribed that the stated behavioral goals of teaching that particular topic should be considered. The stated objectives were expected to translate into questions for formative and summative evaluation after each of the scripts on continuous basis. Also the model requested that an identified media should be used, hence during production of this package, Computer software was used (CD-ROM). Manuscripts were translated into Computer readable language. Hypertexts Mark-up Language (HTML) was the basic markup language used in describing the fonts, colour, graphics and texts in the package. HTML give users a way to identify the structural part of a document. The Editor used, where the source codes are typed before further processing was the macromedia dream weaver 8. Macromedia firework 8, Macromedia flash 8, Corel draw and Swishmax applications were used for the graphic and animation works in the package. Hypertext processor (Php) was the server-side language used for processing and validating

the questions after each of the scripts. Learners can use the package when they want to read alone or in groups. All these were considered during the developmental stage. The developmental pattern was supported by Oyelekan (2008) when developing Computer-Assisted Instructional Package on electrochemistry for secondary Schools in Nigeria and Omiola (2011) that designed, developed and validated a web-based instructional package in Basic Technology for Junior Secondary School Students.

Validation of the CAIP prototype was done using the JSS3 students who are the end-users of the package. Relevant experts also participated in the validation exercise as recommended by Dick, Carey and Carey (2005). The developed package (CAIP) was validated by selected students based on individual (7 students were involved) small group interaction with the content (12 students) and field-trial (30 students). Observation and comments from the category of students were used to revise the package. Their response to the questionnaire was used to judge the quality and viability of the package developed. 5 content experts (Specialists in Basic Science and Physics) participated in the validation process. The 5 content experts agreed that the content of the package developed covered the required areas of the selected topic. The content experts strongly agreed that the SCAIP used for the content of the package covered the specified areas recommended by the curriculum planners on the selected topic-energy conversion and transfer for the junior secondary schools in Nigeria. All the teachers strongly agreed that the subject content was presented satisfactorily, the theses and grammar were correctly used and that the content will not confuse students. They all agreed that the content of the developed package satisfied the U.B.E Curriculum. Observations were made and corrections were effected before the final production of the package.

Seven Programmers and Educational Technologists went through the prototype of the package to validate its technological aspect. Navigation errors were detected by them and corrections were effected. Students strongly agreed that they could understand easily the lessons script in the package and the drawings clear and self-explanatory. They attested to it that explanation given and drawing are related to the environment. Both teachers and students agreed that the test given before and after exposition to the scripts in the package treated the content of the package. And are arranged from simple to complex, this ensures clarity. This results are in line with the results obtained by Oyelekan (2008) and Omiola (2011) in their various works. AECT (2007) also support the Validation process adopted.

Recommendations

Based on the outcome of this research work, it is recommended that the developed package be used as an adjunct to teach Basic Science in Nigeria as it cannot replace textbooks and the computer system cannot replace the teacher. Best results would be achieved if teachers could monitor and assist students when using the package to learn Basic Science. Also the contents of the package are selected from the JSS 1-3 curriculum contents on energy conversion and energy transfer. Therefore, it is recommended that the package should be used for revision and remediation especially when working towards improvement in performance in the Junior Secondary School leaving examinations. There is a need to allow students to interact with computer and the need to buy ready-made software's on different topics in the Basic Science curriculum. Students hardly interact meaningfully with computers except to access mails and face book.

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COLLEGE OF EDUCATION STUDENTS' ACCESSIBILITY, ATTITUDES AND COMPETENCE TOWARDS THE USE OF INTERNET IN OYO STATE, NIGERIA

FALADE, AYOTUNDE ATANDA (Ph.D) & SAMUEL, NATHANIEL

Department of Educational Technology,

University of Ilorin, Ilorin, Nigeria

Email: falade.aa@unilorin.edu.ng Phone No: +234-803-856-6249

Abstract

This study was a descriptive research of the survey type. It examined students' accessibility, attitudes and competence towards the use of ICTs and the internet for learning among Emmanuel Alayande College of Education students in Oyo State Nigeria. Students of the college were randomly sampled from the school of Arts and Social Sciences; Education; Sciences; Languages; and Vocational and Technical Education in the two campuses of the college. The researcher-designed questionnaire was employed and entails items on students' accessibility, attitude and competence towards the use of ICT and the internet for learning. Three hundred and forty-six (346) subjects were involved in the study and the data collected were analyzed using frequency counts and percentage. The findings revealed that a considerable number of students have access to ICTs and the internet; cultivated positive habit towards searching for information to widen their academic base and most of the students were not formally trained on the use of ICT devices and the internet for learning. It is recommended that ICT and internet facilities should be adequately procured for lecturers and students' used in the college. Courses related to ICT should be made compulsory and as core course(s) for every student to facilitate skills and competence development on the use of internet before graduation from the college.

Keywords: College of Education students, Internet ICT, Attitudes, Competence

Introduction

Learning as an integral part of education has over the years moved from one stage of development to the other using diverse of methods and media. Myriads of strategies and innovations using Information and Communication Technologies have been used to improve performance and sourcing of information in various learning institutions. Internet as an integral aspect of the Information and Communication Technologies (ICTs) has become an indispensable tool for quality teaching, learning and research in academic setting. Its impact on the field of education has been massive, thereby engendering such terms like e-teaching, e-learning, virtual teaching/learning, e-training, e-library and so forth, all developed around the application of the Internet (Yusuf, 2004).

Information and Communication Technology (ICT) subsumed the use of the internet to access and disseminate information with ease. The unquantifiable roles play by the ICTs has transformed the present society into a knowledge-based. The use of ICT facilitates rapid dissemination of information from an individual to a vast number of other users through myriads of media formats (Adegbiya, Bola & George, 2011). According to Scholastic (2003), the internet affords the user to easily retrieve the needed information for upgrading and updating of knowledge-bank. Also, the use of the internet provides solutions to academic assignments given by lecturers, and receiving and dissemination of researches to professional colleagues. Yusuf (2004) defined internet as an information superhighway that provides unlimited access to a wealth of information on different topics contributed by people throughout the world.

Kosakowski (2005) enumerates some of the benefits of the use digital devices and the internet facilities as learning resources that: facilitates presentation of knowledge in myriads forms; enables individualistic learning process; improves learners' communication and writing skills; enhances greater problem solving and critical thinking; and develop learners' spirit to interact and collaborate with their fellow students. In spite of the plethora of resources for enriching learning, teaching and research, it should be underscored that the attitude and competence of the user to maximally utilize the internet and other ICT facilities is very paramount.

Having ICT in schools ordinarily will not guarantee their effective use. The potentials of ICTs can fully be explored by resourcefulness, display of good competence of the teachers and students via positive attitude towards their usage. According to Yusuf and Balogun (2011), attitudes refer to one's positive or negative judgment about a concrete subject. Attitudes are determined by the analysis of the information regarding the result of an action and by the positive or negative evaluation of these results (Ajzen & Fishbein, 1980; Yusuf & Balogun, 2011). Studies have established the close associations between users' attitude and their use of ICT. Positive attitudes displayed towards the use of ICT devices and the internet is associated with a higher level of computer skills, experience and competence in their usage (Dyck & Smither, 1995; Teo, 2008; Yusuf & Balogun, 2011). According to Monereo, Fuentes and Sancluz (2000), acquisition of some basic abilities and skills on the use of the ICT and internet will help in no small measure on finding information in the contemporary knowledge based society. Lee (1997) found that a good number of teacher-trainees lacked the basic ICT operational skills. Therefore, failure to acquire these skills and abilities would define a new type of illiteracy and alienation from society.

Edozie, Olibie, and Aghu (2010) further reiterated that skillful use of information and communication technology and the internet facilities could enhance learners' abilities to improve on various life-skills thus strengthening their studying and information surfing capabilities. Such empowerment could be facilitated through positive attitude, skillful and competence displayed for the use of information sourcing via the internet and other ICT facilities. Cloke and Sharif (2001) posited that a considerable level of ICT competencies and positive attitudes are needed in every facet of life in order to fit well into the digital world.

The use of the Internet is more prevalent in tertiary institutions and among the students in sourcing for current information using diverse of media with less stress. The use of ICTs and the internet facilities for surfing information is faster irrespective of gender and location across the globe. The need for teachers and teacher trainee to be dynamic in the use of ICTs in the contemporary knowledge age is acknowledged by Nigerian teacher education institutions. The acceptance of the value of ICTs in teaching and learning engendered the inclusion of components of ICTs in the Nigerian teacher education program as spelt out in Nigerian Policy of Education (FGN, 2009). The uses of ICT devices and internet facilities have been a powerful and useful tool for learning and research in tertiary institutions. The internet itself cannot assume good learning but its potentials can be exploited by skill and competent user or students. Onasanya, Nathaniel, Laleye and Akingbemisilu (2013) found out that the college of education student's learners cultivated a great deal of interest for accessing and surfing myriads of internet sites frequently for fun, entertainment, social interactions chatting, and watching of audio / visuals due to a great deal of interest cultivated for such. Attitude is a major predictor of use ICT devices. This conscious and unconscious attitude put up by the students to acquire coveted learning experiences is termed hidden curriculum. Thus, the study investigated the accessibility, attitudes and competences of Emmanuel Alayande College of Education Oyo students' on the use of ICTs for internet for learning.

Research Questions

The following research questions were generated for the study:

- (i) Do the students of EACOED have access to the use of ICT devices and the internet for learning?
- (ii) What are the attitudes of EACOED students towards the use of the internet?
- (iii) What is the level of competence of EACOED students on the use of ICTs and the internet facilities for learning?

Methodology

Subjects: The subjects involved in the study are students from Emmanuel Alayande College of Education Oyo. The institution has two campuses (Lanlate and Oyo main campus) and five schools: school of Arts and Social Sciences, Education, Science, Languages and Vocational and Technical Education. Students of 200 and 300 levels in the college were randomly sampled from the five schools in the two campuses that are running different courses for the award of Nigerian Certificate in Education. These levels of students were chosen because they would have been familiar with the use of ICT devices and the internet to access academic related materials.

This study was a descriptive research of the survey type. Three hundred and forty-six (346) subjects were randomly sampled from the five schools in the two campuses that were running varied courses for the award of Nigerian Certificate in Education. However, a total of Three hundred and forty-six (346) copies questionnaires were retrieved out of 400 copies that were administered representing 86.5% responses. The instrument employed was a researcher-designed questionnaire to elicit response from the students of Emmanuel Alayande College of Education Oyo. The researchers-designed questionnaire was used to ascertain the respondents' opinion of use of ICT and the internet accessibility, attitudes and competence. The instrument was segmented into four sections. Section A was to gather the respondent's bio-data; section B entails items on students' accessibility; section C was on students' attitudes and section D was on students' competence in the use of ICT and the internet for academic learning.

The items were structured to elicit the respondents' responses based on Likert rating scale of Strongly Agreed (SA), Agreed (A), Disagreed (D) and Strongly Disagreed (SD). Students' responses on Strongly Agreed and Agreed were collapsed as 'Agreed', while Strongly Disagreed and Disagreed responses were also collapsed as 'Disagreed'. The draft of the instrument was given to senior lecturers in the Department of Educational Technology and Computer Science, at the University of Ilorin for face and content validity and to ensure the suitability of the items for the study. The reviewed draft of the instrument was later developed and tested. Cronbach Alpha was used to measure the reliability coefficient of the instrument section by section and has $r=0.75$ $p<0.00$, $r=0.82$ $p<0.00$, $r=0.79$ $p<0.00$ at 0.05 level of significance; for students' accessibility, attitudes and competence of use of ICT and the internet for learning respectively. These responses were then analyzed using frequency counts, means and percentages.

Results

The results of students' frequency of accessibility to ICT devices and internet surfing using Desktop computers, Laptops, Palmtops, Tablets, Ipads, Notebooks and Mobile phones. Three hundred and forty-six students from Emmanuel Alayande College of Education Oyo responses were collected, collated and analyzed using frequency counts, means and simple percentages. Research Question 1 found out the EACOED students' access to the use of ICT devices and the internet for learning.

Research Question 1: Do the students of EACOED have access to the use of ICT devices and the internet for learning?

The data related to students' access to ICT devices and the internet was collected, collated and analysed using frequency counts, means and percentages. Table 1 showed the responses of students' accessibility to ICT devices and the internet for learning.

Table 1: Responses of Students' Accessibility to ICT and the Internet

S/No	Responses of students' access to ICT and the internet.	Agreed		Disagreed		Total
		No of Responses	%	No of Responses	%	
1	I frequently surfs the internet with:					
	• Desktop computer	293	80.49	53	19.51	346
	• Laptop	229	62.91	117	37.09	346
	• Palmtop	125	34.34	221	65.66	346
	• Tablet	264	72.53	82	27.47	346
	• Ipad	188	51.65	163	48.35	346
	• Notebook	178	48.90	168	51.10	346
	• Mobile phone	308	84.62	38	15.64	346
	• Others	136	37.36	210	62.64	346
	Mean score	215	59.07	149	40.93	346
2	I have access to the use of ICT devices and the internet through:					
	• Desktop computer	286	78.57	78	21.43	346
	• Laptop	269	73.90	95	26.10	346
	• Palmtop	166	45.60	198	54.40	346
	• Tablet	273	75.00	91	25.00	346
	• Ipad	177	48.63	187	51.37	346
	• Notebook	186	51.10	178	48.90	346
	• Mobile phone	296	81.32	68	18.68	346
	• Others	107	29.40	257	70.60	346
	Mean score	220	60.44	144	38.56	346
3	I possess the following ICT devices:					
	• Desktop computer	42	11.54	322	88.46	346
	• Laptop	189	51.92	175	48.08	346
	• Palmtop	103	28.30	261	71.70	346
	• Tablet	292	80.22	72	19.78	346
	• Ipad	137	37.64	227	62.36	346
	• Notebook	186	51.10	178	48.90	346
	• Mobile phone	346	100	-	-	346
	• Others	127	34.89	237	65.11	346
	Mean score	180	49.45	184	50.45	346
	Grand mean scores	205	59.25	141	40.75	346

Table 1 showed that the students have access to ICT devices and frequently surfs the internet using desktop computers, laptops, palmtops, tablets, ipads, notebooks and mobile phones. The frequency counts of 215(59.07%), 220(60.44%) and 180(49.45%) affirmed access, frequent surfing of the internet and possess ICT devices. This implies that the students access the internet by other means like going to cybercafé or borrowing the needed ICT devices, while very few owned those devices. Moreover, the frequency counts of ownership of ICT devices by the students showed that all the students had mobile phones 346(100%), tablets 292(80.22%) and notebooks 186(80.22%). Thus, students averagely have access to some information and communication technologies. Research Question 2 found out the EACOED students' attitude towards the use of the internet.

Research Question 2: What are the attitudes of EACOED students towards the use of the internet?

Table 2 showed the responses of students' attitudes to the use of ICTs and the internet for learning. The data were collected, collated and analysed using frequency counts.

Table 2: Responses of Students' Attitudes Towards the Use of the Internet

S/N	Students' Attitudes Towards the Use ICT and the Internet	Agreed		Disagreed		Total
		No of Responses	%	No of Responses	%	
1	I use the internet in:					
	• accessing my mails	279	80.64	67	19.36	346
	• sending mails	242	69.94	104	30.06	346
	• for fun, leisure and entertainment	266	78.88	80	23.12	346
	• accessing Pornography	69	19.94	279	80.06	346
	• accessing learning materials	254	73.41	92	26.59	346
	• accessing social networking sites	328	94.80	18	5.20	346
	• accessing assignments related materials	257	74.28	89	25.72	346
	Mean score	242	69.94	104	30.06	346
2	I access educational materials through the internet:					
	• Daily	319	92.20	27	7.80	346
	• Weekly	294	84.97	52	15.03	346
	• Monthly	148	42.77	198	57.23	346
	• Once in a semester	95	27.46	251	72.54	346
	• Not at all	-	-	346	100.0	346
	Mean score	171	49.42	175	50.58	346
3	The use of the internet by trainee teachers improves learning.	326	94.22	20	5.78	346
4	My attitudes towards the use of the internet is that:					
	• It broadens knowledge base	306	88.44	40	11.56	346
	• It improves performance	298	86.13	48	13.87	346
	• It corrupts mind	44	12.72	302	87.28	346
	• It is time consuming	136	39.31	210	60.69	346
	• I dislike using it	39	11.27	307	88.73	346
	Mean score	165	48.27	181	51.73	346
	Grand mean scores	226	65.32	120	34.68	346

Table 2 showed the related responses of the students' attitudes towards the use the internet. The table showed that the students had flare for accessing social networking sites,

mails, learning materials and assignment related materials with the frequency counts of 242(69.94%) out of 346 respondents. Also, the frequency counts of students' attitudes for accessing educational materials through the internet were 171(49.42%). Thus, it showed that the students averagely surf the internet to access educational enriching information. In a similar vein, the frequency counts of 306(88.44%) and 298(86.13%) affirmed that the internet surfing broadens knowledge base and improves students' academic performances. Therefore, the grand mean score of 65.32% which corresponds to 226 out of 346 responses attested to the students' attitudes to the use of ICT devices and internet facilities. This showed that the students cultivated a positive habit towards searching for information to widen their academic base. Research Question 3 found out the level of competence of EACOED students on the use of ICT and the internet facilities for learning.

Research Question3: what is the level of competence of EACOED students on the use of ICTs and the internet facilities for learning?

Table 3 showed the students' competence of using digital devices and internet facilities for learning. The data were collected, collated and analysed using frequency counts, means and simple percentages.

Table 3: Responses to Students' Level of Competence of Using ICT and Internet Facilities

S/N	Students' competence of using ICT and internet facilities	Agreed		Disagreed		Total
		No of responses	%	No of responses	%	
1	I can operate ICT devices	266	76.88	80	23.12	346
2	I was trained on how to operate ICT to surf the internet at the:					
	• Learning institution (school)	197	56.94	149	43.06	346
	• Cybercafé /Computer training institute	187	39.60	209	60.40	346
	• Self	279	80.64	67	19.36	346
	• Friends and peers	248	71.68	98	28.32	346
	Mean score	215	62.14	131	37.86	346
3	My competence level in using ICT and internet facilities is:					
	• Excellently well	129	37.28	217	62.72	346
	• Good	206	59.54	140	40.46	346
	• Average	288	83.24	58	16.76	346
	• Below average	194	56.07	152	43.93	346
	• Not at all	39	11.27	307	88.73	346
	Mean score	171	49.42	175	50.58	346
4	My competence toward the use of the internet to access learning materials is:					
	• Excellent	146	42.20	200	57.80	346
	• Good	239	69.08	107	30.92	346
	• Average	296	85.55	50	14.45	346
	• Below average	107	30.92	239	69.08	346
	• Poor	28	8.09	183	52.89	346
	Mean score	163	47.11	183	52.89	346
5	I considered finding solution(s) to a given task via the use of internet:					
	• Extremely difficult	94	27.17	254	72.85	346
	• Difficult	156	45.09	190	54.91	346
	• Simple and interesting	271	78.32	75	21.68	346

• Extremely simple	193	55.78	153	44.22	346
Mean scores	179	51.73	167	48.27	346
Grand mean score	199	57.51	147	42.49	346

Table 3 revealed that the frequency counts of 266(76.88%) affirmed having knowledge of operating ICT devices, while the frequency counts of 279(80.64%) and 248(71.68%) attested to learning of ICT devices and internet surfing through self-training, peers and friends. This implies that most students were not formally trained on the use of ICT devices and internet surfing. The data collected rated the students' competence on the use of ICT devices and internet surfing as 171(49.42%) and 163(47.11%) respectively. This implies that the students need formal and extra training to facilitate better skills and competence development on the use ICT devices and internet surfing. Similarly, the data collected showed that the students found the use of ICT devices and internet surfing interesting due to flare and interests they cultivated for such. The grand mean score of students' competence of using ICT and internet surfing was 57.51% which translate to 199 out of 346 responses. This shows that the students' competence towards using the ICT devices and internet was average. Thus students' skills and competences need to be developed to maximize the inherent potentials in the ICT and the use internet for learning.

Conclusion

Based on the findings, the following conclusions have been reached. The findings from this study revealed that a considerable number of students have access to ICT devices and the internet to facilitate their learning. The students also cultivated positive attitudes towards searching for information to widen their academic base. However, they lacked enough skills and competence in the use of ICT and the internet because majority of them were not formally trained.

Recommendations

The findings of this study suggest that lecturers should encourage students to use ICT devices and internet facilities within and outside the school premises to search for educative information in order to enhance learning. It is recommended that ICT and the internet facilities should be adequately procured for lecturers and students' used in the college for research and academic assignments. School administrators could help in supplying ICT devices to the interested students that want to possess such at a subsidized price. Also, Seminars, workshops and trainings could be organized for the students on how to use ICT devices and internet facilities within and outside the college to enhance teaching and learning of the students. Skill development tasks should frequently be given to students using ICT devices for competence and academic improved performances. Courses related to ICT should be made compulsory and as core course(s) for every student to facilitate skills and competence development on the use of internet before graduation from the college.

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INFORMATION AND COMMUNICATION TECHNOLOGY COMPETENCE AMONG LECTURERS OF COLLEGES OF EDUCATION IN NORTH CENTRAL, NIGERIA

ANAZA, ABDULMUMUNI ONUYI¹, ABDULLAHI, MUH'D-JIMOH A².
& OHANADO, CLARA CHIBUZOR³

¹Department of Curriculum and Instruction

²Department of Primary Education

³Department of Library

Federal College of Education, Okene, Kogi State, Nigeria

E-mail: anazaao@yahoo.com, claraohanado20@gmail.com,

Phone No: +234-816-581-8332, +234-803-572-5844

Abstract

Information and Communication Technology (ICT) is a major factor in shaping the new global economy and producing rapid changes in society. Education systems around the world are under increasing pressure to use ICT to teach students the knowledge and skills they need in the 21st century. This study was conducted to provide insights regarding Information and Communication Technology Competence among Lecturers of Colleges of Education in north central, Nigeria. The study is a descriptive research and employed questionnaire in gathering data. A total of 216 participated in the study. The study revealed that lecturers in colleges of education had low competence in the use of ICT software and use of computers with other ICT facilities; they are moderately competent in the use of ICT hardware, basic computer operations and the use of the internet. The study recommended that lecturers should be trained and retrained on the use of ICT to enable them integrate ICT into the teaching and learning process.

Keyword: *ICT, Competence, Use, Lecturers, Colleges of Education*

Introduction

Information and Communication Technology (ICT) is often perceived as a catalyst for change, change in teaching styles, and change in learning approaches and in access to information (Watson, 2005). ICT can help by providing alternative possibilities for education (Casal, 2007). As ICT becomes more ubiquitous in our society, educational settings are being transformed where educators and students are expected to teach and learn using this new technology (Lee, 2003). Educational institutions around the world are beginning to recognise the potential of ICT in pedagogy (Oblinger, 2004).

ICT has become a household term globally and has brought radical changes in the way people live, learn and work. It has become a very powerful tool in education and training by linking students to global information and inducing innovations for lecturers (Ezenwafor, 2011). The author went further to state that ICT are potentially powerful enabling tools for educational advancement and reform. When used appropriately, different ICTs help expand access to education, strengthen the relevance of education to the increasingly digital workplace and raise educational quality by helping to make teaching and learning into an engaging active process to real life. Therefore, the need for individuals of different ages, levels, and vocation to possess competencies and skills in ICT for success in whatever endeavour and can never be overemphasized.

Colleges of education, one of the tertiary institutions in Nigeria, is an institution saddled with the responsibility of training middle class teacher for the lower and upper basic schools. Colleges of education are aimed at producing high level manpower to cater for the lower and upper basic schools (Olumorin, 2008). Olumorin (2008) further noted that colleges of

education are expected to contribute to national development by intensifying and diversifying its programmes for the development of manpower needs of the nation and making professional course contents to reflect our national regiments. These objectives could be achieved through effective teaching, research and other allied academic activities.

For colleges of education lecturers to carry out their job efficiently and effectively especially in this age of knowledge-based technology and globalization, the use of ICT becomes imperative. Interestingly, tertiary institutions all over the world are rapidly incorporating ICT into all facets of teaching, research and management. Lecturers who succeed in making use of ICT in their work processes do not only contribute to improved learning outcomes in their students, but also benefit personally from enhanced work productivity (Carlson, 2002).

Colleges of education lecturers have various tasks to accomplish and these range from teaching, research and publications, marking of tests and examinations, supervising students' research activities, supporting students through advisory roles, attending conferences, providing community services and so on. In order for them to be effective and efficient, they need to acquire an appreciable level of ICT competence. This is necessary in order to meet up with the demands of their job (Yusuf, 2005). Daniel (2002) reported that overwhelming majority of teachers in Europe use ICT to plan lessons more effectively and efficiently. With the use of ICT, lecturers have also been able to communicate and collaborate with other lecturers and this enhances their job performance.

ICT involves a process of creating, processing, storage, retrieval and dissemination of information and data, using computers and telecommunications (Akpan, 2008). In education, it involves the application of digital equipment to all aspects of teaching and learning. Thus, ICT encompasses a combination of technologies for collecting, storing, processing, communicating and delivering of information related to teaching and learning processes (Johnson, 2007). Onuma (2007) reports that ICT can be used to enhance teaching effectiveness, prepare lesson plan, collect and analyze students' achievement. Thus, curriculum contents could be enriched through search in the internet. Akpan (2008) states that ICT can improve the quality of researches and publications in our tertiary institutions through the use of information and quality materials from the internet and to facilitate record-keeping by lecturers. Therefore, the importance of ICT in enhancing colleges of education lecturers' job cannot be overemphasized, hence the need for them to be competent in the use of ICT.

ICT competence is the ability of colleges of education lecturers to make use of the various ICT tools such as computers, the Internet, electronic delivery systems such as radios, televisions, projectors, e-mail, facsimile, World Wide Web, intranets, extranets, online databases and other networking technologies in the performance of their job (Kent & Facer, 2004). Radloff (2001) stated that ICT increases the skills and status of lecturers for job performance. The biggest challenge for promoting teaching effectiveness in the 21st century is the ability of lecturers to acquire ICT competencies and to apply instructional technology in their teaching (van Braak et al., 2004). Premised on this, this study investigated ICT competencies among lecturers of colleges of education.

Similarly, Marija and Palmira (2007) classified ICT competencies into two: basic and educational ICT competence. These competences are further elaborated in the ICT competency standards for teachers developed by the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2011). Based on these documents, ICT competency is more comprehensive than mere focus on ICT skills. Rather, it is a comprehensive approach to education reform in six broad areas of policy, curriculum and assessment, pedagogy, the

use of technology, school organization and administration, and teacher professional development. The UNESCO (2011) standards for teachers are meant to improve teachers' practice in using ICT in an innovative way for teaching, collaborating with colleagues, and for school organization.

Lee (1997) found that a great number of lecturers are not equipped with basic computer operational skills; therefore, for lecturers to be able to integrate ICT into the school curriculum, groundwork must be done. It would, therefore, be interesting to investigate ICT competence among lecturers of colleges of education especially now that ICT is seen as not only crucial for the teaching and learning process but also for professional advancement.

Statement of the Problem

Lecturers are a vital link in the education chain, and for education to truly respond to the needs of 21st century, they must play a central role in leveraging technology, and in particular, using new and old (ICT) devices in teaching and learning. ICT competence among lecturers in colleges of education has been viewed as a prerequisite in adoption and integration of ICT in the school system. It has however been observed that in colleges of education, ICT usage among lecturers in the teaching and learning situation is still very minimal. This informed the researchers' decision to investigate ICT competence among lecturers of colleges of education in north central, Nigeria.

Objectives of the Study

The main objective of the study was to investigate ICT competence among lecturers of colleges of education in north central, Nigeria. Specifically, the study:

- (i) Examined colleges of education lecturers' competence in using ICT hardware and software.
- (ii) Assessed colleges of education lecturers' competence in basic computer operations.
- (iii) Find out colleges of education lecturers' competence in using other ICT facilities with the computer.
- (iv) Investigated colleges of education lecturers' competence in using the internet

Research Questions

The following research questions guided the study:

- (i) Do colleges of education lecturers have the level of competence to use ICT hardware and software?
- (ii) Do colleges of education lecturers have the level of competence to perform basic computer operations?
- (iii) Do colleges of education lecturers have the level of competence to use other ICT facilities with the computer?
- (iv) Do colleges of education lecturers have the level of competence to use the internet?

Methodology

This study is a descriptive research of the survey type. This is because information and findings obtained from this study can be used to describe other Colleges of Education in Nigeria. In this study, survey method was appropriate because of the size of the population

The population for this study was all lecturers in colleges of education in Nigeria while the target population were lecturers in colleges of education in north central, Nigeria. The sample was drawn from lecturers in the 10 colleges of education which consist of five Federal Colleges of Education and six State Colleges of Education. Purposive sampling technique was used to select the 10 colleges of education. Also, random sampling technique was used to select 24 lecturers from each college of education in view of NCCE's directives

that lecturers of colleges of education should be computer literate by 2005. A total of 240 lecturers were used for the study.

Survey Instrument

The research instrument used for this study was a questionnaire adapted from UNESCO's ICT-CFT (UNESCO, 2011). The survey instrument contained four sections. Section A focused on lecturers' level of competence on ICT hardware with 23 items and software with 12 items. The response modes for this section were Likert response mode of Highly Competent, Moderately Competent, Low Competent, and Cannot Use and were rated 4, 3, 2, and 1 respectively. Section B contained 13 items on lecturers' level of competence on basic computer operation with same response mode as in section A. Section C focused on lecturers' level of competence on using other ICT facilities with the computer with six items and response mode as in section A. While section D contained 16 items on lecturers' level of competence on the use of the internet with response mode as in section A.

The questionnaire was given to two Educational Technology lecturers at the University of Ilorin for face and content validity. Their corrections, comments and advices were effected before the final copy of the questionnaire was produced. The items on the questionnaire were pilot tested on 20 lecturers of the Kwara State College of Education, Ilorin. The internal consistency of the instrument for the actual study was calculated using Cronbach Alpha. A value of at 0.87 was recorded at 0.05 significant level. This showed that the items in the instrument had good reliability. Out of the 240 lecturers sampled for this study, 216 returned their questionnaires which were used for the analysis. There are 10% unreturned rate and 90% return rate of questionnaires. The responses from the respondents were arranged, tabulated and computed. Descriptive analysis using frequency and mean were employed to lecturers in colleges of education level of ICT competence. The clarification scheme used for the interpretation of the results are 0.50 – 1.49 for Cannot use, 1.50 – 2.49 for Low competent, 2.50 – 3.49 for Moderately competent, and 3.50 - 4.00 for Highly competent. In calculating the mean, F stands for the frequency while S stands frequency x response rating.

Results

Research Question One: Do colleges of education lecturers have the level of competence to use ICT hardware and software?

The results in Table 1 are on lecturers' level of competence to use ICT hardware

Table 1: Analysis of results on lecturers' level of competence to use ICT hardware

S/N	ICT facilities	LEVEL OF COMPETENCE								Mean
		Highly competent		Moderately competent		Low competent		Cannot use		
		F	S	F	S	F	S	F	S	
1	Desktop Computer	32	128	108	324	43	86	33	33	2.6
2	Laptop Computers	43	172	129	387	10	20	34	34	3.1
3	Palmtop Computers	32	128	76	228	32	64	76	76	2.3
4	Wireless Internet	32	128	86	258	32	64	66	66	2.4
5	Cable Internet	43	172	76	228	43	86	54	54	2.5
6	Digital camera	32	128	64	192	32	64	88	88	2.2
7	Scanner	21	84	21	63	32	64	142	142	2.1
8	Video equipment	54	216	43	129	43	86	76	76	2.3
9	Projector	10	40	54	162	21	42	131	131	1.7
10	Educational software	21	84	54	162	76	154	65	65	2.2
11	Television set	140	560	32	96	21	42	23	23	3.3

12	Interactive boards	54	216	43	129	32	64	87	87	2.3
13	Computer printer	32	128	97	291	54	108	33	33	2.6
14	Photocopiers	32	128	54	162	54	108	76	76	2.2
15	Virtual library	21	84	32	96	54	108	109	109	1.8
16	Electronic bulletin board	10	40	32	96	64	126	110	110	1.7
17	Electronic notice board	10	40	21	63	64	128	121	121	1.6
18	Radio	140	560	43	129	10	20	23	23	3.4
19	Tape recorder	118	472	43	129	21	42	34	34	3.1
20	CD player	108	432	64	192	10	20	34	34	3.1
21	Digital video disc player (DVD)	97	388	64	192	10	20	45	45	3.0
22	Smart phones	108	432	64	192	10	20	34	34	3.1
23	CD/DVD writers	43	172	64	192	32	64	77	77	2.3
	Grand Mean									2.6

Table 1 reveals that lecturers were highly competent in the use of laptop computers; moderately competent on the use of desktop computers, digital camera, interactive board, radio, tape recorder, CD player digital video disc player, smart phones; and low competent in the use of scanner, video equipment, projector, educational software, television, photocopiers, virtual library, electronic notice board and CD/DVD writer. The grand mean of 2.6 indicated that lecturers were moderately competence. This result underscores the need for lecturers to improve on their competence in the use of ICT hardware. The results in Table 2 are on lecturers' level of competence to use ICT software

Table 2: Analysis of results on lecturers' level of competence to use ICT software applications

S/N	Software applications	Level of Competence								Mean
		Highly competent		Moderately competent		Low competent		Cannot use		
1	Operating system	32	128	64	192	10	20	110	110	2.1
2	Word Processing Application (e.g MS Word)	43	172	86	258	43	86	44	44	2.6
3	Spread Sheet packages (e.g MS Excel)	21	84	64	192	43	86	88	88	1.7
4	Graphical software (e.g CorelDraw)	10	40	32	96	76	152	98	98	1.8
5	Presentation software (e.g power point)	10	40	54	162	76	152	76	76	2.0
6	Design tools (e.g paint brush)	21	84	10	30	76	152	81	81	1.6
7	Animation tools	10	40	43	129	32	64	131	131	1.7
8	Web browsing (e.g internet explorer)	43	172	86	258	32	64	98	98	2.7
9	Database Application	10	40	76	228	32	64	167	167	2.3
10	Multimedia Applications	10	40	43	129	43	86	120	120	1.7
11	Communication software e.g video conferences	10	40	32	96	64	128	110	110	1.7
12	Electronic Learning Management System (EMLS)	10	40	32	96	54	128	120	120	1.8
	Grand Mean									2.0

Table 2 shows that none of the lecturers were highly competent in the use of ICT software. However, they are moderately competent in the use of word processing application and web browsing. They are equally low competent in operating system, spread sheet application, graphical software, presentation software, design tools, animation tools, database application, multimedia application, communication software and electronic learning management system. The grand mean of 2.0 shows clearly that lecturers in colleges of education had low level of competence in the use of ICT software. Thus, lecturers need to be more competent on the use of ICT software.

Research Question Two: Do colleges of education lecturers have the level of competence in basic computer operations?

The results in Table 3 are on lecturers' level of competence in basic computer operations.

Table 3: Analysis of results on lecturers' level of competence in basic computer operations

Operations		Level Of Competence								
S/N	Statements	Highly competent		Moderately competent		Low competent		Cannot use		Mean
1	Boot a computer	140	560	43	129	21	42	12	12	3.4
2	Identify icon on desktop	151	604	21	63	21	42	23	23	3.4
3	Select an application	129	516	54	162	10	20	23	23	3.3
4	Run application	118	472	32	96	43	86	23	23	3.1
5	Use the keyboard	129	516	54	162	21	42	12	12	3.4
6	Use the mouse	140	560	43	129	10	20	23	23	3.4
7	Search for a document	108	432	75	225	21	42	12	12	3.3
8	Insert and access CD	97	388	86	258	21	42	12	12	3.2
9	Save a document on CD/flash	86	344	86	258	21	42	23	23	2.0
10	Connect the computer with other devices using cables	54	216	97	291	43	86	22	22	2.5
11	Print a document	97	388	54	162	32	64	33	33	3.0
12	Close an application	108	432	64	192	21	42	23	23	3.2
13	Shut down the computer properly	151	604	32	96	21	42	12	12	3.5
	Grand Mean									3.1

Table 3 reveals that lecturers were highly competent in shutting down the computer properly; moderately competent in booting the computer, identify icon on the desktop, selecting an application, running application, using the keyboard and mouse, selecting document, inserting and accessing CD, connecting the computer with other devices using cables, printing documents and closing application. They are low competent in saving a document on a CD/flash. The grand mean of 3.1 indicated that lecturers were moderately competent in basic computer operations. Hence, the need for lecturers to acquire more training on basic computer operations.

Research Question Three: Do colleges of education lecturers have the level of competence to use other ICT facilities with the computer?

The results in Table 4 are on lecturers' level of competence to use other ICT facilities with the computer

Table 4: Analysis of results on lecturers' level of competence to use other ICT facilities with the computer

		Level of Cmpetence								
S/N	Statements	Highly competent		Moderately competent		Low competent		Cannot use		Mean
1	Connect handset to the computer	64	256	75	225	43	86	34	34	2.8
2	Connect the digital camera to the computer	43	172	64	192	43	86	66	66	2.9
3	Use the interactive white board with the computer	21	84	64	192	54	108	77	77	2.1
4	Use web cam to capture images	43	172	43	129	64	128	66	66	2.3
5	Connect a multimedia projector to the computer	43	172	21	63	75	150	77	77	2.1
6	Use a scanner to create and copy images	32	128	21	63	64	128	99	99	1.9
	Grand Mean									2.4

Table 4 reveals that none of the lecturers was highly competent in using other ICT facilities with the computer but moderately competent in connecting digital camera and handsets to the computer and low competent in using interactive whiteboard with the computer, using web cam to capture image, connecting multimedia projector with the computer and using the scanner to create and copy images. Lecturers need to be competent on the use of computer with other ICT facilities in view of a grand mean of 2.4 recorded which indicated that lecturers had low competence.

Research Question Four: Do colleges of education lecturers have the level of competence to use the internet?

The results in Table 5 are on lecturers' level of competence to use the internet

Table 5: Analysis of results on lecturers' level of competence to use the internet

Table 3: Analysis of results on lecturers' level of competence to use the internet										
S/N	Statements	Level of Competence								Mean
		Highly competent		Moderately competent		Low competent		Cannot use		
1	Surf the internet using a computer	64	256	43	129	86	172	23	23	2.7
2	Surf the internet using a smart phones	75	300	43	129	64	128	34	34	2.7
3	Use a search engine such as Google, devilfinder etc.	86	344	54	162	43	86	33	33	2.9
4	Make a web book mark	43	172	43	129	43	86	87	87	2.2
5	Upload a file	75	300	86	258	21	42	34	34	2.9
6	Download information on the computer	97	388	64	192	10	20	45	45	3.0
7	Save downloaded information on computer	97	388	75	225	21	42	23	23	3.1
8	Use images from a web page	32	128	54	162	86	172	44	44	2.3
9	Modify an image or graphic with computer	21	84	32	96	64	128	99	99	1.9
10	Participate in an online	43	172	75	225	43	86	55	55	2.5

	discussion or newsgroup									
11	Create and upload a webpage	21	84	64	192	43	86	88	88	2.1
12	Send e-mail with an attachment	54	216	75	225	43	86	44	44	2.6
13	Use information from web for a project or assignment	64	256	86	258	32	64	34	34	2.8
14	Chat online using facebook, yahoo messenger, whatsapp, 2go, and so on	86	344	64	192	21	42	45	45	2.9
15	Copy information from a download	54	216	108	324	10	20	44	44	2.8
16	Paste copied information on a working page.	54	216	86	258	21	42	55	55	1.6
	Grand Mean									2.6

Table 5 reveals that none of the lecturers were highly competent in the use of the internet. However, they were moderately competent in surfing the internet using computers and smart phones, using search engines, uploading files, downloading information, saving downloaded information on the computer, participate in online discussion or newsgroup, sending e-mail with attachment, using information from the web for projects or assignment, chatting online using facebook, yahoo messenger, whatsapp, 2go, and copy information from download; low competent in using image from a web page, modifying image or graphics with computer, creating and uploading a web page and pasting copied information on a working page. Hence, lecturers should acquire more competence on area that they had low competence because, the grand mean of 2.6 indicated that lecturers were moderately competence.

Discussion

The potentials of ICT as an educational tool in teacher education had been well established by several studies. This study investigated ICT competence among lecturers in colleges of education in north central, Nigeria. Results from the self-report questionnaire used for this study revealed that lecturers of college of education lack skills in various ICT facilities and applications that support and enhance teaching, learning experiences and ICT integration in instruction. Generally, Lecturers in the colleges of education had low competence in the use of ICT software and the use of computers with other ICT facilities. Lecturers equally had moderately competence in the use of ICT hardware, basic computers and the use of internet.

This underscores the need for more emphasis to be placed on exposing lecturers to advanced training in the use of ICT in the teaching learning process. Lecturers in Nigerian colleges of education would need to improve on their ICT competence in line with the UNESCO ICT-CFT competency standards for teachers for them to meet up with the challenge of the information age.

The implication of the findings of this study is that some kinds of training and retraining programmes are needed by lecturers of colleges of education to effectively implement the ICT applications in teacher education programme.

Limitations of the Study

The questionnaire, a self-report, was used to gather data. The overall approach would have been strengthened by the use of classroom observation, interviews, and focus-groups. Observation would have been relevant in gathering data on lecturers' ICT skills and actual

use of ICT. Focus group would have been good for identifying and exploring pre-service teachers' views in-depth about ICT provision and their construction of meaning. Another major weakness is the fact that the sample included only lecturers who happened to be in office on the days when the questionnaire copies were administered. Despite these limitations, in the view of the researcher, the gains for the research far outweigh the limitations.

Conclusion and Recommendations

The results revealed that among the basic computer competency sub-divisions, lecturers indicated low competency in general. The findings underscore the need to introduce lecturers to more training on ICT with needed hand-on experiences so as to promote effective integration of ICT. In addition, it brings to the fore the need for teacher educators to model good use of ICT in their instruction.

One of the problems facing the development of ICT in colleges of education include the fact that there is limited infrastructural facilities, difficulties in infusing Internet use into the curriculum and also lack of appropriate lecturers' development. It is very important that these problems are addressed since it is lecturers who would produce highly teachers competent in future. Also, provisions should be made for lecturers to be able to integrate ICT-based methodology into their lectures; and also, all classrooms should be equipped with necessary infrastructure and, lastly, all students should be provided with access to media laboratories.

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INVESTIGATION INTO VOCATIONAL TECHNOLOGY TEACHERS COMPETENCY AND UTILIZATION OF INFORMATION AND COMMUNICATION TECHNOLOGY FOR INSTRUCTIONAL DELIVERY IN LAGOS STATE

OLABIYI, O STEPHEN (Ph.D.)¹, JIMOH, J. A. (Ph.D.)²
& OWODUNNI, A. SAMUEL (Ph.D.)³

^{1&2}Department of Science and Technology Education,
Faculty of Education, University of Lagos, Akoka

³Department of Industrial and Technology Education,
Federal University of Technology Minna, Niger State

E-mail: Solabiyi@unilag.edu.ng Phone No: +234-706-220-9015

Abstract

The paper examines effective utilization of ICT tools by technology teachers for efficient instructional delivery. It sought to determine the competency level of ICT required of technology teachers and extent at which technology teachers use ICT to improve students' learning outcomes. The study was conducted in Lagos State Technical Colleges, Nigeria. A descriptive survey research design was used. Structured questionnaire was used for data collection. 210 technology teachers participated in filling the questionnaires. Analysis through the use of Statistically Packages for Social Science computer program was carried out on the responses of 198 respondents who returned the questionnaires. The findings among other things showed that teachers are to demonstrate competent in: using power point presentation for lesson delivery; incorporate use of media and technology for teaching where appropriate and the extent at which teacher use ICT tools is very low. It was recommended that TVET institutions should spend a considerable amount of time and efforts developing teachers' competency in ICT pedagogy to improve students' learning outcomes.

Key words: Information Communication Technology Tools; Technical and Vocational Education Training (TVET); Learning Outcomes; Competency level and Instructional delivery.

Introduction

A good number of researchers have shown that the quality of learning and teaching can be significantly enhanced when Information communication Technology (ICT) tools is utilized as an intellectual multi-tool. Utilization of ICT tools in various fields of education and training has been a topic of discussion by educational researchers Wang, (2009); Howie and Blignaut, (2009); Bryderup, Larson and Quisgaard (2009); Rogers, (2002); Gulbahar, (2007); Louw, Brown, Muller and Soudien, (2009), Jimoyiannis, (2010), United Nation Education Scientific Culture Organisation (UNESCO), (2008); Asian Development Bank (ADB), (2009), and stakeholders in other sectors of the economy. This might be unconnected to the fact that ICT tools gained its application in almost all areas of educational specialization; in architecture Wang, (2009), mathematics and science Howie and Blignaut, (2009), social sciences Louw et-al, (2009), geographical information system Muniandy & Lateh, (2010), vocational education Jantrakool, (2010) and in other human development programs too numerous to mention.

Educational, financial, social, and professional development sectors have been benefiting from ICT tools for years (Minuandy & Lateh, 2010; Wang, 2009). Utilization of ICT tools in technology education have been one of the major area emphasized by UNESCO, due to the fact that ICT tools are becoming inexpensive, reachable and interactive, in which their application into all levels of education is expected to be imperative in making educational

results labor-market oriented. ICT tools have been recognized to be very powerful tool in education reform. It has radically influenced the way knowledge and information are generated, developed and transmitted. ICT has also reduced the entire world into a global village and replaced the use of physical strength in performing task with automation. Teachers, teacher trainer and educationist who are not familiar with ICT will find themselves threatened by professional obsolescence (Adewoyin, 2009).

Since education is perceived generally as an instrument par excellence for effecting social changes. The Federal Government of Nigeria fully appreciates the role of ICT in national development, consequently, has put in place (in the year 2001), a policy document entitled the national policy for information communication technology. The policy clearly spelt out the ICT vision, mission and policies for Nigeria. Also, Federal Government of Nigeria (FGN), (2004) acknowledge the importance of using ICT in improving knowledge and thus states in the national policy that government shall provide necessary infrastructure and training for the integration of ICT in advancing knowledge and skill in the modern world (FGN, 2004). It is assumed that government policy has been implemented; teacher in our school system must have acquired ICT skills which will help them for effective instructional delivery as well as facilitating teaching and learning. No wonder that Iwiyi (2007) pointed out that computer acquisition and use is an important aspect of the teaching and learning process. If a teacher is to function effectively, and meet with the challenges of the 21st century, the teacher education process must make adequate provision of individualized computer training for would be technology teachers, for a better output.

Information Communication Technology according to Adewoyin (2009) is the new communication and computing technology use for creating, storing, selecting, changing, developing, receiving and displaying many kinds of information. According to Adewoyin ICT is classified into three groups namely: (i) those that process information e.g. computer (ii) those that disseminate information e.g. communication, i.e. electromagnetic devices and system and (iii) those for presentation of information e.g. multimedia. Obi (2002) describe ICT as a technological tools and resources used to communicate, create, organize, disseminate, store, retrieve and manage information. In this study ICT does not only mean computers, it has to do with technological tools. These technological tools according to Chika (2008) include computers, the internet, broadcasting technologies (radio and television) and telephone.

Studies have shown that quality learning and teaching can be significantly improved when ICT is utilized as an academic multi-tool. Teaching is an attempt to assist someone to acquire skills, attitudes, ideas, appreciation and change behavior. The teacher's job therefore is to influence desirable changes in the behaviour in learners through the use of hardware and software such as video, computer, internet, radio. Learning on the other hand is a process of gaining knowledge or acquiring skills or having understanding a new thing and has a better way of carrying it out. Considering the role of technology education in the national development. Technology teachers should possess relevant ICT skills that will aid effective instructional delivery. In view of the importance attached to ICT, relevant authorities in Nigeria have made the acquisition of basic ICT skills and capabilities part of national minimum standards for certification and practice at both Nigerian certificate in education and degree in education. The relevant authorities include National Commission for College of Education (NCCE). National University Commission (NUC) and Teacher Registration Council (TRC). In the word of Njoku (2006) these developments are the strongest indication ever that the era of teachers without ICT skills are gone. To show that you are a teacher today, you must prove your e-capabilities.

For technology education teacher to meet up with the demands of global world, they must be dynamic to innovations in educational system. This will enable Technical and Vocational Education Training (TVET) to achieve the objectives for which it was established. The modern technology must be able to source for information locally and globally as the entire world has become a global village. Materials acquired in one environment can be used to solve problems in another environment. Technical and Vocational Education Training (TVET) is viewed as that form of education involving, in addition to general education, the study of technologies and related sciences, and the acquisition of practical skill, attitudes, understanding and knowledge relating to occupations in various sectors of economic and social life (UNESCO & ILO, 2002; FGN, 2004). According to UNESCO and ILO, and FGN, TVET is further understood to be an integral part of general education, a means of preparing for occupational fields and for effective participation in the world of work, an aspect of lifelong learning, a preparation for responsible citizenship and a method of facilitating poverty alleviation. TVET is one of a recognized and effective process by which quality, up-to-date, information literate and knowledgeable workers are prepared, trained or retrained worldwide.

In a nutshell, TVET prepares human resources for the ever changing world of work. In that, for effective participation in the world of work the study of technologies and related sciences' as reflected in the definition, is of paramount significance that can be realized with adequate ICT arrangement in TVET institutions. Practical skills can now be delivered virtually via a well-organized ICT set up; gone are the days where practical skills are taught using hands-on learning only. Programmed instruction in form of software and interactive video made it easy for practical skills to be taught using ICT. So also, job that requires only hands-on experiences are now possible via computer controlled programs. As such, the need for ICT tools utilization in TVET remains a great challenge, considering the impact ICT tools make in the world of work that needs knowledgeable workers skilled in information technologies. By implication, the use of ICT tools in the training, up-grading and re-training of workers is of paramount significance and an essential aspect of teaching's cultural toolkit in the twenty first century, affording new and transformative models of development.

In Nigeria, TVET courses were taught in secondary schools, Technical colleges, Colleges of education (Technical), Polytechnics and Universities to produce skilled, semi-skilled manpower, craftsmen/master craftsmen, and technical teachers at Nigerian Certificate in Education (NCE) and bachelor level and technicians/technologists, in various sectors of the economy for industrial and technological development (Federal Government of Nigeria (FGN), 2000).

In technology education students have to relate directly with tools, equipment, materials and situation which can be visualized through ICT. ICT plays vital role in sourcing, assessing, retrieving and managing information that can facilitate teaching and learning. If technology teachers are ICT compliance, they can browse on the internet to get useful information which could be of help in technology education instruction. They can use computer to store and retrieve information, television and radio which form part of technological tools can also be used as instructional strategy to facilitate teaching and learning which enhance their competencies. Competency is a standardized skill or set of skills for an individual to perform a specific job. Competency is ability to do something well, measured against a standard especially acquired through experience or training. Technology education materials can be store in disk, CD-ROM, Memory card, Flash drives, and can be used during instruction. Any teacher who is knowledgeable in the use of ICT tools is at liberty to judiciously use any of these technologies to enrich teaching and learning. In agreement with the above facts Chika (2008) succinctly puts that ICT tools can provide easy

access to information source, enable communication, create interacting learning environment and promote change in methods of instruction. Quality and access to up-to-date materials can be improved while offsetting some cost of textbooks.

Statement of the Problem

Despite the importance of ICT tools for teachers in improving knowledge, and how it affects technology education subjects and use it in their teaching. Literature reveals that technology education teachers lack knowledge and skills for presentation of ICT teaching materials, lack of teacher competency (Albirini, 2006), and teachers slowness to adopt ICT (Hayes, 2007). Majority of technology teachers in our secondary schools and technical colleges do not have fundamental knowledge of ICT tools. This invariably jeopardizing the fundamental objectives of vocational technical education and vision, mission and policy of ICT as stated in the National Policy of ICT (2001) to produce ICT- skilled graduates. A nation with high turnover rate of TVET graduates and graduates not being employed or under employed is certainly in a problem socially, economically and politically. This situation may ultimately lead to frustration, lawlessness and brain drain of its citizen. To prevent such situation, TVET institutions, whose part of responsibility is to prepare individual for (self-) employment and to be a medium of evolution for people to the world of work; by making individual to have a sense of belonging in their communities.

Purpose of the Study

The main purpose of the study is to investigate vocational teacher's competency and utilization of ITC for instructional delivery in Lagos State. Specifically, the study sought to determine:

- (i) The ICT competencies required of technology education teachers to enhance effective instructional delivery.
- (ii) The extent to which technology education teachers use ICT tools to improve students' learning outcome.

Research Questions

Base on the purpose of the study, the following research questions are raised;

- (i) What is the competencies level of ICT required of technology education teachers to enhance effective instructional delivery?
- (ii) To what extent do technology education teachers use ICT tools to improve students' learning outcomes?

Hypotheses

The following non hypothesis were formulated to guide the study and tested at 0.05 level of significance

- H₀₁: Is there any significant difference in the mean responses of NCE (Technical) and Bachelor degree Technology teachers regarding the competencies level of ICT required to enhance effective instructional delivery.
- H₀₂: Is there any significant difference in the mean responses of NCE (Technical) and B.Ed Technology teachers regarding the extent at which they make use ICT tools to improve students' learning outcomes.

Methodology

The research employed descriptive survey research design. Two hundred and ten (210) technology/vocational teachers in the five state own Lagos technical colleges participated in the study which comprise of 52 NCE (Technical) and 158 B. Ed (Technology) teachers. Structure questionnaire and observation were used as instrument to collect data from respondents. The instrument has three sections. Section A, B' and C'. Section 'A' sought

information on personal data of the respondents such as gender years of experience and age. Section 'B' contains information on the competencies level of ICT required of technology teachers to enhance teaching and students learning outcomes. Section 'C' contains items on extent at which technology teachers use ICT tools to improve learning outcomes. The questionnaire items were structured on a likert scale type. The questionnaire was subjected to face and content validation by three experts from Department of Science and Technology Education, University of Lagos. The internal consistency of the instrument was determined using Cronbach Alpha. The instrument was administered on twenty technical teachers in Federal college of science and Technical. Yaba, Lagos. The reliability coefficient established were as follows: Section B- $\alpha = .80$; Section C – $\alpha = .82$; and overall – $\alpha = .88$. The instrument was administered by the researcher through personal contact. Out of 210 questionnaires administered, 198 were duly filled and returned by the respondents. These represented 94.2% rate of return. Data generated from the questionnaire were analyzed using mean, standard deviation, t-test statistics at .05 level of significance. SPSS was used in the data computation.

Results

Research Question 1. What are the *ICT Competencies required of technology teacher to enhance effective instructional delivery*

In order to answer Research Question 1, mean and standard deviation of respondents was carried out and presented in Table 1.

Table 1: ICT competencies required of technology teachers to enhance effective instructional delivery N= 198

S/N	ICT Competencies required of technology teacher to enhance effective instructional delivery	Mean	SD
1	Starting and shutting down computer system/peripherals successful	4.08	.63
2	Ability to identify and use of icons, menu and window clearly	3.60	.86
3	Competent to make backup copies of documents and files	4.52	.50
4	Protect and care for storage media	4.44	.50
5	Skilled in cutting, copy and paste document/text	4.00	.50
6	Using words processing for typing and other applications correctly	4.71	.45
7	Skill to prepare and use power point presentation for lesson delivery	4.47	.50
8	Design and management of learning environment and resources	4.69	.45
9	Use media and tools to address differences in learning and performance	4.70	.51
10	Incorporate use of media and technology for teaching where appropriate	3.55	.52
11	Use technology tools to support learning of student with learning disability	4.32	.76
12	Select and create learning experiences relevant to learners and based principle of effective teaching	3.97	.93
13	Develop performance tasks that require students to locate and analyze information as well as draw conclusion.	4.28	.55
14	Ability to add and delete documents on computer	4.08	.54
15	Ability to use computer and video source for large screen presentation	4.21	.83
16	Use varieties of media to communicate and present information clearly	3.95	.71
	Overall mean	4.15	.88

Table 1 above presents technology teachers' average total scores and standard deviations on ICT competencies required to enhance effective instructional delivery. The overall score of (4.15) shows that technology teachers required these skills to effectively carry out instructional delivery. Among ICT competencies required are: ability to identify and use of

icons, menu and window clearly; use words processing for typing and other applications correctly; skill to prepare and use power point presentation for lesson delivery; incorporate use of media and technology for teaching where appropriate; use media and technology to support learning of student with learning disability and use varieties of media to communicate and present information clearly. With means values ranges from 3.60 to 4.71 above the cut-off point of 3.50.

Research Question 2. To what Extent do technology education teachers use ICT tools to improve students' learning outcomes

In order to answer Research Question 2 mean score and standard deviation of respondents was completed.

Table 2: Extent at which technology education teachers use ICT tools to improve students' learning outcomes N=198

S/NO	Extent at which technology teachers use ICT tools to improve students' learning outcomes	Mean	SD
1	Practical skills are easy to be taught using programmed instruction in form of software	2.67	.53
2	Regular use core-draw to develop, design and drawing as well as print materials improve student skills	2.98	.46
3	Micro-soft excel to is very effective in preparing students records and results	3.01	.50
4	Use of power point presentation for lesson delivery to students regularly enhance students performance	2.68	.45
5	I usually connect video and devices with computer to present information for large screen display for students	3.00	.55
6	Regular browsing on internet enhance source for relevant materials in instructional delivery	3.56	.65
7	I make use of white board in instruction delivery	2.06	.40
8	C-drom and other storage tools are effective to store relevant materials obtain from internet and computers	3.67	.65
9	Interactive video made it easy for practical skills to be taught using ICT tools.	2.56	.51
10	Television and radio part of technological tools are used as instructional strategy to facilitate teaching and learning	2.89	.52
11	Application of smart board to develop cognitive and affective skill in students	2.43	.76
Overall mean		3.01	.93

Results presented in Table 2, shows the responses of respondents on the extent at which technology education teachers use ICT tools to improve students' learning outcomes was low as they disagree with most items among which include: practical skills are easy to be taught using programmed instruction in form of software; regular use core-draw to develop, design and drawing as well as print materials improve student skills; micro-soft excel to is very effective in preparing students records and results and use of power point presentation for lesson delivery to students regularly enhance students' performance. With means values ranges from 2.43 to 3.01 below the cut-off point of 3.50.

Testing of the Hypotheses

Hypothesis 1: Is there any significant difference in the mean responses of NCE (Technical) and Bachelor Degree Technology teachers regarding the competencies level of ICT required to enhance effective instructional delivery.

In order to test the hypothesis on the competencies level of ICT required in enhancing effective instructional delivery; an independence sample t-test was conducted to compare the mean scores of NCE and Degree teachers. The independent sample t-test scores were presented in Table 3.

Table 3: t-test results of respondents on the competencies level of ICT required in enhancing effective instructional delivery N=210

Variables	N	df	$\bar{X}$	SD	F	p
NCE (Technical) teachers	52	208	3.64	.50	.258	.797
Bachelor degree teachers	158		3.57	.61		

As shown in Table 3, there were no statistically significant differences between the NCE (Technical) and Degree technology teachers in Lagos state technical colleges' mean scores on ICT competencies required in enhancing effective instructional delivery. ($t=.258, p>.05$) In other words technology teachers in technical colleges are required to possess certain level of competencies to enhance effective instructional delivery.

Hypothesis 2: H_{02} : Is there any significant difference in the mean responses of NCE (Technical) and B. Ed Technology teachers regarding the extent at which they make use ICT tools to improve students' learning outcomes.

In order to investigate the extent at which NCE (Technical) and Bachelor degree technology teachers use ICT tools to improve students' learning outcomes; an independence sample t-test was conducted to compare the mean scores of NCE (Technical) and Bachelor degree teachers. The independent sample t-test scores were presented in Table 4.

Table 4: t test results of respondents on the extent at which NCE (Technical) and Bachelor degree technology teachers use ICT tools to improve students' learning outcomes (N=210)

Variables	N	df	$\bar{X}$	SD	F	p
NCE (Technology) Teachers	62	208	4.20	.38	.659	.512
Bachelor degree Teachers	35		4.63	.48		

As seen in Table 4, Bachelor degree teachers in Lagos technical college had relatively higher mean scores than NCE (Technical) teachers. However, there were no statistically significant differences between the NCE (Technical) and Bachelor degree teachers mean scores on the extent at which they make use of ICT tools to improve students' learning outcomes ($t=.659, p>.05$). The results show that degree teacher use ICT tools more often than NCE teachers and thereby influence students learning outcomes.

Discussion

ICT competencies are measured in terms of ability of technology teachers to effectively use ICT tools to carry out their assignment properly, measured against a standard especially acquired through experience or training i.e. from skilled-based to ICT-Capable work force. The competencies required of technology teachers identified from the study are: Skill to

prepare and use power point presentation for lesson delivery; design and management of learning environment and resources; incorporate use of media and technology for teaching where appropriate; use media and technology to support learning of student with learning disability; select and create learning experiences relevant to learners and based principle of effective teaching and ability to use computer and video source for large screen presentation. The findings support previous research work on utilization of ICT in teaching and learning process. Njoku (2006) found out that technology teachers should possess necessary skills that will help them use ICT for effective instructional delivery, Adewoyin (2009) emphasized that if technology teachers is to function effectively, and meet the challenges of 21st century, teachers must be competent to use ICT tools. Albirini (2006) in his study found lack of teacher competency in schools as a main obstacle to their utilization. As such, serious work needs to be done to curtail the worseness of the situation, considering the fact that the fast changing world of work never awaits anybody. Also, Hayes (2007) stated that teachers' slowness to utilize ICT reflects their effort to discern how best to incorporate new technologies into old teaching practices. In order to ensure that ICT tools meet learners' educational needs, teachers should be competent to facilitate ICT-mediated learning.

Determine the extent at which technology education teachers use ICT tools to improve students' learning outcome, as shown in table 2 revealed that majority of respondents disagree that practical skills are easy to be taught using programmed instruction in form of software; micro-soft excel is very effective in preparing students records and results; use of power point presentation for lesson delivery to students regularly enhance students' performance; use of white board in instruction delivery; usually connect video and devices with computer to present information for large screen display for students and application of smart board to develop cognitive and affective skill in students. The findings supported the view of Chika (2008) who found out that majority of secondary and technical college teachers do not possess the necessary competent and therefore cannot use ICT tools to obtain information and materials for improving learning outcome. Adewoyin (2009) lament that TVET institutions do not use ICT resources to cope with the challenges and at the same time our education and training system are not adequately and effectively equipped to provide opportunity for teachers to use ICT tools and retraining of teachers. Allan (2003) Observed that when ICT tools are appropriately used, it offers an excellent and powerful tool to facilitate the improved delivery of many courses and modules. So familiarization with the ICT tools provides a whole range of pedagogical options Forsyth, Jolliffe & Stevens (1995): Maier, Barnett, Warren & Brunner, (1998) ICT tools can be utilized in the curriculum to facilitate learning by those with different learning styles. It should, if integrated and used properly, encourage and support more professional delivery of teaching and learning materials and thus facilitate student learning outcome.

Implication of the Findings

The study has shown that utilization of ICT tools eases the expansion and reinforcement of TVET by enhancing networking and knowledge sharing opportunities, also has the capability to make available practical learning experiences that are needed to the direct work situations. The study sensitizes TVET institutions to establish the necessary measures that need to take to ensure that TVET teachers possess the necessary ICT competencies. These may include conducting needs assessments to determine the ICT comfort level of teachers, establishing minimum training standards, developing training plans and establishing appropriate mechanisms to monitor training results. The study further sensitizes technology teachers need to develop themselves on the use of ICT by vigorously pursue ICT training with seriousness for teaching and learning process. As such, serious work needs to be done to curtail the worseness of the situation, considering the fact that the fast changing world of

work never awaits anybody. This situation also poses a great challenge to stakeholders, policy makers and curriculum implementers.

Conclusion

The study has revealed that ICT tools are globally recognized tools that needs to be fully utilized in all educational fields especially TVET, considering the nature and the importance of TVET to the economic, industrial and human resources development, in public or private sector. However, the finding of study shows that technology teachers required skill to prepare and use power point presentation for lesson delivery; design and management of learning environment and resources; incorporate use of media and technology for teaching where appropriate; select and create learning experiences relevant to learners and based principle of effective teaching and ability to use computer and video source for large screen presentation.

The findings of this study further show that technology teachers use of ICT tools is very low as respondents disagree that micro-soft excel is very effective in preparing students records and results; use of power point presentation for lesson delivery to students regularly enhance students' performance; use of white board in instruction delivery; usually connect video and devices with computer to present information for large screen display for students and application of smart board to develop cognitive and affective skill in students. It was recommended that Federal and state government should ensure that her policy statement regarding the provision of necessary infrastructure and training for the utilization of ICT tools in the school system is effectively implemented. Teachers and TVET institutions should spend a considerable amount of time and efforts developing teachers' competency in ICT pedagogy to improve students' learning outcomes.

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EFFECTIVENESS OF RATIONAL-EMOTIVE BEHAVIOUR THERAPY IN REDUCING BULLYING BEHAVIOUR AMONG IN-SCHOOL ADOLESCENTS BASED ON GENDER AND AGE

MUSTAPHA, MULIKAT LADI ABDULQADIR (Ph.D) & MUHAMMED SHUAIB ABOLAKALE & ALWAJUD –ADEWUSI MARIAM B

Department of Counsellor Education,
Faculty of Education, University of Ilorin, Ilorin, Nigeria

E-mail: ladiuthman9150@gmail.com

Phone No: +234-806-214-8082

Abstract

Bullying behaviour is a deliberate, unprovoked, aggressive behaviour displayed repeatedly with the aim of harming or hurting others. It is characterised with imbalance of power (physical/psychological). This study investigated the effectiveness of Rational-Emotive Behaviour Therapy (REBT) in the reduction of in-school adolescents bullying behaviour. REBT is a theory based on the assumption that human beings are born with the ability of rational thinking and constructive behaviour. The theory attributes bullying behaviour to the irrational aspects of in-school adolescents belief system formed in childhood. The research design adopted in the study is quasi experimental in nature using 2×2×2 factorial design. It is made up of two (2) row groups (one experimental and one control) and two column groups (age and gender). Instrument used in purposively selecting the participants in the study was Bullying Identification Questionnaire (BIQ). Perpetrators of bullying behaviour (i.e bullies only) were identified and participated in the study. REBT treatment procedure packages were administered to participants in the treatment group. It was revealed that REBT produced significant reduction in the bullying behaviour of in-school adolescents, mean difference was observed in the pre and post-test scores of participants in the treatment group. ANCOVA was used to test for significant reduction of bullying behaviour yielding $F = 85.8$, $df (1, 47)$; gender and age had moderating effects on the reduction of bullying behaviour of in-school adolescents $F (df=1,47)=34.2$; $F (df=1,47) =51.9$, $p<0.05$ respectively. It is recommended that REBT be used in the treatment of bullying behaviour of secondary school students

Key words: Bullying behaviour, In-school adolescents, Rational-emotive behaviour therapy

Introduction

Bullying behaviour is the intimidation or mild aggression perpetrated by someone who possesses more strength to the less powerful on a constant basis, bearing it in mind to hurt the less powerful one physically/ emotionally. Bullying behaviour is quite common in schools worldwide as revealed by prevalence studies (Lumsdem, 2002; Nansel, Craig, Overpeck, Saluja and Ruan, 2004; Popoola, 2005; Aluede, Adeleke, Omoike & Afen-Akpaida, 2008, Mustapha, 2010).

Various factors such as the child rearing practices of the family, association with violent peers among others have been recognised to be closely associated with aggression in youths. Similarly, counselling theories have viewed the causes of aggressive behaviour such as bullying in various ways. These theories include innate or biological theory, drive theories, social learning theories among others. Rational-Emotive Behaviour theory viewed bullying as behaviour that emanates from a person's evaluative belief that is rigid, absolute and dysfunctional. Studies of bullying behaviour revealed short - and – long-term devastating consequences on the bullies, the bullied as well as spectators. Peppler and Craig (2002) identified the effect of bullying on the bullied to include feeling anxious, insecure and lack of confidence. They stressed that they go to school everyday with the fear harassment,

taunting and humiliation. For the bullies, they are at increased risk for negative outcomes that include inability to develop and maintain positive relationships (Idowu & Yahaya, 2006) exhibition of deviant behaviours such as harassment, date violence, wife battering, gang attack and child abuse at adult stage (Peppler & Craig, 2002). These findings provide compelling reasons for initiating interventions to prevent bullying in schools. To reduce the prevalence of bullying and the devastating effects on individuals involved, various strategies emanating from different psychological theories have been developed by various researchers across the globe. Examples of such strategies include: Restorative Group Conferencing (RCG) by Burssens and Vettenburg (2004); Urban Improve (a theatre-based youth-violence prevention programme for elementary school children); Victim's Impact Statement by Borg (1998) among others. RCG was recommended for escalated bullying behaviour at interventory stage, that should be reserved for serious problems. Borg (1998) found Victim Impact Statement had effect on elementary school bullies while secondary school bullies felt indifferent or satisfied with the victim's feeling. Thus, indicating that the strategy was not effective for secondary school bullies. This study focused on reducing bullying behaviour of in-school adolescents before it leads to serious problem using Rational-Emotive Behaviour Therapy (REBT).

Rational-Emotive Behaviour Therapy (REBT) framework assumed that human beings are born with the ability of rational thinking and constructive behaviour. REBT attributes bullying behaviour to the irrational aspects of client's belief system, which were formed in childhood. The REBT therapist engages the bullies in an educational process that directly teaches the client how to identify and replace irrational and self-defeating beliefs with more rational and self-helping beliefs. One of the main objectives in REBT is to show bullies that how they perceive and interpret the events in their lives has a direct impact on how they feel. The central aim of REBT is to increase the clients' adaptability with the introduction of a more rational and constructive philosophy of themselves, others and the world.

Rational-Emotive Behaviour Therapy is one of the earliest forms of cognitive therapy. According to Ellis (1973), when an emotional consequence (C) follows an activating event (A), it is not A that causes C but the individual's beliefs (B). See fig. 1

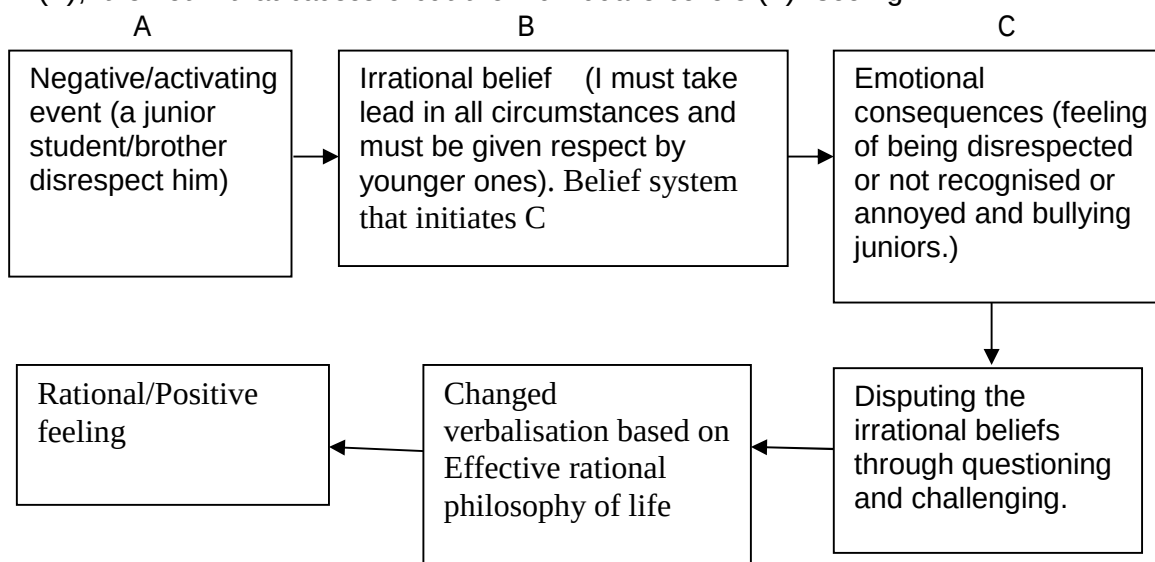


Fig. 1: The A-B-C model that underlies the use of REBT

According to Ellis (1993), emotion, in turn, helps to sustain irrational beliefs, i.e. goal of REBT is to change pervasive patterns of irrational thinking. It largely consists of the use of logic-empirical method of scientific questioning, challenging and debating (Ellis, 1977) so the

REBT therapist is challenging and confrontational, asking questions like, where is it written that you must be respected by everyone especially those weaker than you? Or, who said you are not worthy, if not recognised by someone else?

A common technique used in this form of therapy is to engage in self attacking exercise, in which clients are encouraged, to deliberately do something they find embarrassing, to show that the consequences are not catastrophic. RET was changed to REBT in 1993, 2001.

Purpose of the Study

Bullying behaviour is the primary variable of interest. Bullying behaviour at adolescence period without appropriate intervention, progresses to serious deviant or criminal behaviour at adulthood stage (Peppler & Craig, 2002, Idowu & Yahaya, 2006). The purpose of this study is to identify in-school adolescents that bully others, then subject them to treatment using Rational-emotive behaviour therapy; the study also aimed at creating awareness on how effective REBT is in reducing bullying behaviour among in-school adolescents. Bullying behaviour has been found to be perpetrated by both male and female adolescents, this study is observing if treatment will be effective for both gender or not. Age has also been observed to affect treatment of bullying (Borg, 1998), it is therefore pertinent to consider whether age will have impact on treatment of bullying behaviour in adolescents.

Research Questions

- (i) Is there any difference in the reduction of bullying behaviour among in-school adolescents exposed to REBT and those in the control group?
- (ii) Is there any difference in the reduction of bullying behaviour among in-school adolescents exposed to REBT based on age?
- (iii) Is there any difference in the reduction of bullying behaviour among in-school adolescents exposed to REBT based on gender?

Hypotheses

- (i) There is no significant difference in the reduction of bullying behaviour among adolescents exposed to REBT and those in the control group.
- (ii) There is no significant difference in the reduction of bullying behaviour among adolescents exposed to REBT experimental treatments based on gender.
- (iii) There is no significant difference in the reduction of bullying behaviour among adolescents exposed to the REBT experimental treatments based on age.

Methodology

This study is a qualitative research; thus, adopting the Quasi-experimental research design using two x two x two (2 X 2 X 2) factorial design. The experiment had three levels: the experimental level (Gp), age level (B) and Gender (M). The experimental level was made up of two (2) groups: Rational-Emotive Behaviour Therapy (Gp1), and the control group (Gp2). The age had two levels 10 -14 (B1) and 15 – 19 yrs (B2), and gender had two levels, Male (M1) and Female (M2). The design is a completely randomised 2 X 2 X 2 factorial design.

The independent variable of primary interest is Rational-Emotive Behaviour Therapy, gender and age are moderating variables. Scores from the Bullying Identification Questionnaire were used in the selection of the bullies. Research has shown that bullying interaction involved three distinct groups: bully, victim and bully-victim. BIQ was used to categorise in-school adolescents into four groups: bully, victim, bully-victim and neutral. Respondents that scored 22 and above on bullying items and very low on victimisation items participated in the treatment. Similarly, those that tick 3 or 4 on at least 3 or 4 bullying items were not

denied participation even if their cut off score was less than 22. Only the bullies are selected to participate in this study.

The target population of the study are all secondary school bullies in Ilorin metropolis. The selected sample in the two schools were divided into two: Rational-Emotive Behaviour Therapy (REBT) group and control group. Participants in the control group were not exposed to treatment. Stratified random sampling technique was used for selecting the two schools from the pool of schools. Co-educational schools were selected to determine if gender affect treatment. Purposive sampling technique was employed in selecting the study sample using Bullying Identification Questionnaire. Five experts in the Counsellor Education Department, University of Ilorin, ascertained the content validity of the instrument. The reliability coefficient of BIQ was 0.70 using measure of consistency.

Treatment Procedure

The following steps were taken to collect data for this study:

- (i) pre-treatment phase
- (ii) treatment phase
- (iii) post treatment phase

Pre-treatment phase: The main instrument used for assessment was the self-report survey titled "Bullying Identification Questionnaire" . it was an adapted version of Bullying Category Measure first developed by McConville and Cornel (2003) but was adapted by Stein, Dukes and Warren (2007). BIQ has 2 sections, first required demographic data on age, school and gender. The second section contains self-report survey to identify the bullies among secondary school students. The 18 items cover physical, verbal and relational bullying behaviour categorised into bullying and victimisation items with 4 points Likert-type scale of response. The inventory was administered to the randomly selected sample intact classes. Responses were scored according to the two levels, bullying items and victimisation items. Only subjects that scored high on bullying items alone were included in the treatment. The cut off point for bullying items was 22, however students that scored higher on at least three or four bullying items were not excluded from treatment programme even if they scored less than 22 in the section. A sample of forty- eight went through the treatment procedure. The number of participants varied with gender, with more males (14) than females (10).

Treatment and Post Treatment Phases: The treatment was spread to cover eight weeks. There was the REBT treatment group and one control group that were exposed to a lecture that had no relationship with the treatment group. The sessions covered one hour per week. The last session was used for the evaluation of the total programme and the post treatment assessment. Rational-Emotive Behaviour Therapy was not applied to the control group. They were only exposed to placebo in form of lecture on factors that threaten the environment and ways to control the degradation.

Method of Data Analysis

The data obtained from this study were analysed to determine whether the independent variables: Rational-Emotive-Behaviour Therapy had effect on the reduction of bullying behaviour among in-school adolescents in secondary schools in Ilorin, Nigeria.

The analysis covered the effectiveness of Rational-Emotive Behaviour Therapy in the rows. It also covered the moderating effects of age and gender (in columns) on the reduction of bullying behaviour among in-school adolescents. Analysis of Covariance (ANCOVA) was used to test the hypotheses,

Results

To test the effectiveness of Rational-Emotive Behaviour Therapy in reducing bullying behaviour of in-school adolescents in Ilorin, Nigeria, descriptive statistics were used to answer the research questions as shown in table 1

Table 1: Means (X and Y) in-school adolescents bullying behaviour scores on experimental levels (rows), gender and age levels (columns)

NO	Exptl level	Male				Female				10-14yrs				15-19yrs			
		N	X- x	Y-x	x	N	X-x	Y-x	x	N	X-x	Y-x	x	N	X-x	Y-x	x
1.	REBT	1	22.	13.	9.8	1	26.	15.	10.	1	25.	14.	10	8	23	12.9	10.
	Grp	4	9	1		0	2	6	6	6	3	7					5
2.	Contr	1	26	24	2.0	0	23.	25.	-	1	24.	24.	-	1	25.	23.7	2.2
	ol Grp	5				9	7	1	2.6	4	6	9	0.3	0	9		

Keys:

X- x = pre-test mean scores

Y-x = post-test mean scores

N = No of participants in a group

x = mean difference between pre and post-tests

Table 1 shows that the pre-test mean scores of the two groups were 22.9 and 26.0 for the males while the females had scores of 26.2 and 23.7 respectively. For participants within the age range of 10-14yrs, the pre-test scores were 25.0 and 24.6, while those within the age range of 15-19yrs had scores of 23.0 and 25.9 respectively. The post-test mean scores for the males were 13.1 and 24.0. For the females, the scores were 15.6 and 25.1. participants within the age range of 10-14yrs had post-test scores of 14.7 and 24.9 while those within age range of 15-19yrs had mean scores of 12.9 and 23.7; the results of the comparison of post-test mean scores of the treatment groups indicated reduction in bullying behaviour taking a critical look at the mean differences in the various groups.

To test for significant difference in the reduction of bullying behaviour the following hypotheses were tested using Analysis of Covariance (ANCOVA).

Hypotheses 1: There is no significant difference in the reduction of bullying behaviour among in-school adolescents exposed to REBT and those in the Control group.

Table 2: Analysis of covariance showing pre and post treatment comparison of in-school adolescents' bullying behaviour based on REBT and control

Source	df	Sum of square	Mean square	Cal. F	Cri. F
Row	1	1083	1083.0	85.8*	4.08
Within	47	580.9	12.6		
Total	48				

*Significant at $p < 0.05$

The result on table 2 shows that Rational-Emotive Behaviour Therapy had a significant effect on the reduction of bullying behaviour. Cal. F value of 85.8 which is greater than critical F value of 4.08 which is significant

Hypothesis 2: There is no significant difference in the reduction of bullying behaviour among in-school adolescents exposed to experimental treatments based on gender.

Table 3: ANCOVA showing reduction in bullying behaviour across two groups based on gender

Source	df	Sum square	of Mean square	Cal. F	Cri. F
Row	1	1303.8	1303.8		
Column	1	1303.8	1303.8	34.2*	4.08
Within/error	47	1790.19	38.1		
Total	48	3094.0			

Keys:

Row = group

Column = gender

Table 3 indicates that the reduction in the bullying behaviour of in-school adolescents exposed to REBT is dependent on gender. Calculated F-value of 34.2, which was considerably greater than critical F-value of 4.08, showed that gender influenced reduction in bullying behaviour of participants in the experimental groups.

This indicated that gender had moderating effect in the reduction of bullying behaviour among in-school adolescents based on the group. This significant effect needs more clarification using simple effect analysis and simple comparisons if the simple effects were significant.

Table 4: Simple effect analysis and comparisons of interaction between gender, and between the experimental and control groups

Parameter	B	Std. Error	t	Sig.
REBT	13.1	1.6	8.1	0.000
Control group	0			
Male	4.1	1.5	2.9	0.006
Female	0			
REBT male	-5.5	2.0	-2.7	0.009
REBT female	0			

This parameter estimates reiterates the result revealed in Table 4 which spelt out the mean of each gender in relation to the experimental groups. The interaction between the two experimental groups and gender revealed that interactive effect is reflected in the Rational-Emotive Behaviour Therapy. When the groups were statistically controlled, significance of 0.006 was found which is less than alpha level of 0.05. This indicated that females were able to reduce their bullying behaviour more in the treatment group than males.

The table also indicated interaction between gender and REBT with significance level of 0.009 which is less than 0.05 alpha level. This means that female participants exposed to REBT were able to reduce their bullying behaviour more than the male participants

Hypothesis 3: There is no significant difference in the reduction of bullying behaviour among participants exposed to experimental treatments based on age.

Table 5: ANCOVA comparing means of bullying behaviour reduction based on group and age

Source	df	Sum of squares	Mean square	Cal. F	Critical F
Row	1	1624.8	1624.8	51.9*	4.08
Column	1	1624.8	1624.8		
Within/error residual	47	1469.2	31.3		
Total	48	3094			

*Significant $p < 0.05$

Keys:

Row = group

Column = age

Table 5 further demonstrates that age has moderating effect on the reduction of bullying behaviour using REBT package. Significant difference existed as Calculated F- value of 51.9 compared to critical F-value of 4.08 at $p < 0.05$. Age therefore has moderating effect in reduction of bullying behaviour using Rational-Emotive Behaviour Therapy.

Discussion

Hypothesis one stated that there is no significant difference in the reduction of bullying behaviour among participants exposed to REBT and those in the control group. The results of the two statistical analyses presented in Table 2 do not support this hypothesis since significant difference was found. This indicates that in-school adolescents exposed to Rational-Emotive Behaviour Therapy were able to reduce their bullying behaviour more than those who are in the control group who did not receive any treatment. Bullying behaviour in this study covers physical, verbal and relational. The findings of this study is congruent with the research findings of Egbochuku (2008) who found REBT effective in reducing test anxiety of adolescents in Nigerian secondary school.

Hypothesis two stated that there is no significant difference in the reduction of bullying behaviour among participants exposed to experimental treatments based on gender. The descriptive statistics in Table 1 shows that the female in-school adolescents exposed to REBT were able to reduce their bullying behaviour than their male counterparts comparing the mean difference in the pre-test and post-test scores of 10.6 and 9.8 respectively. This hypothesis was rejected as the results ANCOVA also revealed significant difference in the reduction of bullying behaviour among participants who are males and those that are females. This shows that both male and females do differ in their level of response to the treatment. The results revealed that female were able to reduce their bullying behaviour than male participants in REBT

The finding of the moderating effect may be due to the assertion by Dodge, Coie and Lynam (2006) which stated that the links between early bullying behaviour and subsequent bullying behaviour may not be strong for females as they are for males. Crick, Nelson, Norales, Cullerton-Den, Cases and Hickman (2001) and Underwood, (2002; 2003) found that girls are more likely than boys to engage in relational bullying behaviour which involves such behaviours like spreading malicious rumour in order to get others to dislike a child or ignoring someone when angry at him or her.

However, the finding is not in agreement with the results obtained by Egbochuku, Obodo and Obadan (2008) when they treated examination anxiety with REBT. Similarly, Ojewola

(2008) also revealed no significant difference in the reduction of aggressive behaviour among male and female across treatment groups. The result is also not in line with that of Adewuyi (2006) who found that gender had no effect on the attitude of teachers in the Federal Government owned secondary schools in Lagos state towards retirement, after exposing them to the treatment package of REBT.

Hypothesis three stated that there is no significant difference in the reduction of bullying behaviour among participants exposed to experimental treatments based on age. The hypothesis was rejected because significant difference existed in the reduction of bullying behaviour among participants who are within the age range of 15 and 19 years and the participants who are within the age range of 10 and 14 years.

The result of this finding was in line with other researchers. Borg (1998) worked on the effectiveness of victim's impact statement in reducing bullying behaviour among the bullies. He found that age of the bully had an effect on the bully's sympathy or regret after the event had been perpetrated. The difference between this finding and Borg's work was that the later researcher found that victim's impact statement was more effective at influencing the bully's moral development and reduction in bullying behaviour in the elementary school child than in an older child. However, the present research work found Rational-Emotive Behaviour Therapies to be more effective in reducing physical, verbal and relational bullying among adolescents between the age range of 15 to 19 years. The reason for this might be due to the level of cognitive development of the older bullies who have reached the formal operation stage according to Piaget. The therapeutic methods deal with thinking and emotions and the older adolescents are capable of exploring and utilizing them more effectively than the younger bullies.

Conclusion

This study focused on the effectiveness of REBT on the reduction of bullying behaviour of in-school adolescents in Nigerian schools. It also inquired into the effect of gender and age on the reduction of bullying behaviour. The following were the findings:

- (i) Rational-Emotive Behaviour Therapy produced significant reduction in physical, verbal and relational bullying behaviour among in-school adolescents than lecture on environment delivered to those in control group.
- (ii) There was significant difference in the reduction of these forms of bullying behaviour among participants exposed to treatment groups based on gender. Thus, female participants exposed to REBT reduced their bullying behaviour more than their male counterparts
- (iii) Age had moderating effect on the reduction of bullying behaviour among participants exposed to treatment groups. Participants within the age range of 15–19 years were able to reduce their bullying behaviour than those within the age range of 10–14 years.

Conclusively, REBT procedure is effective in reducing bullying behaviour among in-school adolescents. On gender effect, the treatment worked for both male and female participants in reducing their bullying behaviour, however, female participants exposed to treatment were able to reduce their bullying behaviour more than the males. Age had moderating effect on treatment. Participants within the age range of 15-19 years were able to reduce their bullying behaviour than those within the age range of 10-14 years.

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THE EFFECT OF ANXIETY ON PUPILS LEARNING AND RETENTION OF MATHEMATICAL CONCEPTS IN SOME SELECTED PRIMARY SCHOOLS IN BOSSO LGA OF NIGER STATE

BABA WACHIKO¹ & AHMADU HUSSAINI²

¹Department of Primary Education Studies

²Department of Computer Science Education

Niger State College of Education, Minna, Nigeria

E-mail: wachikobaba35@yahoo.com

Phone No: +234-803-799-1635, +234-703-868-3373

Abstract

This study investigated the effect of anxiety on pupils learning and retention of mathematical concepts in Bosso local government area of Niger State. The sample for the study consists of one hundred and fifty primary five pupils (80 male and 70 females) randomly selected from three primary schools in Bosso local government. The study adopted a survey research design. The instrument used for data collection were Mathematic Achievement Test (MAT) and Mathematics Anxiety Questionnaire (MAQ). The mathematics Achievement Test (MAT) consists of forty items multiple choice in selected topics in geometry and trigonometry. The Mathematics Anxiety Questionnaire (MAQ) consists of fifteen items on modified likert four-point scale. Two weeks of instruction using a carefully prepared lesson plan on selected mathematical concepts. The data collected from the study were analyzed using the mean, standard deviation. The result obtained showed that there was no significant difference in mathematics achievement level of boys and girls arising from anxiety related factors. Also, there was a significant difference in the retention ability of male than in female. Recommendations were made for training of mathematics teachers through adequate funding and support by major stakeholders to boost their morale that will lead to high commitment to duties.

Keywords: Anxiety, Pupils' Learning, Retention, Mathematical Concepts, Primary Schools.

Introduction

The role of science and technology in the modern world cannot be overemphasized. Science and technology has become critical factors of economic and social development. Learning science requires the learner to have certain abilities in using mathematics. It is not only used by scientists but by bankers, architects, market women, tailors, surveyors to mention but a few. Due to the importance of mathematics to man and society at large, the teaching of the subject was made compulsory from primary to tertiary level in Nigeria. This is reflected in the National Policy on Education (FRN, 2004) where it states that "teaching mathematics is compulsory at both primary and secondary school levels.

Mathematics was made a core subject of science curricular, yet students performance in the subject continue to worsens as years go by (Segun, 2011 and Hussaini, 2013). An appraisal of pupils' achievement at common entrance and other local examinations revealed a sympathetic situation of poor performance in science and mathematics in particular (Nathaniel, 2009). Obodo (1999) stated that the nature of mathematics demands a lot of thinking and time from pupils. These thinking processes are in three levels they are critical, postulation and analytical thinking, that all these requires considerable energy and patience. Research findings by Bayo (2008) and Segun (2009) show that 52% of failure rate recorded in mathematics across the globe is traced to anxiety related factors especially at the primary school level.

Anxiety is an unpleasant, complex and varied pattern of behavior which individuals show when reaching to internal and external stimuli (Femi, 2012). It is a psychological construct that is inferred from verbal report, physiological indicator, general behavior or combinations of some of these factors. Shadow (2002) identified some of the symptoms of anxiety to include nervousness, restlessness, heart pounding, panic, trembling and feeling that familiar things are strange. Several studies have identified anxiety as one of the most serious problems impending pupils' performance in science, mathematics and technology especially in external examinations (segun, 2011, & Hussaini, 2013). Anxiety is a state of confusion, disorder and usually cause as a result of over-reaction of somebody hormones. This psychological disorder often resulted into high blood pressure, stress and memory failure. It is deduced that pupils' poor performance in mathematics may be attributed to their high anxiety level during and after classroom instructions. Segun (2011) stated that anxiety has factors that determine what pupils can do and to what extent. Also, teaching methods and availability of instructional materials had significance impact on how much learners can acquires in mathematics. Clearly, the researcher is prompted to carry out this research after reading this study by (Ken, 2005).

Research finding by (Adam, 2009 & Eze, 2013) revealed that anxiety poses a threat to a positive character manifestation and acquisition of knowledge either on individual bases or group. Anxiety is seen to have negative impact on attention and poor attention resulted to low assimilation, hence decline achievement. This present study is designed to assess and investigate the effect of anxiety on pupils' achievement in mathematics.

A student's overall mathematics anxiety is, for example, a composite of his intellectual appreciation of mathematics and his emotional reaction to it. Those who suffer from mathematics anxiety report a range of emotional responses when confronted with numbers: increased heart rate, increased perspiration, a feeling of light-headedness and dry mouth, a mind that "goes blank" among others. In short, mathematics anxiety is not some hysteria, or tactics used to get out of doing school work, mathematics anxiety is a real physiological response set off by the thought of doing mathematics. Individuals with this anxiety become extremely nervous and go to great lengths to get away from the sources of their fear. These persons learn about mathematics under duress, which further increases their anxiety, and may immediately forget whatsoever facts they were forced to learn.

The concept of anxiety offers an example of how patterns of behavior can range from those anxiety moments before an individual goes into problem solving state, to those manifested in degrees, at one end it may just prevent the individual from performing to his full capacity and at the other end it may evolve panic. In a severe state of anxiety, the individual enters a state of stress because of some internal conflict which he has been unable to resolve.

Statement of the Problem

Most previous studies of mathematics anxiety have focused on high school students or adults, while mathematics may also provoke strong and adverse reactions in children (Adam, 2005). Ages 9 to 11 seems to be in a critical stage for the development of attitudes and emotional reactions towards mathematics (Hussaini 2013). In addition, childhood, being a period of rapid change, may be a time when anxiety is especially evident. Although, attitudes may deepen or change throughout schools, generally, negative attitudes and anxiety are difficult to change and may persist into adult life, with far-reaching consequences.

Some of these consequence include avoidance of mathematics (Ken 2005), distress (Deji, 2010) and interference with conceptual thinking and memory processes (Segun, 2011).

Some researchers expanded the concept of mathematics anxiety to include both facilitative and debilitating anxiety. Deji (2010), for example, claimed that the negative affective reactions component of mathematics anxiety may be debilitating while the cognitive component might actually have some positive motivational consequences for the amount of effort pupils put into mathematics and thus for mathematics performance. Depending on the individual and the task, a moderate amount of anxiety may thus actually facilitate performance. Beyond a certain point, however, anxiety becomes debilitating in terms of performance, particularly in the case of higher mental activities and conceptual processes (Femi, 2012). Although, mathematics anxiety may in some cases have positive effects, it is perhaps more important for educationalists to focus on its possible negative consequences for performance. The present study investigated the effect of anxiety on pupils' achievement and retention of mathematical concepts in some selected primary schools in Bosso local government area Niger State.

Objective of the Study

Specifically, the study was conceived on the following objectives which include among others to:

- (i) Determine the effect of anxiety on male and female pupils' achievement in mathematics
- (ii) Investigate extent of retention among pupils of different academic level
- (iii) Assess factors that generate and promote anxiety among school children in Bosso local government area

Research Questions

The following research questions were developed to guide the study.

- (i) Do the male and female pupils differ in their mathematical achievement as a result of anxiety?
- (ii) Are there difference in the male and female pupils' retention capability based on anxiety?
- (iii) What are those factors that promote mathematical anxiety among school children in Bosso local government area?

Methodology

This study adopted a survey research design. This design allows respondents to be selected from vast area of the population. The result from the sampled schools of varied characteristics can be generalized. The population of the study consisted of all primary five pupils in Bosso local government area of Niger State. However, the sample made up of one hundred and fifty (150) consisting of 80 females and 70 males were randomly selected from three primary schools in Bosso local government. A simple random sampling using lucky dip method was used to select the one hundred and fifty primary five pupils used for the study.

The instrument for data collection were (i) Mathematics Achievement Test (MAT). (ii) Mathematics Anxiety questionnaire (MAQ). The MAT and MAQ were constructed based on the subject matter and the objective of the study. The instruments were validated by two senior lecturers from Ahmadu Bello University Zaria and one educational psychology expert from the College of Education Minna. The advice of the validation helped in the final selection of the items from both instruments. To determine the reliability coefficient of both instrument, test-retest method using person moment correlation formula and Cronbach alpha formula for the MAT and MAQ respectively. A coefficient of 0.78 and 0.92 were obtained for MAT and MAQ respectively.

To collect data for the study, the pupils from the three schools were pretested to determine their entry level equivalence of the group. The researchers carried out two weeks of classroom instruction using carefully prepared lesson plan on selected mathematical concepts. The pupils were then subjected to a post test using the two instruments. The scores from both instruments were used to answer the research questions. Scores from MAT were used to answer the research question 1 and 2, while MAQ was used to answer research question 3.

tMean and standard deviation were statistical tool used to analyze data collected from MAT. Mean and standard deviation were statistical tool used to analyze data collected from MAT and MAQ.

Results

The data collected from both instruments were analyzed and presented in tables below:

Research Question 1: Do the male and female pupils differ in their mathematics achievement as a result of anxiety?

Table 1: Mean and standard deviation of male and female pupils in MAT

Gender	N	Mean ($\bar{x}$)	S.D
Male	70	56.24	0.784
Female	80	55.76	0.923

Table 1 above revealed the mean and standard deviation of male and female pupils in the mathematics achievement test. An examination of the figures on the table 1.1 above shows the mean and standard deviation values of 56.24, 0.784 and 55.76, 0.923 for male and female pupils respectively were not significantly different. Similarly, the standard deviation values of 0.784 and 0.923 were not significantly different. This result indicates that the male and female perform nearly the same in mathematics irrespective of the anxiety manifestation.

Research Question 2: Are there differences in the male and female pupils' retention capabilities in mathematics used on anxiety?

Table 2: Mean and standard deviation of male and female pupils' relation

Gender	N	P/mean($\bar{x}$)	R/mean($\bar{x}$)	PS.D	RS.D
Male	70	56.24		55.28	0.784
					0.862
Female	80	55.76		50.94	0.923
					0.708

Keys: P = Previous; R = Retention

Table 2 above revealed the mean and standard deviation values in the retention of male and female pupils in selected primary schools in Bosso local government area. The mean difference of male and female pupils are, 0.96 and 4.82 respectively. This result indicated that female had higher mean depreciation of 4.82 compared to the male with 0.96. This shows that the female gender easily forgets learned mathematical concepts compared to their male counterparts. Hence, retention is higher in male than female.

Research Question 3: What are those factors that promote mathematical anxiety among school children in Bosso local government area?

Table 3: Mean and standard deviation of respondents on factors that promote mathematical anxiety among school children

S/N	Items	Mean (x)	S.D
1	I hate mathematics because of addition and subtraction.	2.43	0.562
2	Learning mathematics is not interesting.	3.98	0.764
3	Mathematics is a difficult subject.	4.22	1.147
4	No textbooks for teaching mathematics.	2.76	0.994
5	Maths teachers are wicked.	3.76	0.456
6	Reasoning is key to success in mathematics.	4.15	1.248
7	Mathematics if for lazy pupils	2.62	0.762
8	No calculator to solve problem.	2.44	0.889
9	My mind beep when it is time for maths lesson.	4.33	2.140
10	Maths teachers are not patient.	3.66	1.365
11	Teaching methods adopted by teachers.	2.87	0.621
12	Abstract nature of some concept in mathematics.	3.04	1.412
13	Mathematics teachers mark only correct answer.	2.21 3.92	0.871 2.249
14	Mathematics curriculum is wide.	2.50	1.333
15	No pleasure in solving mathematics.		

Table 3 revealed the mean and standard deviation values of questionnaire items 1-15 on factors that promote mathematical anxiety among primary school pupils in Bosso local government. Items 3,5,9,10,11,12 and 14 with their respective means values as 4.22, 3.76, 4.33, 3.66, 2.87, 3.04 and 3.92. These figures indicated among others which mathematics associated with anxiety. They include mathematics is a difficult subject, no adequate textbooks for teaching the subject, requires a lot of reasoning, mathematics teachers are not patient enough, poor instrumental strategies adopted by teachers, wide curriculum and abstract nature of the subject.

Discussion

From the findings, it revealed that mathematics anxiety had profound effect on pupils achievement because it hinders their learning of mathematics. Pupils' with mathematics anxiety are psychological disorder earn little mathematics.

The finding on table 2 agreed with research finding by (Adam 2005) & Ladoke 2008) which indicated low academic achievement in mathematics and science by pupils with psychological problems arising from anxiety and related threats while those that are free from these threat performed better. It however, revealed that pupils with low anxiety level are found to achieve better in mathematics than pupils with higher level of mathematics anxiety.

Similarly, the finding in table 2 is in support of James (2009) research on gender influence in mathematics and science achievement of primary schools in Nasarawa local government of Nasarawa state. Also, table 3 shows comparison of various anxiety symptoms and manifestation with their corresponding relative effect on the learning of mathematics which was supported by Bayo (2005) that panicking and restlessness are the most top list on the learning of mathematics.

Conclusion

The study examined the effect of anxiety on pupils' achievement in mathematics especially at the middle basic. It was observed that several factors accounted for the high anxiety rate of primary school pupils and consequent failure in the subject. Anxiety is an act that generates tense and degenerate performance among school children. The findings of the study, the following conclusion was drawn:

It was observed from the mean and standard deviation values that there is no difference in mathematics achievement level of boys and girls arising from anxiety related factors such as panicking. Panicking, restlessness among other are the sign and symptoms of anxiety manifestation in mathematics instructions.

Recommendations

In the light of findings of this study, the following recommendations were made:

- (i) Mathematics teacher should be more friendly with their pupils and more committed to their work
- (ii) Provision of learning materials and appropriate counseling activities by government and other stakeholders will reduce the difficulty and abstraction of some mathematical concepts.
- (iii) Paying special attention by sharing love and care by teacher during classroom teaching and scoring of pupils' work.
- (iv) Adequate funding and support by major stakeholders to boost the morale of mathematics teachers leading to high commitment to duties.

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IDENTIFICATION OF MISCONCEPTIONS ABOUT PLANT HELD BY SENIOR SECONDARY SCHOOL STUDENTS IN ILORIN METROPOLIS, NIGERIA

BELLO, ZAKARIYAU ADEBAYO, BELLO, GANIYU (Ph.D)
& PROF. ISAAC O. ABIMBOLA

¹Department of Integrated Science,

Kwara State College of Education Ilorin, Nigeria

²Department of Science Education, University of Ilorin, Nigeria

E-mail: zakbay26@gmail.com, bello.g@unilorin.edu.ng, bllganiyu@yahoo.com,
abimbola@unilorin.edu.ng

Abstract

In this descriptive survey study, misconceptions about plant held by secondary school biology students in Ilorin were identified. The population of the study consisted of all the biology students in the 40 public secondary schools in Ilorin metropolis. Only 191 students that were randomly selected from 20 out of the 40 public secondary schools part in the study. Simple random sampling technique was used to select the schools and the students. Data gathering was carried out through the use of an instrument designed by the researchers entitled "Students' Conceptions about Plant Test". The reliability coefficient of the instrument was 0.64. Results of the study indicated that the students held 26 misconceptions about plants, categorized into seven categories. Over simplification and conceptual confusion were the most prevalent types of miscomputation held by the students while the most frequent source of the misconceptions was didasklogenic. The paper advocated the use of meta-cognitive strategies such as the Study Technology by the teachers and students alike during teaching and learning process. Also, it called upon biology teachers to provide students with adequate knowledge of plants such that they can contribute meaningfully to the global efforts on combating climate change.

Keywords: Biology Education, Biology Teachers, Biology Students, Students' Misconceptions, Science Education, and Plant.

Introduction

Biology, the scientific study of living organisms, is a core subject in Nigerian secondary school curriculum. Biology arguably has the most significant impact on the life of every individual globally compared to other science subjects. Indeed, the European Union Forum (2011) rightly noted that without the study of biology, epidemic diseases caused by some viruses and bacteria such as Ebola and Bubonic plague could have wiped out the whole of mankind. In the view of Milford (n. d.) the study of biology 'is one of the fundamental reasons why the human race has progressed and thrived over the last 2000 years. Its importance to mankind should never be underestimated since it touches every facet of human existence. No matter what we do biology is intrinsically involved in our day-to-day lives. Given the immense impacts of biology on human beings, it is not surprising that biology educators and researchers are worried about the abysmal performance of students in the subject. Students' misconceptions of biology concepts are one of the major reasons adduced for the students' poor achievement in biology by researchers. (Abimbola 2013; Altunolu, & Seker, 2015; Singer, 2015)

The term 'misconception' is often used to describe ideal held by individual that is not compatible with that held by the scientific community. Misconceptions is also referred to as misunderstood word, naive theory or wrong idea. According to Coley and Tanner (2015) cognitive and developmental psychologists noted that human uses the intuitive conceptual system to reason about the living world. Intuitive conceptual systems refer to the use of

teleological, essentialist, and anthropocentric thinking to provide explanations about the natural world. Coley and Tanner (2015) conducted a study on students' misconceptions in biology. The results of the study indicated linkages between the pupils' intuitive conceptual system of thinking and their misconceptions in discipline-based reasoning.

Plants are multicellular organisms characterized by the possession of chloroplast, a pigment that enables them to convert solar energy into food through a complex process called photosynthesis. As rightly noted by Johnson and Coburn (2010) and the United States Geological Survey (n.d.) plants play crucial role in biological sequestration, a process through which carbon dioxide is removed from the atmosphere or reduce its emission. Biological sequestration helps to stabilize the concentration of greenhouse gas in the atmosphere thereby mitigating climate change, which is a major threat to the survival of human and other forms of life. It is evident from the foregoing that plants play invaluable roles in the sustainability of life on the earth. It is thus imperative for human to possess a meaningful understanding of plant as part of measures to combat climate change. However, students are noted to possess misconceptions about plants in their cognitive structures. For instance, Hershey (2004) documented 50 misconceptions about plant held by students. Also, Vitharana (2015) identified 18 misconceptions about plants held by Sri Lanka Students, while the Ohio State University (2009) documented several misconceptions about plants held by American students.

Several frameworks were used in science education literature (Bello, 1998; Boo, 2006; Coley & Tanner, 2012; Hershey, 2004; Sesen, 2010; Wikipedia, 2014) to categorized students' misconceptions. Some of the common categories of students' misconceptions include:

- (a) *Teleological thinking*: It is simply reasoning based on the assumption that events and everything around us have purposes, end or aim. In the field of biology teleology is often applied inappropriately such that biological structures and phenomena are explained by the presupposed functions, goals, or purposes;
- (b) *Typological thinking*: The basic assumption in typology is that there exist unobservable essential property that is common to all members of a category, which gives the category identity and underlies the observable attributes. Its application in biology led to the assumption that biological structure, species, and system have a core property that determines its observable features and identity;
- (c) *Anthropocentric*: A way of thinking based on a misapplication of analogical reasoning strategy. Anthropocentric thinking created the tendency to explain unfamiliar biological structure, species, system and processes by analogy to humans.
- (d) *Perceptual confusion*: Perceptual process provides the sensory experience of the world around us. Perceptual confusion occurs in situation where two patterns are mistakenly identified as each other;
- (e) *Semantic confusion*: This occurs when a word is wrongly perceived as one that has a similar meaning;
- (f) *Over generalization*: It refers to the logical fallacy that occurs when conclusion about a group is based upon unrepresentative sample
- (g) *Over simplification*: The act of making something seem simpler than it is, in an

attempt to make the thing easy to understand. It is the act of presenting an explanation that excludes detail information.

Statement of the Problem

Misconceptions of biological concepts constitute a substantial obstacle to the realization of the goals of biology education as revealed in several studies (Abimbola 2013; Altunoğlu, & Seker, 2015; Singer, 2015; Vitharana, 2015). In Nigeria, several misconceptions studies on biology concepts have been carried out as reported by Abimbola (2013), but there seems to be no sufficient studies targeted directly at identifying students' misconceptions of the plants. There are indications that Nigerian students also held misconceptions about plants. For instance, the West African Examinations Council Chief Examiners' Report (2013) indicated that the few students that attempted questions on plants were reported to have performed poorly due to misconceptions. Therefore, the focus of this study was to identify misconceptions about plants held by biology students in Ilorin metropolis as part of measures to promote meaningful learning in biology.

Purpose of the Study

The purpose of this study was to identify misconceptions about plants held by the senior secondary school biology students in Ilorin metropolis. Specifically, the study attempted to;

- (i) Determine whether secondary school biology students in Ilorin hold misconceptions about plants;
- (ii) Identify and classify the misconceptions about plants held by the students;
- (iii) Determine the most prevalent category of students' misconceptions about plants;
- (iv) Determine the probable sources of the identified students' misconceptions about plants; and
- (v) Identify the most prevalent source of students' misconceptions about plants.

Research Questions:

The following research questions were raised and answered in the study:

- (i) Do senior secondary school biology students in Ilorin metropolis hold misconceptions about plant?
- (ii) What are the various categories of misconceptions about plants that the senior secondary school biology students in Ilorin metropolis holds in their cognitive structures?
- (iii) What is the most prevalent category of misconceptions about plant that the senior secondary school biology students in Ilorin metropolis holds in their cognitive structure?
- (iv) What are the sources of the identified students' misconceptions about plants?
- (v) What is the most prevalent source of the identified students' misconceptions about plants?

Methodology

Research Design: The study adopted the descriptive survey research design.

Population of the Study: The study population consisted of all the biology students in the 40 public secondary schools in Ilorin Metropolis.

Sample and Sampling Technique: Simple random sampling method was used to select 20 secondary schools from the list of 40 public secondary schools within Ilorin metropolis. Also, simple random sampling method was used to select ten biology students in their second year of the senior secondary school education programme (SSS II students) from each selected school. *Research Instrument:* The researchers designed a test called Students' 'Conceptions about Plant Test', to collect data in the study. The instrument consisted of ten

items which required the students to provide short open-ended response. Students were expected to complete the test within a duration of one hour and thirty minutes.

Validity and Reliability of the Research Instrument: One senior lecturer in the field of biology education, and two experienced secondary school biology teachers helped to determine the face and content validity of the research instrument. The reliability coefficient of the instrument was determined through the test-retest technique and was found to be 0.64.

Method of Data Collection: Data collection was carried out through the administration of the research instrument (Conceptions about Plant Test). The researchers employed the service of biology teachers in the 20 selected secondary schools to administer the instrument to the 200 selected students however, only one hundred and ninety-one (191) students took part in the test. The responses of the students to the questions in the test were the data gathered in the study.

Method of Data Analysis: The students' responses to the questions in the Conceptions about Plant Test were subjected to qualitative analysis through identification of misconceptions about plants contained in the responses. The identified students' misconceptions about plants were grouped into seven categories based on the existing frameworks in science education literature. Three biology education lecturers helped to validate the identified misconceptions held by the students. The list of the identified students' misconceptions about plants was revised based on the input of the validators. The identified students' misconceptions about plants were then subjected to quantitative analysis. Simple percentage computation was used to analyse the prevalence of each type of misconceptions held by the students.

Results

The results of the data analyses were summarised and presented in the tables.

Research Question 1: Do senior secondary school biology students in Ilorin metropolis hold misconceptions about plant?

Twenty- six misconceptions about plant were identified in this study. Table 1 presents the list of the misconceptions. Based on the foregoing, it is evident that the biology students held misconceptions about plants. This finding provides the answer to research question 1

Table 1: Misconceptions about plant held by senior school biology students in Ilorin metropolis

No	Misconceptions	Categories	Sources
1	Plants are living things that own their food by themselves with the aid of some enzymes	Anthropocentric	Didaskologenic / Textbooks
2	Plants breathe in oxygen and breathe out carbon dioxide like us	Anthropocentric	Didaskologenic / Textbooks
3	Plants don't make use of oxygen because they don't breath in like us	Anthropocentric	Intuitive Naivety
4	Plants cannot respond to stimulus because they cannot feel any touch	Anthropocentric	Intuitive Naivety
5	The survival of other organisms depend on Plants because they are the most populous organism	Overgeneralization	Didaskologenic / Textbooks
6	Plant is the only source of food	Overgeneralization	Didaskologenic / Textbooks

7	Plants breathe in carbon dioxide and breathe out oxygen.	Oversimplification	Didaskologenic / Textbooks
8	Plant do respire through one part present on the leave alone	Oversimplification	Didaskologenic / Textbooks
9	Plant feeds through sunlight in the sky	Oversimplification	Didaskologenic / Textbooks
10	Plants excrete by breathing out oxygen only	Oversimplification	Didaskologenic / Textbooks
11	Plants use carbon dioxide to produce energy alone	Oversimplification	Didaskologenic / Textbooks
12	Carbon dioxide is the only gas that plants consume	Oversimplification	Didaskologenic / Textbooks
13	Plants are living things that their colour is green	Perceptual confusion	Didaskologenic / Textbooks
14	Plants feed when they are being wet by someone or raining day	Perceptual confusion	Intuitive Naivety
15	Plants excrete by removing old parts e.g. leaves to grow new once	Perceptual confusion	Intuitive Naivety
16	Insects and plants is a parasitic association so insect feeds on flowers	Perceptual confusion	Didaskologenic / Textbooks
17	Plants response to stimuli because when we push plants they tend to move little bit	Perceptual confusion	Intuitive Naivety
18	Water move in and out of the plants when watering them	Perceptual confusion	Intuitive Naivety
19	Plants do respire through the process of photosynthesis	Semantic Confusion	Semantic Confusion
20	Relationship between butterfly and plant is a mutualism and symbiosis association	Semantic confusion	Semantic Confusion
21	They makes use of oxygen in the process of transpiration	Semantic confusion	Semantic Confusion
22	Plants are like animals which produce food for the consumption of man	Teleological thinking	Didaskologenic / Textbooks
23	Plants use soil in other for them to grow	Teleological thinking	Intuitive Naivety
24	Butterfly benefits from the plants that is why they are always their because plants give food	Teleological thinking	Intuitive Naivety
25	The survival of other organisms depend on Plants because plant fertilize the soil	Teleological thinking	Didaskologenic / Textbooks
26	Plants breathe just because is among living things	Typological thinking	Intuitive Naivety

Research question 2: What are the various categories of misconceptions about plant that the senior secondary school biology students in Ilorin metropolis hold in their cognitive structures?

The 26 misconceptions about plant that were held by the biology students were in seven categories as shown in Table 1. This finding provided the answer to research question 2 posed in this study.

Research Question 3: What is the most prevalent category of misconceptions about plant that senior secondary school biology students in Ilorin metropolis held in their cognitive structure?

Table 2 presents the prevalence of each category of misconceptions identified in this study. It indicated that Oversimplifications and Perceptual confusion were the most prevalent categories. This result provided the answer to the third research question raised in this study.

Table 2: Prevalence of categories of students' misconceptions about plant

SN	Categories of Misconceptions	Frequency (%)
1	Typological thinking	1 (3.84)
2	Overgeneralization	2 (7.69)
3	Semantic Confusion	3 (11.53)
4	Anthropocentric	4 (15.38%)
5	Teleological thinking	4 (15.38%)
6	Oversimplifications	6 (23.07)
7	Perceptual confusion	6 (23.07)
	Total	26 (100 %)

Research Question 4: What are the sources of the identified students' misconceptions about plants?

The identified misconceptions about plants are traceable to four probable sources as presented in Table 1. This finding provided the answer to research question 4 raised in this study.

Research Question 5: What is the most prevalent source of the identified students' misconceptions about plant?

The most prevalent source of the students' misconceptions is didaskologenic. Fourteen out of the twenty-six (53.84%) students' misconceptions about plants established in this study were probably from didaskologenic source as indicated in Table 3. This finding provided the answer to research question 5.

Table 3: Prevalence of sources of students' misconceptions about plant

SN	Sources of Misconceptions	Frequency (%)
1	Didaskologenic / Textbooks	14 (53.85)
2	Intuitive Naivety	9 (34.62)
3	Semantic Confusion	3 (11.53)
	Total	26 (100 %)

Discussions

As stated earlier, findings from this study revealed that secondary school biology students in Ilorin metropolis holds seven categories of misconceptions about plants. Results of many earlier studies (Bello, 1998; Boo, 2006; Coley & Tanner, 2012; Hershey, 2004; Sesen, 2010) had also identified these categories of misconceptions. Students' misconceptions about plants is a clear indication of their inadequate knowledge of plants. Given the significant role of plants in mitigating climate change, biology teachers should provide students with adequate knowledge of plants such that they can contribute meaningfully to the global efforts on combating climate change.

Biology is a unique science subject with a number of biology –specific principles or concepts that distinguished it from physical sciences. For instance, typological thinking is not applicable in every areas of biology as is the case in physical sciences. Population thinking is the new framework that replaced typology principle in modern biology, it stresses that every individual is unique and differs from all others. Although analogical reasoning is a legitimate tool of the mind in science as explained by Abimbola (2006). Whenever analogy is poorly

used it can result into learning difficulties such as anthropocentric category of misconceptions. Usually spontaneously generated analogies often lack the criteria for credibility. Teleology is an essential philosophical foundation of many established religions such as Christianity and Islam, consequently teleological thinking is a widespread cognitive construct that at least tentatively helps individuals to make sense of the world around us. References to the supposed functions, goal, or purposes of structures and processes in organisms tend to re-enforce teleological way of thinking that the students had already inappropriately extended into biology.

Results of this study indicated that oversimplification and perceptual confusion are the most prevalent categories of misconceptions held by the biology students. This calls to question the level of pedagogical content knowledge of the biology teachers, because they ought to realize that oversimplification is akin to providing students with distorted information thereby creating what is referred to as 'steep or skipped gradient' in the field of Study Technology. A steep gradient is a barrier to learning according to Abimbola (2015). Oversimplification is also, very common in biology textbooks, as noted by Hershey (2004). Perceptual confusion could be the results of lack of exposure of the students to sensory experiences through hand-on and mind-on activities. This suggests that biology teachers are most likely not allowing the students to interact with the actual physical objects and biology specimens during class lessons thereby creating a barrier to learning referred to as a lack of 'Mass' in the field of Study Technology.

Findings from this study identified semantic confusion as another category of misconceptions held by the students. Semantic confusion is an indication of lack of meaningful understanding of concept words, this is referred to as 'misunderstood word' in the field of Study Technology, it is considered to be the most significant barrier to learning. Abimbola (2015) identified lack of mass, steep or skipped gradient, and misunderstood word as the three major barriers to learning. It is obvious from the findings of this study that students had encountered the three major barriers to learning. Metacognitive strategies such as Study Technology could be used to overcome barriers to learning and also, learning how to learn for meaningful understanding.

Results of this study indicated that didaskologenic is the most prevalent source of the identified students' misconceptions about plants. Earlier studies (Bello, 1998; Boo, 2006; Wikipedia, 2014) on students' misconceptions in biology had also identified didaskologenic, intuitive naivety and semantic confusion as sources of students' misconceptions. Didaskologenic stems from overgeneralization and oversimplification of biology concepts by the teachers. It is thus, necessary for the biology teachers to avoid instructional strategies that could lead to oversimplification and overgeneralization statements on biology concepts

Summary of the Major Findings

- (i) Twenty-six misconceptions about plants were held by senior secondary school biology students in Ilorin metropolis.
- (ii) The categories of misconceptions held by the biology students are, Anthropocentric, Overgeneralization, Oversimplifications, Perceptual confusion, Semantic Confusion, Teleological thinking, and Typological thinking
- (iii) Oversimplifications and Perceptual confusion are the most prevalent categories of misconceptions held by the senior secondary school biology students.
- (iv) The identified students' misconceptions about plants are traceable to didaskologenic, Textbooks, Intuitive Naivety and Semantic confusion sources.
- (v) The most prevalent source of the identified students' misconceptions about plant is didaskologenic.

Conclusion

Given the foregoing findings, the study concludes that senior secondary school biology students in Ilorin metropolis held misconceptions about plants in their cognitive structures. The existence of misconceptions about plants in the students' cognitive structures indicated that they encountered major barriers to learning during class lessons on plants. The seven categories of misconceptions held by the students include, Anthropocentric, Overgeneralization, Oversimplifications, Perceptual confusion, Semantic Confusion, Teleological thinking, and Typological thinking. The most prevalent categories of misconceptions were an oversimplification and perceptual confusion while the most common source was didasklogenic.

Recommendations

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

- (i) Biology teachers should avoid using typology framework to provide explanations during class lessons;
- (ii) It is important for biology teachers to be sensitive to the misleading applications of typology in biology and recognize that secondary school biology textbooks often contain subtle typological statements;
- (iii) Biology teachers should teach their students how to recognize and avoid using typological explanations;
- (iv) Biology teachers should not use spontaneously generated analogies that lack the criteria for credibility to avoid anthropocentric misconceptions;
- (v) References to the supposed functions, goal, or purposes of structures and processes in organisms should not be made by the biology teachers to avoid re-enforcing teleological way of thinking that the students had already inappropriately extended into biology;
- (vi) Biology teachers should always identify students' pre and post instructional misconceptions, and expose them to conceptual change strategies to eliminate the misconceptions;
- (vii) Biology students should learn and employ Study Technology metacognitive strategies to enable them overcome barriers to learning and also, learning how to learn for meaningful understanding;
- (viii) Biology teachers should provide students with adequate knowledge of plants such that they can contribute meaningfully to the global efforts on combating climate change; and
- (ix) Students should be regularly exposed to sensory experiences through hand-on and mind-on activities to prevent a lack of 'Mass' and perceptual confusion.

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THE PERCEPTION OF COLLEGES OF EDUCATION LECTURERS TOWARDS INTEGRATING SOCIAL MEDIA IN INSTRUCTION IN SOUTHWEST, NIGERIA

OLASEDIDUN, OLUTOYE KUNLE (Ph.D) & BADMUS, AYODEJI MUIDEEN (Ph.D)

Department of Curriculum and Instruction

Emmanuel Alayande College of Education, Oyo State, Nigeria

E-mail: olutoyeolasedidun@yahoo.com & badmusayomuideen@gmail.com

Phone No: +234-803-728-6108, +234-806-789-7787

Abstract

The study sought to find out the perception of colleges of education (COE) lecturers towards integrating social media in instruction in Southwest, Nigeria. The target population was lecturers from Federal and State owned Southwest COE. 150 respondents were selected using stratified random sampling along gender and experience in each of the institutions. In all, 1069 lecturers responded. A questionnaire adapted online was used to collect data. The validity of the instrument was established and cronbach's alpha values of 0.86 and 0.77 for reliability of the two major sections of the instrument. Three research questions were raised and the data collected was analysed using simple percentages and means. The result indicated that Facebook topped the list of social media subscribed to by COE lecturers and they positively perceived the usefulness and ease of use of social media in instruction. It was recommended among others that all stakeholders in the education industry (especially, COE), should see the integration of social media as a new innovation which must be welcomed and should thus do all within their capacity to support and sustain its usage.

Keywords: Perception, Lecturers, Social media, Colleges of Education.

Introduction

Most students still experience instruction that is largely lecture-based and extensive national education investments in technology have not yet resulted in widespread transformation of learning opportunities. However, the quest for interactivity has become a necessary goal in the design and provision of qualitative education. This interactivity has paved way for the integration of information and communication technology (ICT) into the teaching and learning process. With ICT, studies have been made easy in a way that it can be carried out in groups or in clusters (Orunmoluyi, 2012). With ICT, people can connect online to do desired task.

Yusuf (2005) noted that ICT provide opportunities for student teachers, academic and non-academic staff to communicate with one another more effectively during formal and informal teaching and learning. ICT is affecting the way education is delivered and how researches are conducted. Observers have predicted that with ICT, the role of teachers will change from being 'transferers' of a predefined body of knowledge to being 'mentors' and 'managers' of the learning environment (Mcintosh, Oliveras, Sullivan & Whitson, 1996). Many are of the opinion that ICT will enable academics to teach large numbers of students in a more effective manner. This will allow them (academics) to concentrate their limited time on research activities (Pritchard, 1996). Technologies like computer, ipod, I-phone and mobile phone could bring new opportunities for teachers to connect with students who are already spending large amount of time in these activities in creating a more collaborative learning environment (Ayonote-Yusuf, 2012).

ICT is a phrase used to describe a range of technologies for gathering, storing, retrieving, processing, analyzing and transmitting information (Adenegan, 2009). ICT has found its way

into different networks of life such as social (facebook, skype, twitter, Hi-5, games, etc.), academic/research, communication and commercial networks. ICT is a development with tremendous impact and potentials on tertiary education in particular and education in general.

Social media has been defined in different ways. Bryer and Zavatarro (2011) saw it as technologies that facilitate social interaction, make possible collaboration and enable deliberation across stake holders. These technologies include blogs, wikis, media (audio, photo, video, text) sharing tools, networking platforms (including Facebook) and virtual worlds. Kaplan and Haenlein (2010) defined social media as a group of internet-based applications that builds on ideological and technological foundations of Web 2.0, and that allow the creation and exchange of user-generated content. That is, social media are social software which mediates human communication.

If social media tools will be relevant within an education context, the lecturers' perception of the usefulness and ease of use in teaching must be looked into. Anderson and Dron (2011) explained that the responsibility of a teacher is not just to define, generate or assign content, but it is to help learners build learning paths and make connections with existing and new knowledge resources. In order to remain relevant in this information age, colleges of education have to take advantage of the opportunities offered by ICT to enhance teaching, learning and research. Student teachers that will use computers and ICT in later teaching practice must have observed their teachers using computers (Jegede, 2009; Jegede & Adelodun, 2003).

The word perception is the process of attaining awareness or understanding of sensory information. It can also be defined as the process by which organisms interpret and organise sensation to produce a meaningful experience of the world (Falade, 2011). The perception of lecturers on the integration of social media into the teaching and learning process will go a long way in its easy adoption. Perceived usefulness, according to Davis (1989), is the degree to which a person believes that using a particular system would enhance his or her job performance while perceived ease of use is the degree to which a person believes that using a particular system would be free from effort.

The origin of colleges of education in Nigeria dates back to the 1950s. That was in the report of Ashby commission of 1959 with emphasis placed on the need to provide middle level manpower to meet Nigerian needs. In the report, it was observed that many teachers were uncertificated and untrained (Taiwo, 1980). This observation was followed by a suggestion for greater expansion of intermediate education for intermediate teachers targeted at upgrading the existing teaching force. The commission recommended the establishment of Advanced Teacher Training College (ATTC) in Nigeria. This led to the establishment of ATTC at Owerri, Ondo, Lagos and Zaria between 1961 and 1962; Kano and Abraka in 1964 with the name colleges of education in 1968 (Eheazu, 1988). According to Isiyaku (2007), the ATTC in the 1960s turned out graduates who were holders of the Nigeria Certificate in Education (NCE), a non-degree but qualitative professional certificate in education. These ATTCs are the progenitors of the present colleges of education.

The primary duties of teachers in the world are research and teaching and lecturers are important group of users who play vital role in the successful implementation of new information technology (Akegbejo, 1998). Olumorin (2008) explained that the successful integration of ICT into higher education depends not only on awareness and availability but also on the extent to which instructors are willing to use it and able to use it. This study

therefore looks into the perception of colleges of education lecturers towards integrating social media in instruction in Southwest, Nigeria.

Statement of the Problem

One of the tenets of education throughout the world is the introduction and integration of ICT in education (Jhuree, 2005). Social media and networking technologies have significant potential to recreate the learning environment between student and teacher. Learning can be experienced as a uniquely social enterprise; course content can be co-created by a community of learners, where the instructor is a learner along with students. The role of instructor might then transform to become as much facilitator as subject matter expert (Fountain, 2001). However, in Nigerian higher institutions today, not much has been done with social media in the education arena especially in employing them as tools for instruction (Folorunso, Vincent, Adekoya & Ogunde, 2011).

Kember (2008) noted that for social media to be relevant in education, it is essential for teachers to focus on the pedagogy behind the use. Moreover, colleges of education lecturers also occupy important position in transmitting technology culture in instructional delivery to future generations of teachers who will be found in the classroom. Therefore, if social media tools will be relevant within the education context, the lecturers' perception of its usefulness and ease of use in instruction should be investigated. This is the gap that the researcher wants to fill to add to knowledge.

Research Questions

This study sought answer to the following questions:

- (i) What are the categories of social media COE lecturers subscribed to?
- (ii) What is the perception of colleges of education lecturers towards the usefulness of social media in instruction?
- (iii) What is the perception of COE lecturers towards the ease of use of social media in instruction?

Methodology

This study was a descriptive research type utilizing cross-sectional survey method. The targeted population for the study consists of all the lecturers in Federal government and state owned colleges of education in the Southwestern states of Nigeria. Ten Federal and State colleges of education were contacted. The colleges include Emmanuel Alayande College of Education (EACOED), Oyo; Federal College of Education (FCE) (Special), Oyo; Federal College of Education (FCE), Osiele, Abeokuta; Michael Otedola College of Primary Education (MOCPE), Epe, Lagos; Adeniran Ogunsanya College of Education (AOCOED), Ijanikin, Lagos; Federal College of education (FCE) (Technical), Akoka, Lagos; Adeyemi College of Education (Adeyemi COE), Ondo; College of Education (COE), Ilesa; Osun State College of Education (OSSCE), Ila and College of Education (COE), Ikere-Ekiti. Stratified random sampling technique was used to divide lecturers along gender and experience across all the schools in each of the colleges. One hundred and fifty lecturers were randomly selected from each of the colleges of education for the study. In all, the research instrument was distributed to a sample of 1,500 out of which 1069 adequately responded and was analyzed in the study.

The instrument for this study was a questionnaire adapted online from the previous studies of Lin, Chuan-chuan and Lu (2000), Chang (2004), and Yusuf, Mejabi, Fakomogbon, Gambari, Azuquo and Oyeniran (2013). The questionnaire contained three major sections, Sections I, II and III. Section I dealt with the lecturers' biographical information. Section II sought to find out the social networking sites the respondents subscribed to. It contained

the battery of the social networking sites and the respondents were to tick the one(s) they subscribed to. Section III was sub-divided into two (A & B). Each of these sub-divisions contained 10 question items. The response mode for the items was Likert response modes of Strongly Agree (SA = 4), Agree (A = 3), Disagree (D = 2) and Strongly Disagree (SD = 1).

The instrument was given to computer science lecturers and educational technologists that are ICT literate in colleges of education for validity. The reliability of this construct was previously demonstrated in the study by Lin, et al (2000) with a Cronbach's alpha value of 0.85, and a Cronbach's alpha value of 0.93 from Chang (2004). For this study, the reliability of the instrument was determined section by section based on the two major variables. For perceived usefulness of social media in teaching, the Cronbach's alpha value was 0.86 while that of perceived ease of use was 0.77. The researcher personally administered the copies of the questionnaire to the lecturers in all the ten sampled institutions with the help of research assistants. The analysis and interpretation of data obtained through the questionnaire was done using descriptive and inferential statistics. The frequencies were converted to percentages and means to answer the research questions. Section III was ranked 4 for Strongly Agree, 3 for Agree, 2 for Disagree and 1 for Strongly Disagree for questionnaire items that were positively worded and vice versa for items that were negatively worded.

Results

Research Question 1: What are the categories of social media COE lecturers subscribed to?

Table 1: Percentage distribution of respondents by social media subscribed to

S/N	Social Media	No. of Respondents	%
1.	Facebook	883	82
2.	Flicker	18	1.7
3.	Technorah	3	0.3
4.	Linkedin	104	9.7
5.	Orkut	2	0.2
6.	Twoo	31	2.9
7.	Google Plus	409	38.3
8.	You Tube	211	19.7
9.	Scribd	20	1.9
10.	Xing	15	1.4
11.	Myspace	32	3.0
12.	Slideshare	19	1.8
13.	To Go	278	26.0
14.	Digg	7	0.7
15.	Rogo	5	0.5
16.	Bebo	13	1.2
17.	Blogger.com	10	0.9
18.	Vimeo	9	0.8
19.	Twitter	303	28.3
20.	Delicious	2	0.2
21.	Hi5	42	3.9
22.	Friendster	11	1.0
23.	Ning	2	0.2
24.	Whatsapps	203	19.0

Table 1 reveals that Facebook, with 883 (82.6%) gained wide acceptance among the respondents. This was followed sequentially by Google plus 409 (38.3%), Twitter 303 (28.3%), To Go 278 (26.0%), YouTube 211 (19.7%), Whatsapps 203 (19.0%) and LinkedIn with 104 (9.7%) number of users respectively among the respondents. Other social media like Orkut, Delicious and Ning seemed not yet popular with only 2 (0.2%) users each. Technorah had only 3 (0.3%) users and all others had less than 45 users each among the respondents.

Research Question 2: What is the perception of colleges of education lecturers towards the usefulness of social media in instruction?

Table 2: Perception of the respondents towards the usefulness of social media in instruction

S/N	Perceived Usefulness of Social Media	Mean ($\bar{X}$)
1.	Using social media will enhance my effectiveness in the teaching job.	3.39
2.	Social media usage will give me control over my work.	2.99
3.	Social media support the critical part of my tasks.	3.00
4.	The use of social media in teaching will make my lesson more diverse.	3.08
5.	Social media usage will increase my daily productivity.	3.11
6.	The use of social media will be counter-productive due to insufficient technical resources.	2.61
7.	Social media usage will reduce stress and tension inherent in teaching large class.	3.22
8.	Social media will eliminate eye contact and reduce students' seriousness.	2.47
9.	Social media will make me finish the content of my lesson quickly.	2.90
10.	The teaching learning process will be easier with the use of social media.	3.20
Grand mean ($\bar{X}$)		3.00

Table 2 reveals that enhancing effectiveness in the teaching job using social media was ranked highest having the mean score of 3.39 out of 4. This was followed by the use of social media helping to reduce stress and tension inherent in teaching large class, that the teaching learning process will become more easy with the use of social media and that the use of social media will increase daily productivity having the means of 3.22, 3.20 and 3.11 respectively. The lowest mean score was 2.47 (approximately 2.5) with the statement that social media will eliminate eye contact and reduce students' seriousness. However, the grand mean score for perceived usefulness was found to be 3.00. Using 2.0 as the average benchmark, it can then be inferred that colleges of education lecturers perceived the usefulness of social media in teaching positively.

Research Question 3: What is the perception of COE lecturers towards the ease of use of social media in instruction?

Table 3. Perception of respondents towards the ease of use of social media in instruction

S/N	Perceived Ease of Use of Social Media	Mean ($\bar{X}$)
1.	The use of Social Media will make my lessons more difficult.	3.17

2.	Using Social media to teach will be frustrating.	3.15
3.	The use of social media will take more of my time than necessary.	2.94
4.	Using social media are effortless.	2.19
5.	Network problem will hinder lessons using social media.	2.40
6.	I can use social media in teaching without written instructions.	2.41
7.	Social media usage is always cumbersome.	2.84
8.	Social media are easy to navigate.	2.64
9.	It is easy to become skillful at using social media in teaching.	2.84
10.	Social media utilization in teaching will be too complex.	2.91
Grand mean ($\bar{X}$)		2.75

It could be noted from Table 3 that the respondents were of the opinion that the use of social media will not make their lessons more difficult and that using social media to teach will not be frustrating as the mean score were 3.17 and 3.15 respectively. Moreover, it was revealed that the use of social media will not take more of the respondents' time than necessary with a mean score of 2.94. On the other hand, the respondents perceived using social media as not effortless with a mean score of 2.19. Also, it was perceived that network problem will hinder lessons using social media and that they cannot use social media in teaching without written instructions with mean score of 2.40 and 2.41 respectively.

On the final analysis, the grand mean score for perceived ease of use of social media in teaching was found to be 2.75. With 2.0 as the benchmark, it means that the respondents have positive perception towards the ease of use of social media in instruction though the perception was not on the very high side.

Discussion

The result of the study as examined by research question 1 showed that if social media will be integrated into the teaching learning process, especially in the colleges of education, it could start with facebook which has gained wide acceptance among the lecturers. This will enable smooth integration. This finding corroborated that of Kaplan and Haenlein (2010) that in the year 2010, social media became one of the most powerful sources for news updates through platforms like Twitter and Facebook.

The perception of COE lecturers towards the usefulness of social media in instruction was examined using research question 2. The result of the mean score established that colleges of education lecturers positively perceived the usefulness of social media in instruction. This finding corroborated the earlier findings of Falade (2013) that stakeholders' perception of the usefulness of ICT integration into distance learning in Nigeria was positively on the high side. However, Clark (1983) as explained by Orunmoluyi (2012) claimed that technologies are merely vehicles that deliver instruction but do not themselves influence the teaching learning process. Kozma (2001) also argued that it is not the computer per se that influences the teaching learning process but the design of the real-life models and simulations which students interact with. By implication, since the perceived usefulness of social media in instruction had gained the attention of the COE lecturers, efforts need to be made on the training and retraining of lecturers to become experts in the use of social media. Moreover, materials needed for smooth implementation should be made available both for the lecturers and the students.

Based on the mean values of the results of the COE lecturers' perceived ease of use of social media in instruction, the respondents' perception was positive. Though some were of the opinion that network problem will hinder lessons and that they cannot use social media in

teaching without written instructions, the grand mean score showed positive perception. This finding supported that of Falade (2013) who revealed that the stakeholders' perceived ease of use of ICT integration into distance learning in Nigeria was positively on the high side. This showed that majority of the lecturers are not likely to have problem if social media should be finally integrated into teaching at the colleges of education level. Capacity building of lecturers as well as administrators and managers will therefore play a major role.

Conclusions

This research explored the perception of colleges of education lecturers towards integrating social media in instruction in South-West Nigeria. The result obtained from data gathered and analyzed in this study indicated that the perception of COE lecturers toward the usefulness of social media in instruction was positive. It also showed that the lecturers positively perceived the ease of use of social media in instruction.

Recommendations

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

- (i) Colleges of education lecturers should acquire higher skills and develop their proficiency in the utilisation of social media tools;
- (ii) lecturers should seek for more knowledge on the utilization of social media for instruction by making themselves available for workshops, seminars and conferences within and outside the country; and
- (iii) all stakeholders in the education industry should see the integration of social media as a new innovation which must be welcomed and should thus do all within their capacity to support and sustain its usage.

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A DATA ENVELOPMENT ANALYSIS STUDY OF NIGERIAN UNIVERSITIES' EFFICIENCY

¹OYENIRAN, SAHEED (Ph.D), ²PROF. A.Y. ABDULKAREEM &

³ATOLAGBE, ADEDAPO ADETIBA (Ph.D)

^{1, 2 & 3}Department of Educational Management

University of Ilorin, Ilorin, Nigeria

E-mail: saheed.oyeniran@gmail.com, ayabdulkareem@yahoo.com,
atolagbeadedapo@gmail.com

Phone No: +234-706-886-0689, +234—803-590-3513, +234-806-077-5914

Abstract

The study was carried out to determine the efficiency of Nigerian Universities. This is to determine the extent to which the institutions were performing relative to one another. The questions of how well the universities minimize their input relative to their output were also addressed in the study. The researcher adopted a descriptive type of ex-post-facto research design. Stratified random sampling technique was used to select 30 out of the 84 public universities. The stratification was based on geographical location, state, federal, conventional and specialized universities. A researcher-designed instrument tagged, "University Cost and Efficiency Checklist" (UCEC) was used to gather data for the study. The instrument was validated by five experts in Measurement and Evaluation, Educational, Management, Operation research and statistics. Four research questions were raised. Statistical techniques such as percentage, mean score and standard deviation were used in the descriptive analysis of the data collected. A Linear Programming technique called Data Envelopment Analysis (DEA) was used to evaluate university efficiency. The study showed that the mean technical efficiency of the institutions was 77.1%. In addition, about 66.7% of the institutions were small in size and had not exhausted their productive capacity. Based on the findings of this study, it was recommended that, allocation of resources to the universities should be made to be highly competitive and this should be based on the performance of the institutions in the previous year. In formulating policy for the universities, the government should eliminate systemic factors that could cause wastage in the use of resources.

Keywords: Data Envelopment Analysis, Technical Efficiency, Scale Efficiency, Nigerian Universities

Introduction

The relative effectiveness and efficiency with which university education is being provided in Nigeria guides a number of important policy decisions relating to the allocation of public resources. The ultimate concern of the policy makers is to allocate scarce resources in efficient and effective manners. Considering the huge amount of public funds committed to university education and the quality of products from the universities, the government is highly concerned about the efficiency and effectiveness of these institutions. This is to identify the extent to which the resources accrued to universities are utilized to achieve the objectives for which they were established and from which a number of decisions can be made regarding the institutions that are not efficient in the use of resources. The measurement of public sector efficiency, especially when it involves service provision as the case of universities is a difficult empirical issue because it involves value judgement. However, this is viewed in comparing public resources in term of total amount money expended, personnel and other resources used by Nigerian universities and output indicators of universities such as student' academic performance, graduation rate and research quality.

Blanchard (2004) opined that good performance in higher education is expected provide positive growth. But Nigerian universities are far behind this level when compared with other universities in Europe and America. This is why there is a need for the measurement of efficiency in Nigerian universities to determine those institutions that produced maximum output from a given quantity of inputs and those that used minimum cost to produce a vector of outputs and to suggest ways of improvement to institutions which are yet to be efficient.

In addition, with increasing ennoblement in Nigerian universities, the Federal Government is faced with the problem of providing university education in a more effective manner that will enable the existing resources to be used to meet the increasing demand for university education. Since 1999 the federal Government had shown great interest in trying to reduce the burden of public finances of university education by attempting to raise the efficiency of Nigerian universities. This is being done by allowing private participation in the provision of university education in Nigeria. Other initiatives in the last decade are: introduction of policies and reforms in Nigeria universities such as the auditing of all universities and associated parastatals, revocation of vice chancellors privilege of personally selecting 10% of student intake each year, reconstitution of all universities Governing councils with broader representation, licensing of new private universities, exemption of university from public salary scales and regulation and a 180% increase in funding of university system that raised a student allocation from the equivalent of \$970 per annum (NUC,2000). This reorganization and growth in Nigerian universities has raised concerns about whether possible level of efficiency can be achieved, such that universities cost and production functions will be consistent with the universities reforms of the Federal government of Nigeria.

The first step in determining university efficiency is to identify some standard or benchmarks from which estimates could be derived. This is done by identifying those institutions using the least amount of input to produce its present level of output. The empirical studies of higher education production function represent the process of transformation, which is central to production theory can be applied in principles to all areas of economic activities including education. The notion of improving the standard of education is also viewed as a productive activity involving the combination of various inputs such as capital and labour to transform one set of input to another set of outputs. This is because a number of indicators will be brought to the limelight in order to assess the efficiency of the universities. Moreover, in assessing the efficiency of universities, the question of how well the universities were performing compared to one another and the levels at which they were able to minimize their inputs relative to their output will be addressed.

In view of the fact that universities are multi input and output organisation, there is a need to conduct performance evaluation of universities based on measuring of relative efficiency of one university to the others. This will give a practical and productive efficiency measures as well as information on where to improve efficiency. This study is therefore design to examine scale and technical efficiency of Nigerian Universities. This is to examine the theoretical understanding of the concept of university efficiency. It is this gap on the perception of the need for efficiency, productivity and cost effective management in Nigerian universities that has motivated the researchers to carry out this study.

The study was carried out to achieve the following specific objectives: (i) to address the question how well Nigerian universities are performing relative to one another, (ii) to examine the extent to which universities are able to minimize their level of inputs for a given level of outputs, (iii) to determine the levels at which universities operate at an optimal size, (iv) to determine the wastage rates in the universities.

DEA Theory

DEA is commonly used to evaluate the efficiency of a number of producers. It is an extreme point method that compares each producer with only the “best” producers. A fundamental assumption behind DEA is that if a given producer A is capable of producing Y (A) unit of output with X (A) inputs, then other producers should be able to do the same if they are to operate efficiently. In the same vein, if producer B is capable of producing Y (B) unit of output with X (B) inputs then other producers should also be capable of the same production schedule. Producers A, B and others can be combined to form a composite producer, since this composite producer does not necessarily exist it is sometimes called virtual producer (Anderson, 1996).

The measurement of relative efficiency where there are multiple, possibly incommensurate inputs and outputs, as was noted earlier, was addressed by Farrel (1957) in his classic paper on the measurement of productive efficiency. This was further developed by Farrel and Field house (1962) focusing on the construction of hypothetical efficient unit, as a weighted average of efficient unit to act as a comparator for an efficient unit.

A common measure for relative efficiency is stated as (Dyson et al., 1990):

$$\text{Efficiency} = \frac{\text{weighted sum of outputs}}{\text{Weighted sum of inputs}} \text{-----}(1)$$

Written as (Dyson et al., 1990):

$$\text{Efficiency of unit } j = \frac{u_1 y_{1j} + u_2 y_{2j} + \dots}{v_1 x_{1j} + v_2 x_{2j} + \dots} \text{-----}(2)$$

Where:

- u_1 = *weight* given to output 1
- y_{ij} = amount of output 1 from unit j
- v_1 = *weight* given to input 1
- x_{ij} = amount of input 1 to unit j

The initial assumption is that this measure of efficiency requires a common set of weight to be applied to all units. This assumption may be unsatisfactory since it raises the problem of how such an agreed common set of weights can be obtained. Charnes et al (1978) recognized the difficulty in seeking a common set of weights to determine the relative efficiency. They recognized legitimacy of the proposal that units might value inputs and outputs differently and therefore adopt different weights and proposed that each unit should be allowed to adopt a set of weights, which shows it the most favourable light in comparison to other units.

Data Envelopment Analysis as a Method of Assessing Efficiency

Data Envelopment Analysis (DEA), introduced by Charnes, Cooper and Rhodes (1978), is a linear programming method for calculating the relative efficiencies of a set of organizations that possess some common functional traits but whose efficiency may vary due to internal differences such as management style (Mahgary and Lahdelma, 1994). Essentially, Charnes et al. (1978) operationalised by means of linear programming the production economic concepts of empirical efficiencies put forth by Farrel (1957). And since 1978, both theoretical developments and practical applications of DEA have advanced at an explosive pace. Far more to the point in using DEA is the building of an understanding of how transformation of resources to outcomes works. DEA will reveal what operating practices; mix of resources, scale sizes, scope of activities e.t.c, an operating unit may adopt to improve its performance.

Furthermore, DEA is an empirically based methodology that eliminates the needs for some of the assumptions and limitations of traditional efficiency measurement approaches (Bowlín, 1998). It was originally intended for use as a performance measurement tools for organisations that lack profit motivation e.g. not-for-profit and governmental organizations. However, since its introduction, it has been developed and expanded for variety of uses in for-profit as well as not-for-profit situations. It is a multifactor productivity analysis model for measuring the relative efficiency of homogenous set of decision-making units (Talluri, 2000).

DEA is also a non-parametric method, which extends efficiency measures from a single input, single output efficiency analysis to multi-input, multi-output situations. In contrast to the parametric approach, DEA does not require any assumption about functional form; the efficiency of a Decision-Making Unit (DMU) is measured relative to all other DMUs with simple restriction that all DUMs lie on or below efficient frontier (Seiford & Thrall, 1990).

DEA Models

DEA models are essentially linear programming formulations. As it applies to universities, it involves solving a linear programming model for each university. The solution to the model consists of information about the peers of the institution and efficiency of the institution relative to its peer group. This work focuses attention on two basic DEA models: the Charnes, Cooper and Rhodes (1978) (CCR) model and the Banker, Charnes and Cooper's (1984) (BCC) model.

The Charnes, Cooper and Rhodes (CCR) Model

The model is stated by Bowlín (1998) as:

$$\begin{aligned}
 \text{minimize:} \quad & \Theta - \varepsilon \left[\sum_{i=1}^m S_i^- + \sum_{r=1}^s S_r^+ \right] \\
 \text{Subject to:} \quad & \sum_{j=1}^n \lambda_j x_{ij} = \Theta x_{io} - S_i^- \quad ; \quad i = 1, 2, \dots, m \quad \text{-----(3)} \\
 & \sum_{j=1}^n \lambda_j x_{ij} = y_{ro} + S_r^+ \quad ; \quad r = 1, 2, \dots, s \\
 & \lambda_j, S_i^-, S_r^+ \geq 0
 \end{aligned}$$

The above model yields an objective evaluation of overall efficiency and identifies sources and estimates the amounts of the inefficiencies thus identified, (Charnes et al., 1994). The model is to evaluate the relative performance of a DMU_o (the DMU being evaluated), based on observed performance of $j = 1, 2, \dots, n$ DMUs. The terms y_r, x_{ij} in the model are constants, which represent amount of the r^{th} output and i^{th} input of the j^{th} DMU in a collection of $j = 1, 2, \dots, n$ entities, which utilized these $i = 1, 2, \dots, m$ inputs and produced $r = 1, 2, \dots, s$ outputs. One of the $j = 1, 2, \dots, n$ DMUs is singled out for evaluation and accorded the designation DMU_o, and placed in the function to be maximized in while also leaving it in the constraints. It then follows that DMU_o's maximum efficiency score will be $\Theta_o^* \leq 1$ by virtue of the constraints. The star (*) indicates an optimal value obtained from solving the model.

S_i^- and S_r^+ in (1) are inputs and output slack values. If any one of these values is positive at the optimal solution to the model, it means that the corresponding input or output of

DMU_o can improve further, after its input levels have been reduced to the proportion Θ_o^* . The sum of weights is represented by λ_j .

The ε in (1) represents a non-Archimedean constant which is smaller than any positive valued real number. In practice, the DEA computer software used handles this non-Archimedean constant. Hence, it needs not be specified explicitly (Bowlin, 1998).

According to the CCR model (1), a DMU is efficient if and only if the following two conditions are satisfied (Charnes et al., 1994):

- i. $\Theta_o^* = 1$,
- ii. All slack values (S_i^- and S_r^+) are equal to zero.

The nonzero slack values and the value of $\Theta_o^* \leq 1$ identify the sources and amount of any inefficiency that may be present (Charnes et al., 1994).

The CCR model assesses the constant return to scale (CRS) to scale and assume that an increase in inputs is expected to result in a disproportionate increase in the outputs produce by the DMUs.

Banker, Charnes and Cooper (BCC) Model

The second version of the DEA model is the Banker, Charnes and Cooper (1984) model. It distinguishes technical and scale inefficiencies by estimating pure technical efficiency at a given scale of operation and identifies whether increasing, decreasing or constant returns to scale possibilities are present for further exploitation (Charnes et al., 1986). The primary difference between this model and the CCR model is the treatment of returns to scale. The CCR version bases its evaluation on the constant returns to scale (CRS). The BCC version on the other hand is more flexible and allows variable return to scale (VRS). Below is the mathematical formulation of the BCC model:

The difference between the CCR and the BCC model is that the term 2 (also known as the convexity constraint) is now restricted to summing to one. This has the effects of removing constraints in the CCR model that DMU must be scale efficient. Consequently, the BCC model allows variable return to scale and measures only technical efficiency for each DMU. That is, for a DMU to be considered as CCR efficient, it must be both scale and technically efficient. For it to be considered as BCC efficient, it only needs to be technically efficient (Bowlin, 1998). Under the CCR it is assumed that there is no significant relationship between the scale of operations and efficiency. This implies that big universities are not more efficient than smaller ones in the transformation of their inputs to outputs.

Methodology

Population, Samples and Sampling Technique

The population for the study consists of all universities in Nigeria while the target population comprised of all the public universities. The target population is 79 universities comprising of 40 federal and 39 state universities out of which 30 universities were selected (Oyeniran, 2010). This number is large enough to ensure that all the categories of public universities were adequately represented so that valid generalisation can be made for the university system as a whole. In view of this, stratified random sampling technique was used for the selection of the sample. These strata consisted of federal, state, conventional and specialised universities. The proportional random sampling based on 40% of the total

number of universities in each geopolitical zone will select at least two universities in each of the six geopolitical zone of Nigeria.

Research Instrument

The research instrument used for data collection for this study is a checklist titled “University Cost and Efficiency Checklist” (UCEC). The instrument was designed to collect data on variable of efficiency and cost. The instrument administered to each university through the Academic Planning Unit while some data were collected from the National Universities Commission (NUC). The instrument consists of eight sections, which are sections A to H. Section A has to do with biodata of each university. Section B deals with teaching inputs while section C deals with teaching outputs. Section D is on research inputs while section E is on research outputs and sections F and G is on recurrent and capital expenditures respectively. (Oyeniran, 2010)

Research Questions

The following research questions were raised to guide study:

- (i) What is the technical efficiency of Nigerian Universities?
- (ii) What is the scale efficiency of Nigerian Universities?
- (iii) What is the wastage rate in Nigerian Universities?
- (iv) At what levels of return to scale are Nigerians universities operating?

Formulation of DEA Models for Universities

In order to estimate the efficiency of universities, each university is divided into three units and a model was formulated for each of the units. This division is based on the assumption of general system theory of non-linearity and complex interaction among other parts making up the systems. Therefore, the university is considered as a system within a number of systems. It is the believe of the researchers that the degree with which these sub systems operate will to a greater extent influence the overall system. Hence we have modelled three different organizational units. These models are formulated in line with Coelli (1991) study and as follows: (1) the university model seeking to evaluate the overall performance of the university, (2) the academic model which sought to evaluate the academic activities of university and (3) the administration model which sought to examine the administrative aspect of university operation. For each model, two inputs and two outputs were specified. These are shown below:

University Model

Outputs

Total Number of students (full time equivalent)

Number of PhD degrees awarded

Inputs

Total Number of staff (academic and non-academic staff)

Total Cost (including maintenance cost, recurrent cost, capital cost)

Academic Model

Outputs

Total Number of students (full time equivalent)

Number of PhD degrees awarded

Inputs

Total Number of academic staff

Academic expenses (including direct teaching cost, research grant, teaching and research equipment and library expenses)

Administrative Model

Outputs

Total Number of staff (academic and non-academic staff)

Total Number of students (full time equivalent)

Inputs

Total number of Administrative staff

Administrative Expenses (including stationary cost and cost of administrative equipment)

Variable Return to Scale (VRS) DEA and Constant Return Scale (CRS) DEA were conducted to determine technical and scale efficiencies.

Results

Research Question 1: What is the technical efficiency of Nigerian universities?

Table 1: Analysis of technical efficiencies in Nigeria Universities.

S/N	DMUs	University Model	Academic Model	Administrative Model
1	DMU1	100	100	100
2	DMU2	71.7	76.4	95.4
3	DMU3	83.3	61.5	67.2
4	DMU4	68.5	67.5	100
5	DMU5	69.9	72.1	75.7
6	DMU6	100.	100	96.7
7	DMU7	79.3	70.7	42.2
8	DMU8	84.0	88.7	46.7
9	DMU9	86.9	100	88.1
10	DMU10	85.5	64.4	75.4
11	DMU11	62.4	99.1	61.2
12	DMU12	94.9	65.1	100
13	DMU13	100	57.4	100
14	DMU14	100	100	100
15	DMU15	95.5	88.0	94.9
16	DMU16	100	92.4	88.3
17	DMU17	100	100	90.0
18	DMU18	64.4	93.0	100
19	DMU19	72.9	89.7	64.4
20	DMU20	80.8	100	80.2
21	DMU21	100	100	100
22	DMU22	74.7	100	100
23	DMU23	100	78.3	100
24	DMU24	50.8	89.8	93.5
25	DMU25	66.5	100	65.4
26	DMU26	100	100	100
27	DMU27	83.1	100	67.0
28	DMU28	67.2	69.7	67.2
29	DMU29	99.5	97.0	79.8
30	DMU30	61.2	72.5	90.1
	Mean	81.4	86.4	84.3

Research Question 2: What is the scale efficiency of Nigerian universities?

Table 2: Analysis of scale efficiency in Nigerian universities

S/N	DMUs	University Model	Academic Model	Administrative Model
1	DMU1	76.7	65.3	53.3
2	DMU2	85.8	81.5	77.0
3	DMU3	77.9	78.0	80.6
4	DMU4	83.0	99.8	100
5	DMU5	95.9	92.3	75.9
6	DMU6	100	100	76.4
7	DMU7	90.6	89.2	86.3
8	DMU8	69.9	78.8	86.7
9	DMU9	76.3	94.8	51.6
10	DMU10	75.0	72.5	77.5
11	DMU11	79.9	75.8	79.6
12	DMU12	96.5	99.5	59.4
13	DMU13	100	98.2	64.1
14	DMU14	55.8	55.2	55.2
15	DMU15	64.6	60.8	91.3
16	DMU16	65.7	57.6	94.3
17	DMU17	63.2	53.1	85.2
18	DMU18	62.5	64.8	100
19	DMU19	99.3	99.5	93.3
20	DMU20	61.5	85.3	95.5
21	DMU21	81.6	100	61.3
22	DMU22	79.8	95.7	100
23	DMU23	100	93.0	100
24	DMU24	99.5	99.5	76.4
25	DMU25	78.1	90.8	99.4
26	DMU26	83.7	92.1	88.8
27	DMU27	100	97.0	89.4
28	DMU28	88.2	100	88.2
29	DMU29	77.5	100	92.2
30	DMU30	98.2	88.9	69.4
Mean				

Research Question 3: What is the wastage in Nigerian Universities?

Table 3: Analysis of wastage rate in Nigeria Universities.

S/N	DMUs	University Model	Academic Model	Administrative Model
1	DMU1	00	00	00
2	DMU2	28.3	23.6	44.6
3	DMU3	16.7	38.5	32.8
4	DMU4	31.5	32.5	00
5	DMU5	30.1	27.9	24.3
6	DMU6	00	00	24.3
7	DMU7	20.7	29.3	57.8
8	DMU8	16.0	11.3	53.3
9	DMU9	13.1	00	41.9
10	DMU10	14.5	35.6	24.6
11	DMU11	37.6	0.9	38.8
12	DMU12	5.1	34.9	00

13	DMU13	00	42.7	00
14	DMU14	00	00	00
15	DMU15	4.5	12.0	55.1
16	DMU16	00	8.0	61.7
17	DMU17	00	00	60
18	DMU18	35.6	7.1	00
19	DMU19	27.1	12.1	35.6
20	DMU20	19.2	00	59.8
21	DMU21	00	00	00
22	DMU22	25.3	00	00
23	DMU23	00	21.2	00
24	DMU24	49.2	10.2	66.5
25	DMU25	33.5	00	34.6
26	DMU26	00	00	00
27	DMU27	16.9	00	33
28	DMU28	32.8	30.3	32.8
29	DMU29	0.5	3.0	20.2
30	DMU30	38.8	27.5	99
	Mean	16.6	13.6	18.6

Research Question 4: At what levels of return to scale are Nigerians universities operating?

Table 4: Analysis of return to scale in Nigeria universities

S/N	DMUs	University Model	Academic Model	Administrative Model
1	DMU1	DRS	DRS	DRS
2	DMU2	IRS	IRS	DRS
3	DMU3	IRS	IRS	DRS
4	DMU4	DRS	IRS	CRS
5	DMU5	IRS	IRS	DRS
6	DMU6	CRS	CRS	DRS
7	DMU7	IRS	IRS	DRS
8	DMU8	IRS	IRS	DRS
9	DMU9	DRS	DRS	DRS
10	DMU10	IRS	IRS	DRS
11	DMU11	IRS	IRS	DRS
12	DMU12	DRS	IRS	DRS
13	DMU13	CRS	IRS	DRS
14	DMU14	DRS	DRS	DRS
15	DMU15	IRS	IRS	IRS
16	DMU16	IRS	IRS	IRS
17	DMU17	IRS	IRS	IRS
18	DMU18	IRS	IRS	CRS
19	DMU19	IRS	DRS	DRS
20	DMU20	IRS	IRS	IRS
21	DMU21	DRS	CRS	DRS
22	DMU22	IRS	IRS	CRS
23	DMU23	CRS	IRS	CRS
24	DMU24	IRS	IRS	DRS
25	DMU25	IRS	IRS	IRS
26	DMU26	CRS	IRS	DRS

27	DMU27	IRS	CRS	DRS
28	DMU28	IRS	CRS	DRS
29	DMU29	IRS	IRS	DRS
30	DMU30	IRS	IRS	DRS

Discussion

Table 1 showed that the mean technical efficiency scores for the university, academic and administrative models are 81.4%, 86.45 and 84.3% respectively. The findings also showed that about 16 universities (53%) had technical efficiency value above the mean score. Furthermore 9 universities (30%) of the universities were 100% technically efficient in the university model. For the academic model, about 19 universities (63%) had the technical efficiency score above the mean technical efficiency. In addition, 11 universities (37%) had the technical efficiency score of 100%. In the administrative sector, about 18 universities (60%) had the technical efficiency score above the mean efficiency score. About 10 universities (33%) had technical efficiency score of 100%. Only four universities are efficient in all the three models. Therefore, it could be concluded that the efficiency score reported in this study are likely to be influenced by management factors and other changes in government policies such as carrying capacity that could influence the efficiency of these institutions.

The wastage rate was found to be 16.6% for the university model, 13.6% for the academic model and 18.6% for the administrative model. This showed inefficiency and that there were potentials for them to reduce their input usage by 16.6% for the university model, 13.6% for the academic model and 18.6% for the administrative model or increase their outputs by the same amount in order for them to be adjudged efficient. This indicated that most resources are not used to the fullest capacity in most of the institutions. The existence of unused capacities at level of these inputs points is inefficiency or outright wastefulness in the use of resources in the universities. The universities should reengineer their service processes that may lead to lean management practices which in turn may reduce inputs or ability to produce more outputs.

Table 3 showed that the mean scale efficiency score for the university, academic and administrative models were 80.8%, 85.3% and 81.6% respectively. For the academic model, 14 universities (47%) had the efficiency score above the mean score, and in the academic model, 19 universities (63%) had the efficiency score above the mean score while 15 universities (50%) had efficiency score above the mean score in the administrative model.

The result also showed that about 67% of the total number of universities were operating at increasing return to scale.(IRS). IRS is associated with increasing long-run unit cost, and for these universities to bring down the unit cost and operate at the optimum scale they need to upsize their enrolment and an increased investment in research. Hence, there is a need for the expansion of university system. This implies that most of the universities are too small in size and they have not exhausted their productive capacity. Furthermore, for them to operate at the optimum scale, they could still reduce their input usage by 16.6%, 13.6% and 18.6% for the university, academic and administrative models respectively or increase their output by the same amount. This therefore indicate source of inefficiency in the resources in the universities. In terms of return to scale 73.3 % (22 Universities) were operating increasing return to scale. This implies that the academic unit of most university need to be expanded. In the same vein, 13 (4 universities) are operating at decreasing and constant return to scale.

In the administrative model about 73% (22 universities) were operating at decreasing return to scale (DRS). DRS is associated with decreasing long-run unit cost. This implies the administrative unit of most universities were large, while 13% (4 universities) were operating at increasing return to scale. Only 13% (4 universities) were operating at optimal scale.

Conclusion

Considered as a group, Nigerian universities are performing fairly well against each other. In the overall, the level of scale efficiency in the university system appears to be high. However, it cannot be concluded there is no scope for improvement in efficiency. The efficiency measure presented in this study are intended as a guide to managerial action or policy making, it is therefore important to recognize that the calculated improvement in inputs or outputs are indicative of potential efficiency or performance increases by universities located below the efficient frontiers. Therefore, the efficiency of each university should be used as an attention-directing device. Furthermore, efficiency score presented can direct management attention toward developing a deeper understanding of why some institutions are located on the efficient frontier and others are relatively inefficient universities.

Universities are very important in the formation human capital. They are also a major expenditure component for tax payers. Moreover, with increasing number of students seeking admission into Nigerian universities and a reduction in the resources made available to these institutions, the efficiency by which inputs produce desired output must be critically examined and should be considered as an important policy issue. This is because university efficiency is an international issue.

In this study, DEA was used to estimate technical and scale efficiency for 30 public universities in Nigeria using five years' data. A number of different measures of output and input were used. Technical and scale efficiency results suggest that the problem confronting Nigeria universities has to do with managerial inefficiency and that which relates to their scale of operation.

Recommendations

Based on the findings of the study, the following recommendations were made: The government should set up a national goal of increasing the Higher Education Participation Rate (HEPR). According to UNESCO's Institute of statistics; HEPR is the proportion of eligible population who have access to higher education. It put Africa's HEPR at 10%, United State of America 50%, Europe 60%, South Africa 18%, Britain 50% and Nigeria 8%. (Okebukola 2008) with the present population of Nigeria, a national target of 20% should be set for University Education Participation rate (UEPR) and to be met at least within a period of ten years' time. This shall also include the expansion and upgrading of the physical facilities such as classroom, laboratory, and offices to accommodate the increased enrolment. Based on this target, National University Commission (NUC) should determine the carrying capacity for each university. In addition to the above, there should be huge investment in research. This is to benefits immensely from economics of scale.

The university authority should embark on cost-saving activities that will reduce unnecessary cost and wastage such as optimal utilization of spaces and optimum enrolment. In order to minimize resource wastage as identified by the finding of this study, resources allocation should be based on the need of each university and should be made to be highly competitive. This should be based on the performance of each university in the previous year. This will improve universities efficiency in Nigeria.

Rigorous quantitative performance assessment technique such as DEA and cost function should be incorporated into universities' accreditation exercise. This will assist the NUC in ranking universities in Nigeria and this will in turn improve efficiency in these institutions.

The federal Government should establish a National Institute of Higher Education Research and Development (NIHERD) to carry out research activities in various aspect of higher education development. This is in recognition of the roles of higher education in human capital formation and sustainable economic development.

Refereces

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