ASSESSMENT OF INTEGRATED SCIENCE LABORATORY AND PRACTICAL PEDAGOGY ON STUDENTS' ACADEMIC ACHIEVEMENT USING NEURAL NETWORK

Adeniji A.A
Department of Integrated Science,
Federal College of Education, Abeokuta, Nigeria.
abidemi4good@gmail.com

Falayi, E.O.
Department of Physics,
Tai Solarin University of Education, Ijebu Ode, Nigeria.
olukayodefalayi@yahoo.com

Usman O.L.
Department of Computer Science,
Tai Solarin University of Education, Ijebu-Ode, Nigeria.
lateefope4us@gmail.com

Awofala, A.A
Department of Biological Sciences,
Tai Solarin University of Education, Ijebu-Ode, Nigeria.

Abstract

Inadequate practical pedagogy endowed lecturers and lack of timely relevant and standard scientific equipment in our integrated science laboratory has created a vacuum in the quality of the expected potential science teachers and the product from Nigerian colleges of education that dominate our secondary schools today. This research evaluates the influence of the availability of integrated science laboratory and practical pedagogy on the learning outcomes of the colleges of education students. Random sampling technique was used for the selection of 1100 students and 76 lecturers from public Colleges of Education in Southwest Nigeria. Artificial Neural Network (ANN) models were used to analyze data obtained through questionnaires used as research instrument. Results from the test of null hypotheses stated confirmed that science laboratory and practical pedagogy have strong influence on the academic performance of colleges of education students. This is reflected in the highly positive correlation coefficient of the neural network (0.984) obtained from the simulated results.

Keywords: *Colleges of Education, Integrated Science Laboratory, Neural Network models, Practical Pedagogy, Secondary Schools, Nigeria*

1.0 Introduction

National Commission for Colleges of Education (2012), describes integrated science as a science that does not disintegrate scientific ideology. It is supposed to be an approach to the study of the environment, free of the limitation imposed by the separate subject disciplines. This is not to decry the value of a subject discipline approach; it clearly has its uses. However, at the level of readiness for learning of secondary school students, the boundaries between the disciplines can only appear as artificial. Integrated Science emphasizes those concepts which are common to all sciences, their processes, and the skills associated with them. The great themes of science such as energy, field and particle theories, conservation, balance and cycles in nature are also emphasized as they relate to everyday life. As a result of the above, the method of inquiry in integrated science has both cognitive and practical aspects (NCCE curriculum, 2012).

These cognitive aspects include the ability to formulate questions, identify variables and design experiments, interpret results, recognize patterns, generate hypotheses, draw conclusions and develop theoretical models. The practical skills required include general skills such as the ability to observe and to measure, and more specialized skills in the handling and use of laboratory apparatus and chemical reagents. It is therefore imperative for higher institution of learning, such as Colleges of Education, where integrated science is offered as a course of study to have timely relevant equipped and standard laboratory with highly skilled lecturers in order to make students cope with both cognitive and practical processes of the course.

There are number of studies on the influence of availability of science laboratory and practical pedagogy on learners' achievement in science knowledge. For instance, Dike and Salisu (2015) investigated the implication of the availability and utilization of laboratory facilities on the academic performance of students in Biology at Senior Secondary Certificate Examination (SSCE) in Zaria, Kaduna State. The study adopted random sampling technique to select 400 from 5423 students and 16 science teachers from the five selected schools. Results from the test of stated hypotheses confirmed that there are inadequate facilities in the Biology laboratories and that teachers do not utilize the facilities effectively which impart negatively as they are not exposed to handling of equipment. In similar manner, the influence of laboratory learning environment on students' academic performance in secondary school chemistry has been investigated by Odutuyi (2015), where a total of 690 student-samples were drawn from public secondary schools in Ondo State, Nigeria. Analysis of variance

(ANOVA) and multiple regression results from the test of hypotheses stated also confirmed the status of availability of well-equipped laboratory on students' performance with the availability of material having the strongest influence on learners' performance.

On the other hand, Kibirige et al., (2014) and El-Rabadi (2013) investigated the effect of practical pedagogy on the learners' achievement in science and Physics respectively. In the two studies, the samples comprise of experimental and control groups. These studies showed that the experimental group who were taught using practical work (laboratory experiment) performs better than the control group who were taught without practical work in the teacher-designed test administered to the two groups. The aforementioned studies focused on a particular science subject in secondary schools. It then becomes imperative to extend this kind of study to colleges of education where the primary and secondary school teachers are produced.

The use of neural networks in modelling data from educational arenas has been for over a decade. Specifically artificial neural networks have been used to model data from secondary schools, colleges, universities and distance education courses for different purposes including predicting the academic performance of learners (Junemann et al., 2007; Oladokun et al., 2008; Lykourentzou et al., 2009; Kalejaye et al., 2015; and Rufai et al., 2015 etc.). As an example, Oladokun et al., (2008) modelled the possible performance of prospective candidates seeking admission into Engineering Course at the University of Ibadan using multilayer perceptron neural network. Kalejaye et al., (2015) applied artificial neural networks to predict the possible final cumulative grade point aggregate (CGPA) of computer science students of Tai Solarin University of Education before graduating such students. Usman and Adenubi (2013) argued that artificial neural network produces satisfactory results when handling data relating to the educational sector because of the intrinsic chaos associated with such data.

It is therefore, on the above premise, that this paper proposes the use of neural network for modelling students' academic performances in integrated science using science laboratory, practical pedagogy and UNESCO interventions as independent variables. UNESCO is included in this research because there has been an age-long argument that Private-Public partnership is the panacea to the survival of educational sector in Nigeria (Ogunsaju, 2009). The study sample comprises of 1100 students drawn from public colleges of education in south-western part of Nigeria. This study is significant because it intends to tackle the problem of academic failure of junior secondary school students in basic science subject by investigating and disclosing the factors that are responsible for poor teaching

performance of colleges of education products that constitute the teachers of basic science in our secondary school. Consequently, the government, through, the Ministry of Education, Science and Technology will know proper action to take so as to nip the situation in the bud. Other specific objectives of the study are highlighted below:

i. To ascertain the efficiency of practical pedagogy undertaken by lecturers and students in Integrated Science in public Colleges of Education in south west.
ii. To give an eyes opener on the weakness and strength and quality of Integrated Science practical conducted in Colleges of Education.
iii. To design and train feed forward neural network (FFNN) that will be sufficient enough to analyze data collected in order to determine the influence of independent variables on student academic performances.

As a means of sense of direction, this study will evaluate the two '*Null Hypotheses'* stated below:

Ho_1: Students' academic performance in integrated science is not influenced by the availability of well-equipped science laboratory, practical pedagogy and aids from international organization (UNESCO).

Ho_2: Artificial neural network models are not significantly sufficient to model data relating to students' academic performance in integrated science based on the independent variables highlighted in hypothesis one.

2.0 Related Works

The science laboratory is a unique learning environment where students can work cooperatively in small groups to investigate scientific phenomena. In the view of Akinbobola (2015), a good laboratory environment promotes learners' curiosity, rewards creativity, encourages a spirit of healthy questioning, avoids dogmatism, and promotes meaningful understanding of thoughtful responses and dialogue. Citing Lunetta, Hoffstein and Clough (2007), kibirige et al., (2014) defined practical work as learning experience in which learners interact with materials or secondary sources of data to observe and understand the natural world. In other words, practical work connotes 'experimental work', 'scientific investigation' and 'practical and investigative activities' etc. Therefore, availability and intensive practical pedagogy have strong influence on the performance of science teachers and integrated science in particular.

There are several studies about the influence of availability of science laboratory, adequate practical pedagogy on learners' academic achievement in science subjects including

integrated science; and of course, the application of artificial neural network in modelling data from educational institutions such as secondary schools, colleges of education, and universities.

Zaytoun (1996) emphasized the necessity of including laboratory experiments and practical pedagogy in the science curriculum as it helps in the achievement of science teaching objectives. According to Okebukola (1999), science laboratory has become an essential component of the education process and science teaching throughout stages. Hussein (2001) also investigated the effect of laboratory experiments and practical work on final grade secondary students' performance in chemistry in Abyan Governorate in Yemen and conclude that laboratory experiments has positive effect on the students achievement in the subject. Salameh (2002) pointed out that planning for practical lesson is important because it stimulates the learners' interest. He therefore advocated for intensive practical pedagogy as part of teachers' basic competencies. Oluwasegun, Ohwofosirai and Emagbetere (2015), and El-Rabadi (2013) studied the effect of laboratory and practical on the students' achievement in Physics and concluded that laboratory and practical work foster learners' retention of physics concepts and recalling them when needed.

On modelling with artificial neural network, Lykourentzou et al., (2009) estimated early, the final grades of students in e-learning courses using multiple feed-forward neural networks and multiple-choice test data administered to the students of National Techical University, Athens, Greece as input. Oladokun et al., (2008) predicted the likely performance of candidate seeking admission into Engineering Course of University of Ibadan using multilayer perceptron network. Finally, Usman and Adenubi (2013), and Kalejaye et al., (2015) applied feed-forward neural network (FFNN) to predicting the learning outcome of computer science students of Tai Solarin University of Education, using their first three-session's academic records. The latter study concluded that neural network was able to predict students' performance with 91.7% level of accuracy.

Therefore, this study is a complementary work to the previous studies; it focuses on the influence of availability of science laboratory, practical pedagogy on the academic performance of integrated science students of colleges of education in south-west Nigeria. It is expected that this study will address the problem of secondary school students' failure in science subjects because the products from colleges of education later become the teachers of science in secondary schools. In this research, a feed-forward neural network was applied to predicting students' performance using the variable identified in the previous sections.

3.0 Material and Method

3.1 Proposed Feed-Forward Neural Network (FFNN)

The diagrammatic representation of the proposed feed-forward neural network (FFNN), is shown in Fig.1. As discussed by Kalejaye et al., (2015), FFNN is a backpropagation network which allows signal to flow one way only, from input to output layer. There is no feedback mechanism (loops). FFNNs tend to be straight forward networks that connect inputs with outputs. In addition, FFNN consists of one or more hidden layers of neurons in which neural connections, called *synapses*, do not form a directed cycle (Haykin, 1999; Lykourentzou *et al.*, 2009; Usman and Adenubi, 2013). The information moves only forward, from the input to the output nodes. During its learning phase, the network is presented with a set of examples called the training set. Each example consists of an input vector and the corresponding output vector. This type of learning is known as the supervised learning. The goal of the FFNN training is to minimize mean square error (MSE) between its actual and target outputs, by adjusting the network synaptic weights and neuron biases. More particularly, these network parameters are adjusted based on the backpropagation algorithm discussed later.

As can be seen from Fig.1, the structure of the proposed FFNN's topology contains three distinct layers: input, hidden and output layers. The input variables are connected to the input layer's nodes which are equal to the number of inputs (three nodes). There are two hidden layers of five nodes each. Selection of the number of neural nodes in the hidden layers is a delicate issue because having a small number of nodes in these layers lowers the processing capability of the network. Similarly, the large number of nodes in these layers will progressively slow down the training time (Oladokun et al., 2008). The growing method of hidden nodes selection, which involves beginning with a small number of nodes and increasing the number progressively, was used in this study. The best performance was achieved at hidden nodes equals ten. The output node is one and is connected to the predicted output variable.

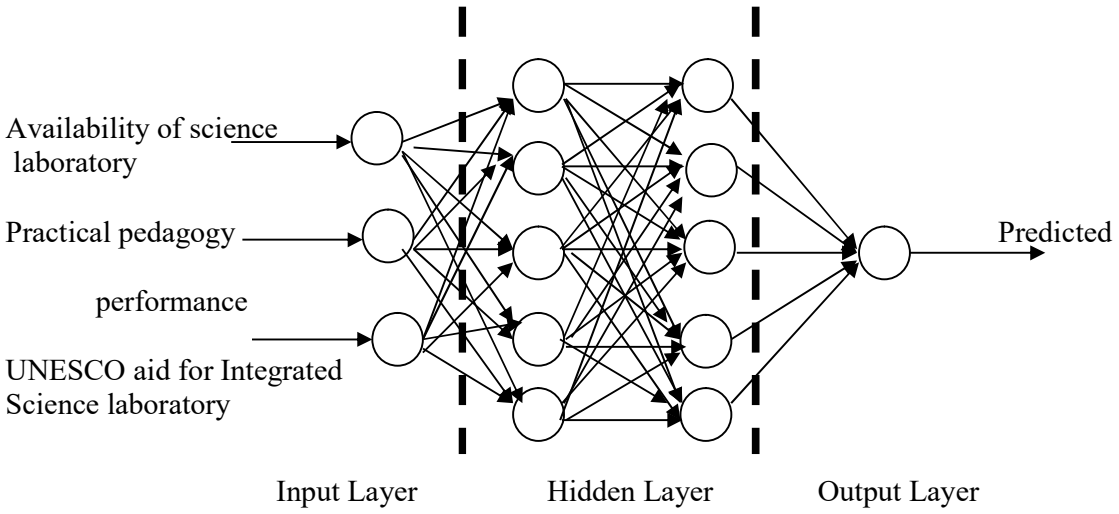

Fig.1: Structure of proposed FFNN

3.2 Instrument of Data Collection, Population and Sampling Techniques

This study adopted survey research design which involves the use of questionnaire to elicit data from target respondents. The population of the study includes all students and lecturers on integrated science in the colleges of education in Nigeria. Due to certain constraints such as finance and mobility, the study is delimited to the eleven colleges of education in southwest, Nigeria. These include: Federal College of Education, Osiele, Abeokuta; Federal College of Education (Technical), Akoka, Yaba; Adeyemi College of Education, Ondo State; Tai Solarin College of Education, Omu-Ijebu, Ogun State; Emmanuel Alayande College of Education, Oyo State; Ekiti State College of Education, Ekiti; Osun State College of Education, Ilesha; Osun State College of Education, Ila-Orangun; Michael Otedola College of Primary Education, Epe, Lagos, Federal College of Education (Special), Oyo State and Adeniran Ogunsanya College, Oto-Ijanikin, Lagos State. Stratified random sampling technique was used to select seventy-six (76) lecturers and One thousand one hundred (1,100) students of integrated science (i.e., 100 students from each school). The questionnaire instrument which was constructed by the researchers for the purpose of the study, and is of two types: Science Laboratory Facilities and Practical Pedagogy Lecturers Questionnaire (SLFPPLQ) and Science Laboratory Facilities and Practical Pedagogy Students Questionnaire (SLFPPSQ) were administered to the lecturers and students respectively. The questionnaire was validated and found to have Cronbach's alpha coefficient

of 0.624 reliability level. The data obtained through the questionnaire were ranked into an adopted four point Likert's scale of measurement.

3.3 Data Preparation, Preprocessing and Network Training

As part of preparation and preprocessing activities, the data obtained through the questionnaire were organized and converted into format suitable for coding within the context of neural network. An important task of data preparation and preprocessing is the Normalization of data which was achieved with the aid of equation (1).

$$x_{norm} = \frac{x_i \quad x_{min}}{x_{max} \quad x_{min}} \quad for\ i = 1, 2, \ldots. \tag{1}$$

where x_{norm} is the normalized form of x_i, which represents individual data point, x_{max} and x_{min} connote maximum and minimum of all data points respectively. The entire normalized equivalents of data were divided into three: train dataset, validation dataset and test dataset in the ratio of 13:3:4. Since neural network learn from examples, it implies that 65% of the data were reserved for the training, 15% for validation and 20% for testing respectively.

The proposed feed-forward neural network was trained with the popular backpropagation algorithm. This algorithm evaluates the error between the simulated output and known values of the training set. This training was conducted in a 'supervised' manner. (For more information on back propagation algorithm, see Haykin, 1999; Lykourentzou et al., 2009; and Kalejaye et al., 2015). The objective of training the propose FFNN is to minimize the cost function define as the means square error (MSE) defined in equation (2) as:

$$E = \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\left(y_j^n \quad x_j^n\right)^2 \tag{2}$$

Table 1 summarizes other parameters set during the training of the proposed FFNN model which was simulated on MATLAB 7.6.0 (2008a) coding environment.

Table 1: Training Setup for the proposed FFNN

S/N	*Parameters*	*Values*
1	Layers	3
2	Input nodes	3
3	Hidden layer	2
4	Hidden nodes	10
5	Output nodes	1
6	Training Algorithm	Backpropagation
7	Optimization Algorithm	Gradient descent
8	Transfer function	Sigmoid
9	Epoch	1000

4.0 Experimental Results and Discussion of Findings

As can be seen from the training interface of Fig.2, the training, which was carried out in a number of iterations (10 epochs) does not exceed 7 seconds with performance of 0.0605 and gradient of 0.00307 after 6 validation checks. Performance plot of Fig.3 showed that the proposed FFNN was able to meet the objective of the training by minimizing the MSE efficiently. Fig.4 depicts the MATLAB representation of the proposed neural network.

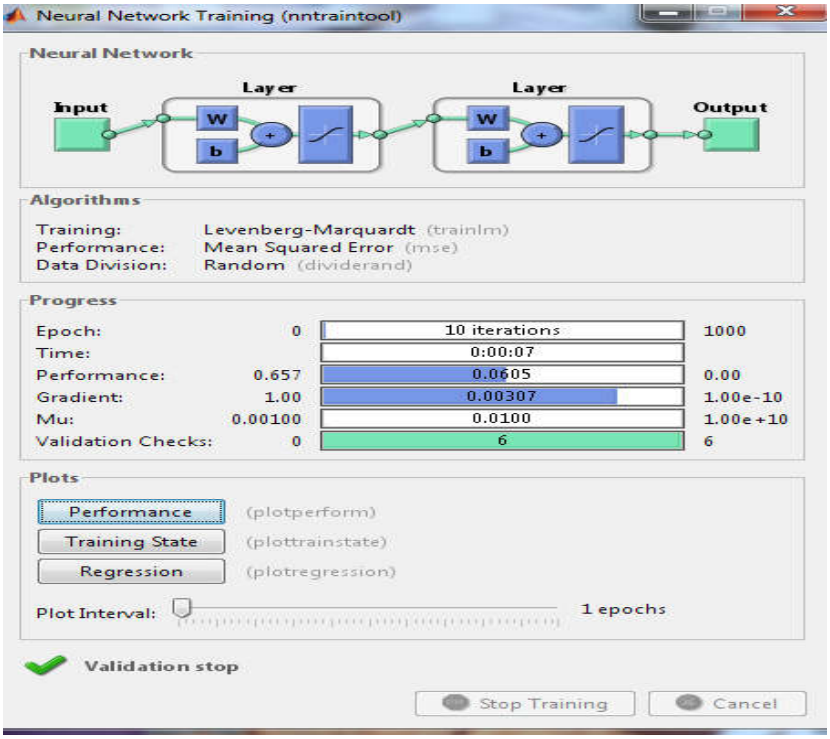

Fig.2: Neural network training interface

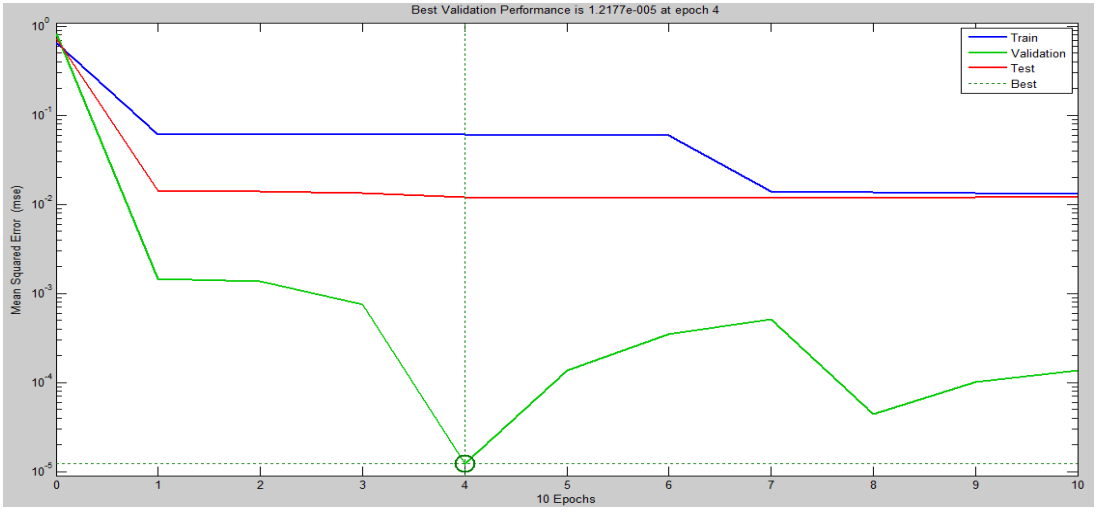

Fig.3: Performance plot

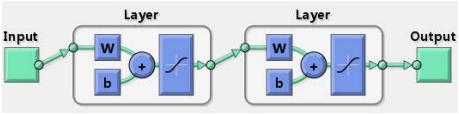

Fig.4: MATLAB equivalent of proposed FFNN

Table 2 and 3 show the results obtained from the experiment for students and lecturers respectively from the eleven colleges of education in southwest, Nigeria. As can be observed from the two tables, the numerical values are expressed in 4.d.p except the last column (Percentage Accuracy of FFNN) where each percentage is expressed in 3.s.f. In the two tables, the errors and percentage accuracies are calculated using equation (3) and (4) defined below:

$$Errors = target\ value \quad Output\ from\ FFNN \tag{3}$$

$$Percentage\ Accuracy = \frac{Output\ from\ FFNN}{Target\ value} x\ 100\% \tag{4}$$

As can be seen from Table 2, the performance of feed-forward neural network did not fall below 73.0% at predicting students' achievement in integrated science at Colleges of Education in southwest, Nigeria. This implies that the least performance of the model occurred when modelling the data relating to the students of Adeyemi College of Education,

Ondo State. There are some cases where the performance of the model are above 100% as can been observed in the cases of Emmanuel Alayande College of Education, Oyo State; Osun State College of Education, Ilesha Osun State; and Adeniran Ogunsanya College of Education, Oto-Ijanikin, Lagos with 100.4%, 104.8% and 113.6% respectively. In the cases, the FFNN predicted outputs are more than the target known values; hence errors from the model fell below 1.000. It can be inferred from this table that the influence of availability of science laboratory, practical pedagogy and both financial and material supports from the international stakeholders in education such as UNESCO are significant to the academic performance of integrated science students of Colleges of Education and potential science teachers in our secondary schools.

S/N	Students Responses	Normalized Input values	Target values	Output from FFNN	Errors from FFNN	Percentage Accuracy of FFNN
1.	Federal College of Education (Special), Oyo State	0.4783 0.7283 0.0000	0.1304	0.1098	0.0206	84.2%
2.	Emmanuel Alayande College of Education, Oyo State	0.9348 0.8261 0.7826	0.7826	0.7856	-0.0030	100.4%
3.	Tai Solarin College of Education, Omu-Ijebu, Ogun State	0.0870 0.0100 0.1304	0.0652	0.0544	0.0108	83.4%
4.	Federal College of Education, Osiele, Abeokuta, Ogun State	0.9130 0.9130 0.9130	0.9130	0.8584	0.0546	94.0%
5.	Osun State College of Education, Ila-Orangun, Osun State	0.1250 0.0000 0.1250	0.0833	0.0794	0.0039	95.3%
6.	Osun State College of Education, Ilesha, Osun State	0.1250 0.3211 0.1270	0.1910	0.2002	-0.0092	104.8%
7.	Adeyemi College of Education, Ondo State.	0.1000 0.1444 0.0000	0.0667	0.0487	0.0180	73.0%
8.	Michael Otedola College of Primary Education, Epe, Lagos State	0.1778 0.1667 0.0778	0.1000	0.0976	0.0024	97.6%
9.	Adeniran Ogunsanya College of Education, Oto-Ijanikin, Lagos State	0.1556 0.1667 0.0778	0.1333	0.1514	-0.0180	113.6%

10.	Federal College of Education (Technical), Akoka-Yaba, Lagos	0.9111 0.9556 0.9556	0.9444	0.8169	0.1275	86.5%
11.	Ekiti State College of Education, Ekiti State.	0.9444 0.8111 0.7778	0.8111	0.7844	0.0267	96.7%

Table 2: Results from FFNN Experiment (students)

Table 3: Experimental Results from FFNN (Lecturers)

N/S	Lecturers Responses	Normalized Input values	Target values	Output from FFNN	Errors from FFNN	Percentage Accuracy of FFNN
1.	Federal College of Education (Special), Oyo State	0.9022 0.9022 0.9022	0.9022	0.8051	0.0971	89.2%
2.	Emmanuel Alayande College of Education, Oyo State	1.000 1.000 1.000	1.0000	0.8328	0.1672	83.3%
3.	Tai Solarin College of Education, Omu-Ijebu, Ogun State	0.7283 0.6522 0.8261	0.7174	0.7446	-0.0272	103.8%
4.	Federal College of Education, Osiele, Abeokuta, Ogun State	1.000 1.000 1.000	1.0000	0.9328	0.0672	93.3%
5.	Osun State College of Education, Ila-Orangun, Osun State	1.000 1.000 1.000	1.0000	0.9728	0.0272	97.3%
6.	Osun State College of Education, Ilesha, Osun State	1.000 1.000 1.000	1.0000	0.8991	0.16718	89.9%
7.	Adeyemi College of Education, Ondo State.	0.9333 0.9333 0.9333	0.9333	0.8146	0.1187	87.3%
8.	Michael Otedola College of Primary Education, Epe, Lagos State	0.9333 0.9333 0.9333	0.9333	0.9135	0.0198	97.8%
9.	Adeniran Ogunsanya College of Education, Oto-Ijanikin, Lagos State	0.9111 0.9111 0.9111	0.9111	0.8078	0.1033	88.7%
10.	Federal College of Education (Technical), Akoka-Yaba, Lagos	1.0000 0.9778 0.9889	0.9778	0.8300	0.1478	84.9%
11.	Ekiti State College of Education, Ekiti	1.0000	1.0000	0.8328	0.1672	83.3%

	State.	1.0000 1.0000				

In Table 3, the percentage accuracies of FFNN observed for individual college of education used in the study also corroborates the results presented in the previous table. As shown in table 3, the least error (-0.027) was observed when modelling the responses of lecturers from Tai Solarin College of Education, Omu-Ijebu, Ogun State as the model predicted output (0.745) is more than the target value (0.717). This resulted in 103.8% percentage accuracy. The average percentage accuracy of FFNN at modelling the responses of all the 76 lecturers used in the study is 90.8% implying that artificial neural network is effective at modelling lecturers' responses on the influence of identified independent variables on the academic performance of integrated science students of colleges of education in Nigeria.

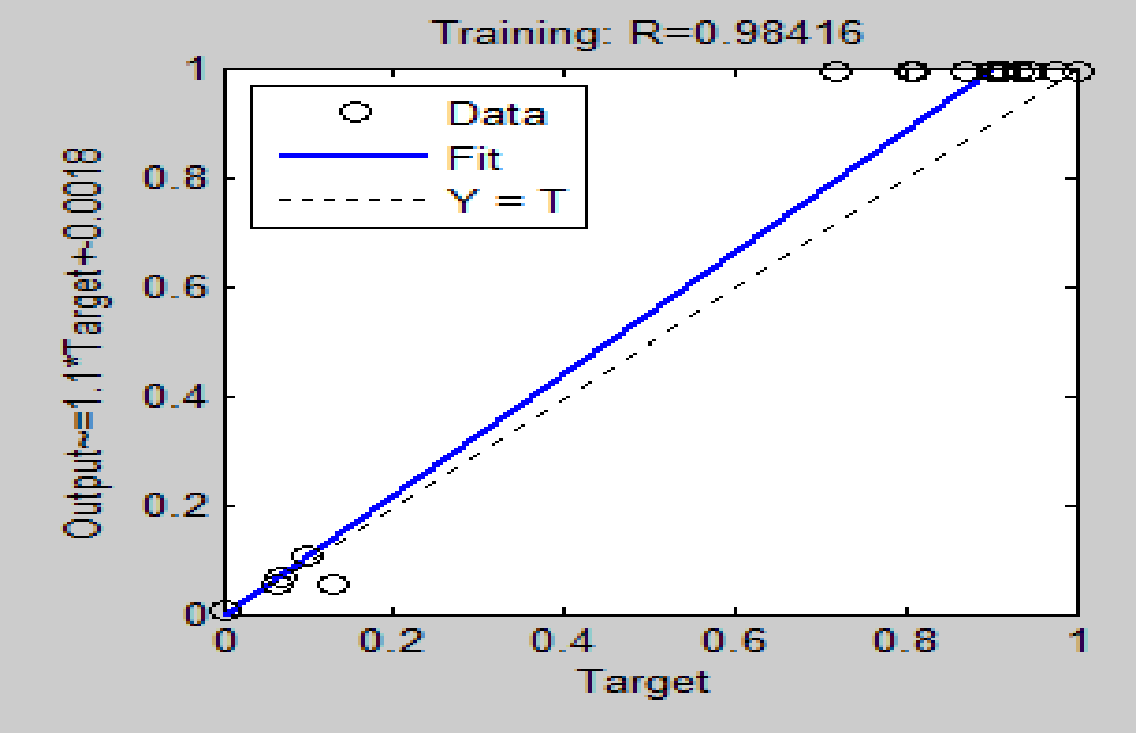

Fig.5: Regression plot of the training session

The regression plot of figure 5, obtained from the training of FFNN, further emphasized the effectiveness and efficiency of FFNN at predicting the learning outcomes of integrated science students in colleges of education based on the identified independent variables. In this figure, the correlation coefficient (R) between the target and the predicted

values is 0.984. By this, we can conclude that FFNN is 98.4% efficient at modelling data relating the students' academic performance. With the results discussed above, the two null hypotheses stated in Section 1.0 are therefore rejected and their equivalent *'Alternative Hypotheses'* accepted.

5.0 Conclusion

This study has been able to uncover the factors that have strong influence on the academic performance of integrated science students of colleges of education in Nigeria. Due to mobility and financial constraints, the study only focused on eleven selected public colleges of education in southwest, Nigeria (federal and state). Results from the test of null hypotheses indicate that students' performances are influenced by the availability of science laboratory with standard and up-to-date equipment, highly-skilled lecturers that will take learners through the practical aspect of the course/subject and supports from international organization such as UNESCO. The study also posits that neural network models are significantly sufficient at predicting the academic performance of integrated science students of colleges of education in Nigeria that will later become the teachers of sciences in our primary and secondary school. Evidences emanated from our study indicated that results from neural network are precise, concise and promising at modelling data relating to the students' academic records. In this research, feed-forward neural network (FFNN) is 98.4% efficient at predicting the learners' academic performance.

Further research can be tailored towards comparing the achievement of neural network model with the known age-long statistical methods that have been reported in the literatures over the years. Meanwhile, the research instrument (Questionnaire) that was used in this study can be changed to achievement test to be conducted on students over a period of time as this better reflects their academic performance based on the identified variables

6.0 Recommendations

Based on the research findings, the following recommendations are made:

1. Laboratory activities should be integrated with theory during regular class period for Integrated Science students in Colleges of Education.
2. Adequate materials and equipment should be provided in the laboratory by the government in order to promote creativity, innovation and learning by doing.
3. Adequate storage facilities should be provided in order to secure the materials and equipment available in the laboratory.

4. Maintenance culture should be enhanced through organizing regular seminars, workshops and conferences for lecturers and students of integrated science.
5. Owing to the fact that government alone cannot finance education, public-private partnership spirit should be encouraged to enable international organization such as UNESCO, voluntary and non-voluntary organizations as well as individual philanthropists invest in science education through the provision finance and standard equipment to the science laboratories.

References

Akinbobola, A.O. (2015), Evaluating Science Laboratory Classroom Learning Environment in Osun State of Nigeria for National Development. Journal of Resources Development and management, 9:14-19.

Dike, N. and Salisu, H. (2015), Inadequate Laboratory Facilities and Utilization: Pedagogical Hindrance to Students' Academic Performance in Biology in Senior Secondary Certificate Examination in Zaria Metropolis, Kaduna State, Nigeria. International Business Research, Published by Canadian Center of Science and Education, 8(9):124-134.

El-Rabadi, E.G.S. (2013), The Effect of Laboratory Experiments on the Upper Basic Stage Students' Achievement in Physics. Journal of Education and Practice, 4(8):62-70.

Haykin, S.(1999), Neural Networks: A Comprehensive Foundation (2nd Edition). *Macmillan College Publishing* Company, New York.

Hussein, A.A.A. (2001), The Impact of Testing Laboratory Oratory in the Achievement of Secondary school Students in Chemistry in Abyan Provice-Yemen.

Junemann, M.A.P., Lagos, P.A.S., Arriagada, R.C. (2007), Neural networks to predict schooling failure/success. In *J. Mira & J.R. Álvarez (Eds.), Lecture Notes in Computer Science*, *Nature Inspired Problem-Solving Methods in Knowledge Engineering.* Berlin: *Springer*, 4528: 571–579.

Kalejaye, B.A, Folorunso, O. and Usman, O.L (2015), Predicting Students' Grade Scores using Training Functions of Artificial Neural Network. Journal of Natural Science, Engineering and Technology, 14(1):25-42.

Kibirige, I., Maake, M.R., and Mavhunga, F. (2014), Effect of Practical Work on Grade 10 Learners' Performance in Science in Mankweng Circuit, South Africa. Mediterranean Journal of Social Sciences, 5(23):1568-1577.

Lunetta, V.N., Hofstein, A., and Clough, M.P. (2007), Teaching and Learning in the School Science Laboratory: An Analysis of Research, Theory, and Practice. In handbook of Research on Science Education, (Ediited by S.K. Abell and N.G. Lederman), pp. 393-431.

Lykourentzou, I., Giannoukos, I., Mpardis, G., Nikolopoulos, V., Loumos, V. (2009). Early and Dynamic Student Achievement Prediction in E-Learning Courses Using Neural Networks. *Journal of the American Society for Information Science and Technology*, 60(2):372-380.

MATLAB, 2008. MATLAB Environment, from http://www.mathworks.com/products/matlab/

National Commission for Colleges of Education Curriculum (2012), Teacher Education: An Imperative for National Development. Published by NCCE, Abuja.

Odutuyi, M.O. (2015), Influence of Laboratory Learning Environment on Student's Academic Performance in Secondary School Chemistry. US-China Education Review A, 5(12):814-821.

Oluwasegun, G., Ohwofosirai, A., and Emagbetere, J. (2015), The Impact of Physics Laboratory on Students Offering Physics in Ethiope-West Local Government Area of Delta State. International Journal of Educational Research and Reviews, 10(7):951-956.

Okebukola (1999). Evaluation of the objectives of a Science Teacher Education Programme, Journal of Science Teachers' Association of Nigeria, 14 (2):141 – 143.

Oladokun, V.O Adebanjo, A.T., Charles-Owaba, O.E. (2008), Predicting Students Academic Performance using Artificial Neural Network: A case study of an Engineering Course. *Pacific Journal of Science and Technology*, 9(1):72-79.

Ogunsaju, S.A. (2009), Private-Public Partnership: A Panacea for Educational Survival. In, Tai Solarin University of Education Growth and Development 2005-2010, Published by Tai Solarin University of Education Press, Ijagun, Ogun State, Nigeria, pp.264-274.

Rufai, F.A, Folorunso, O. and Usman, O.L (2015), Predicting Student's Enrolment Using Generalized Feed-Forward Neural Network. Journal of Natural Science, Engineering and Technology, 14(1):58-70.

Salameh, A.A.E. (2002), Methods of Teaching Science and its Role in the Development of Thinking. Amman: Dar Al-Fikr.

Usman, O.L and Adenubi, A.O (2013), Artificial Neural Network (ANN) model for Predicting Students' Academic Performance. Journal of Science and Information Technology (JOSIT), 13(2):61-71.

Zaytoun, A.M. (1996), Methods of Teaching Science. Amman, Dar El-Shorouk.