NEURAL NETWORK WEB-BASED SYSTEM FOR PROMOTING RURAL EDUCATION IN NIGERIA*

O.C. AGBONIFO and R.O. AKINYEDE+

Department of Computer Science, Federal University of Technology, Akure, Nigeria.

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Abstract

Rural education is as important as its urban counterpart; therefore the need to promote it using the latest (IT) technology is also important. Now that student's enrollment increases and government base funding for education decreases, the use of technology becomes more important to both administrators and instructors in the urban and rural areas. These evolutions of information and communication technologies (ICTs) have changed educational models and teaching organization techniques. The increasing demand for university education in Nigeria that could not be met due to lack of facilities and shortage of personnel; so also workers desire for professional and upgrading opportunities that would not remove workers desire from workplace, the key to unraffle these issues is the use of information and communication technology (ICT). This paper presents the neural network of a web-based learning that will increase access to high quality university education especially in rural areas based on the principle of active learning and knowledge building.

Key words: Rural education, e-learning, neural network, ICT, educational system.

1. Introduction

The era of information and communication technologies have changed educational models and teaching organizational techniques. Classroom education has transformed into virtual educational communities. Instead of face-to-face conferences, we have videoconferences or even personal videoconferences. Traditional media such as radio and educational TV and diverse materials and documentation can be easily accessed on-line. Homework has developed into personal and collaborative workgroups and teaching classes have become web-based contents and interactive materials. In particular, isolated learning has changed because of the possibilities that collaborative framework offers.

The Internet is a worldwide computer network that enables communication among millions of users around the world. It provides access to an unlimited wealth of resources, such as virtual libraries, databases, and electronic communities. In e-education, the World Wide Web and the Internet are the vehicles for information dissemination and retrieval, and also for networking and collaboration. Computer technology is thus broadening choices for the mode of delivery, content, and access, because information can be stored anywhere and transmitted anywhere (Johanna, *et al.*, 2003).

With all these new technologies in place, rural education can be promoted by exploring the advantages the ICT has brought to the global educational sector and other sectors as well.

2. ICT and Educational System

Educational system has been in existence over thousands of years before the advent of new information and communication technology era as supportive mechanism. Education is concerned with creating the kinds of experiences that will be productive and produce healthy people (Fullan, 1995). Consistent with this view, he has argued that the purpose of education is to build learning communities (communities that bring moral into teaching and reconnect teachers with their fundamental purpose as making a difference in young people's lives and changing the quality of relationships throughout the system). The purpose of education is shifting due to the exponential growth in access to information in the past 50 years (Thornburg, 1999). He believes that education now needs to foster lifelong learners, to transform the value we place on what we already know, and to create new ideas for dialog, reflection, and contextual applications of learning in the real world.

Educational adoption of computer networking began in the mid-1970s, following closely upon the invention of packet-switched networks in 1969 and e-mail and computer conferencing in 1971 (Harasim *et al.*, 1995). Many of the researchers involved in early networking experiments, such as DARPA (Defence Advanced Research Project Agency), were also academics, and they began to use new tools in their courses. The technological experimentation by these professors and their students coincidentally generated social and educational innovation: network technologies opened

+ *corresponding author* (email:femi_akinyede@yahoo.com)

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unprecedented new opportunities for education communication, interaction, and collaboration.

Also, with the inception of computer technology in the 1980s and developments in Communication technology in the 1990s, the potential for improving the quality and effectiveness of educational system has grown. This has resulted in the development of a variety of learning technologies and the incorporation of a number of new elements into distance learning: video films, multimedia courseware, and live lessons delivered to remote classrooms. Until the mid 1990s, the integration of such educational technologies was only partly successful, for methodological reasons, and due to considerations of cost and accessibility (Gene, *et al.*, 2000).

Today, we are at the threshold of a new era in which technological learning solutions are developing into effective applications. The Internet has become an essential communications platform; private intra-net networks are providing specific organisations and populations with high levels of Internet service; technological learning environments are being developed; a wide range of improved graphic means presentations are available; and simple, user-friendly means of desktop production are providing solutions which, until recently, required large, expensive facilities. Continuous improvement in Internet capabilities – both in terms of applications and transmissions rates – is transforming it into a vehicle for the delivery of an ultimate learning environment for distance learning in the 21st century.

3. Overview of e-Learning

There have been various definitions of E-Learning given by different E-learning researchers, but all tend to achieve the same objectives. E-learning is the use of Internet technologies to create and deliver a rich learning environment that includes a broad array of instruction and information resources and solutions, the goal of which is to enhance individual knowledge and organizational performance (Rosenberg, 2006). In this definition, both instructional and information solutions are employed. Not all learning requires an instructional solution. Certainly doctors need lots of formal training. But they also learn in other ways, such as reading journals, talking with peers, and accessing new medical research data. Sales people are trained to sell, but then rely on up-to-date competitive and product information to be sure they know the market well enough to be successful. Emergency first responders are highly trained, but on a daily basis, they also need access to database of emergency procedures, high levels of communication with experts and commanders, and the ability to quickly form teams to solve real-time problems. In all of these non-training environments, doctors, sales people, and first responders are still learning.

E-Learning can be used in several ways such as:

(i) Learner-led E-learning: This aims to deliver highly effective learning experiences to independent learners. It is sometimes called standalone or self-directed e-learning. Content may consist of Web pages, multimedia presentations, and other interactive learning experiences housed and maintained on a Web server. The content is accessed through a Web browser.

(ii) Instructor-led E-learning: This uses Web technology to conduct conventional classes with distant learners. These classes use a variety of real-time technologies, such as video and audio conferencing, chat, screen-sharing, polling, whiteboards, and the plain old telephone.

(iii) Facilitated E-learning: This combines the reliance on Web content found in learner-led e-learning with the collaborative facilities found in instructor-led e-learning. It works well for learners who cannot conform to the rigid schedule of classroom training but who want to augment learning through discussion with other learners as well as with a facilitator. Assignments are typically made by posting them to a class discussion forum, where learners can also "hand in" their completed homework. Unlike an instructor, the facilitator does not actually teach.

(iv) Embedded E-learning: This provides just-in-time training. It is usually embedded in computer programs, Help files, Web pages, or network applications. It may even be a component of an Electronic Performance Support System (EPSS).

(v) Telementoring and E-coaching: Telementoring and E-coaching use the latest technologies for one of the oldest forms of learning. They use video conferencing, instant messaging, Internet telephones, and other collaboration tools to help mentors guide the development of protégés. Mentoring relationships tend to be long term and focus on career development. Mentors offer learners a more knowledgeable and perhaps more mature partner from whom they can learn things not written in books or taught in classes. Online coaching has a more short-term, project-specific goal. In online coaching, the contact between adviser and learner is more precisely defined. It is usually limited to a specific subject, such as the solution of a particular problem or completion of a specific project. The online coach serves as a technical or business consultant rather than an adviser or confidante on personal matters and overall career growth. Many large and medium-sized companies recognize the value of telementoring in

capturing and communicating higher-level knowledge and wisdom. It plays a big part in knowledge management initiatives. From a technology viewpoint, telementoring may require nothing more than a telephone and e-mail.

The technologies that can be, and are, used in e-Learning are as follows: screen casts, ePortfolios, EPSS (electronic performance support system), Palm pilots, MP3 Players , the use of web-based teaching materials, hypermedia in general, multimedia CD-ROMs, discussion boards, collaborative software, e-mail, wiki, text chat, computer aided assessment , educational animation, simulations, games, learning management software, etc. Most e-Learning situations use combination of the above technologies.

Key advantages of e-learning are flexibility, convenience and the ability to work at any place where an internet connection is available and at one's own pace. E-classes are asynchronous which allows learners to participate and complete coursework in accordance with their daily commitments. This makes an E-learning education a viable option for those that have other commitments such as family or work or cannot participate easily e.g. depending on a disability. There are also transportation cost (and time) benefits with not having to commute to and from campus.

The cost benefits of e-learning to large corporate organisations are difficult to ignore. When using e-learning to train users of corporate computer systems, normally achieved by way of simulation-based learning content, the learner find himself in a software environment that is exactly like the real one but which does not carry the same error risk. Unlike classroom training, users may repeat the e-learning course without duplicating the cost. It is commonly accepted that the initial cost of an e-learning implementation is expensive (once-off development cost), but that the cost of training (per user) goes down exponentially as more learners use the e-learning course material. When using e-learning simulations to assess learning progress, the instructor is assessing the actual competence of the user to perform a transaction and not merely knowledge of the system.

Other advantages of e-learning are the ability to communicate with fellow classmates independent of metrical distance, a greater adaptability to learner's needs, more variety in learning experience with the use of multimedia and the non-verbal presentation of teaching material. Streamed video recorded lectures and MP3 files provide visual and audio learning that can be reviewed as often as needed. For organizations with distributed and constantly changing learners, e-learning has considerable benefits when compared with organizing classroom training.

4. The Technologies to Promote Rural Education

The Internet is the largest, most powerful computer network in the world, through which vast amount of educational materials in form of text, voice, video graphics etc. can be accessed by rural learners. As more and more colleges, universities, schools, companies and private citizens connect to the Internet either through affiliations with regional not-for profit networks or by subscribing to information services provided by for-profit companies, more opportunities are opened for educators to overcome time and distance to reach learners.

With access to Internet, educators and learners can make use of the following facilities:

(i) Electronic mail (e-mail): Like postal mail, e-mail is used to exchange messages or other information between them. E-mail is being delivered by the Internet software through a computer network to a computer address.

(ii) Bulettin boards: Many bulletin boards can be accessed through the Internet. The two common public boards on the Internet are USENET and LISTSERV. USENET is a collection of thousands of topically organized newsgroups, ranging in distribution from the whole world to single institutions. LISTSERV provides discussion forums on a variety of topics broken out by topic or area of interest.

(iii) World Wide Web (www): This www is an exciting and innovative front-end to the Internet. It is also described as a "wide-area hypermedia information retrieval initiative aiming to give universal access to a large universe of documents" (Hughes, 1994). It would provide the rural learners with a uniform and convenient means of accessing the wide variety of educational materials (pictures, text, data, sound, video). Popular software interfaces, such as Mosaic and Netscape, facilitate navigation and use of the www. The central organizing feature of the www is the "home page".

In addition to the above mentioned, there must be diverse information communication technology media such as radio and television broadcasting dedicated channel for the effective distribution and delivery of instructional materials such as text, data, voice, graphics and other multimedia data to respective learners in remote rural area who could not have access to the Internet and download course materials etc. A major reason for using muilti-channels for instructional material delivery is the need to take care of different learning styles of students and the facilities they can access in their various localities. From the information available, approximately ninety percent of the population has access to radio and television, while very few people currently have

access to Internet-based materials (Adewale, *et al.*, 2004). Also, with the recent satellite communication technology (NIGERCOM SAT1) launched, this will facilitate quick accessibility of instructional materials by the rural learners when other infrastructures are in place.

5. System Design

The basic software component of web-based educational system infrastructure is presented in Fig 1. This includes user interface made of access devices at the remote sites, content management gateway, and data services. This architecture allows rural learners to access the system through the internet web pages using http protocol and the learner's request is transformed into a structured query language using a PHP common content management gateway, which in turn passes it to the appropriate backend systems. The common content management gateway provides a single point entry to the system via a Uniform Resource Locator (URL). Technological approach for the implementation is based on apache web server extended with support for PHP and MySQL relational database system. In recognition of the sensitivity of the data contained in the system, communications over the public network are protected with open secure socket layer for data encryption and role-based authorisation is built into the system to specify access rights to the database system.

The presentation service is the user interface to the system and web server. User interface is currently based on html, so only browser such as netscape, mozilla or Internet explorer is required to use the system at the client side. The system is to be accessed by opening initial web page of the system. User's request is passed to the content management system, and then result of the process is presented. The web server is apache. The content management system represents an interface between the presentation service and data services. At the content management services, user's request is transformed into a structured query language where need be using PHP scripts. Data services represent database management system, and MySOL is used to provide required functionality. The system dynamically creates and returns an HTML page with the results of operation specified by the user to the browser. The database objects are conceptualized using relational database model.

A relation is similar to what is customarily referred to as a file and generally perceived and represented by a set of structured tuples. Each tuple of a relation corresponds to a record in a file and attributes correspond to fields within a record. The general form of a relation is given by $R\,[a_1, a_2, \ldots, a_n]$ where R is the name of the relation and a_i, $i = 1, 2, \ldots, n$ represent the attributes of the relation R. The database objects used in we-based educational system are:

available_courses[course, description]
admission_require[course, x_1, x_2, …, x_n]
waec_result[app_code, a_1, a_2, …, a_n]
neco_result[app_code, b_1, b_2, …, b_n]
applicant[app_code, surname, init, address, waec, wc_num, wc_yr, neco, ne_num, ne_yr, course, next_of_kin, email]
subject_desc[subject_code, description]
course_table[course_code, description, unit, session, status, staff_code]
register[matric, course_code, session, mark]
staff[staff_code, surname, init, status, dept_code, off_num,e_mail]
dept_desc[dept_code, description]
course_material[course_code, staff_code, abstract, session, date, filename]

The home page of the system is presented in Fig. 2, which consists of four main modules: ***public information; administration; registration and presentation; instructional management.***

(a) Public Information Module

Public information module consists of general information about the web-based educational system which general public may have access to. These include how to apply for any of the available courses; admission requirements; application form and admission results for successful potential students; and news.

(b) Administrative Module

The administrative module enables the staff with administrative privileges to process candidates' admission, generate admitted students matriculation numbers, students' enrolment process, manages students assessments records, provide electronic form of transcripts, provides others administrative policies and procedures detailing elements of academic programmes and student supports. See Fig. 2.

To have access to the administrative part of the system, user authentication is required. This is achieved through a simple html form that allows user to input his username and password. Access control ensures that this facility is available to authorised users.

The system is dedicated to the principle of equal opportunity, and its programmes and services are guided by that principle. Educational institutions in Nigeria use a variety of factors when making admission decisions. Some of the evaluation criteria normally used are overall scores in JAMB, institution's admission requirements, and five credits in WAEC/NECO (obtainable at not more than two sittings), and in some cases catchment's areas. In this system, the only admission criterion used is five credits in WAEC/NECO (obtainable at not more than two sittings). The system evaluates potential students'

data against the web-based educational system admission requirements for the courses applied for. The data of those who meet the requirements are verified and offer of admission confirmed to them. The admission procedure model used in this system is as follows.

Let $x_1, x_2, \ldots, x_n$ be the subjects combination admission requirements for course c_{ij}, a_{ij} and b_{ij} represent WAEC/NECO grades obtained respectively by a potential student s_i, where $i, j = 1, 2, \ldots, n$. Let F be the evaluation criterion function for evaluating potentials' data against the admission requirements x_j, where $j = 1, 2, \ldots, n$, then for the course c_i, and potential student s_i,

$$s_i = F(c_i, s_i, x_j, a_{ij}, b_{ij}) = \begin{cases} 1, \textit{ admission requirement met} \\ 0, \textit{ admission requirement not met} \end{cases} \quad (1)$$

and for every $x_j \neq 0$ and student i,

$$F = \prod_{j=1}^{n} [G(a_{ij}) \vee G(b_{ij})] = \begin{cases} 1, \textit{ iff } 2 \leq a_{ij} \leq 4 \textit{ or } 2 \leq b_{ij} \leq 4 \\ 0, \textit{ otherwise} \end{cases} \quad (2)$$

G is a function that evaluates and return 1 *iff* $2 \leq a_{ij} \leq 4$ or $2 \leq b_{ij} \leq 4$ otherwise G returns 0 for every $x_j \neq 0$. Equations (1) and (2) are used to evaluate potential students' data against the admission requirements for the course c_i applied for. The data of those who meet the requirements, that, $F = 1$, is then verified and offer of admission is confirmed to them.

(c) Registration and Presentation Module

This module presents the web-based educational system students to have access to the handbook, course registration on semester-by-semester, basis digitised archived instructional materials (*on-line education*), access to respective student's assessments grade and reports and allows collaboration between peers and course lecturers via bulletin boards and electronic mail technologies.

The following expressions allow for student automatic course registration. Each of the courses to be registered for on semester-by-semester basis is as follows:-

$$courses = \begin{cases} x_{i1}, x_{i3}, \ldots, x_{i2n-1} \textit{ for first semester} \\ \qquad\qquad i = 1,2,3,4,5 \\ x_{i2}, x_{i4}, \ldots, x_{i2n} \textit{ for second semester} \end{cases} \quad (3)$$

where i represents the student's current level., n represents number of courses, and the total units registered for the first year is

$$15 \leq \sum_{j=k}^{2n,2n-1} w_{ij} \leq 24, \begin{cases} k=1,3,5,\ldots,2n-1 \\ k=2,4,6,\ldots,2n \end{cases} \quad (4)$$

and w_{ij} is the corresponding unit of course x_{ij}. Equation (4) holds for the first year. From the second year on and for the current student's level i =2(5)1, the registration process takes outstanding courses in the corresponding previous semester(s) into consideration. Hence, equations (3) and (4) are modified to accommodate the outstanding courses as follows:

$$courses = \begin{cases} F(x_{ij}), x_{i1}, x_{i3}, \ldots, x_{i2n-1} \textit{ for first semester} \\ \qquad\qquad i = 1,2,3,4,5 \\ F(x_{ij}), x_{i2}, x_{i4}, \ldots, x_{i2n} \textit{ for second semester} \end{cases} \quad (5)$$

where F is a function that returns the list of courses such that $mark(x_{kj}) < 40$ for every k<i. Then the total units is expressed as follows:

$$15 \leq O(w_{ij}) + \sum_{j=k}^{2n,2n-1} w_{(ij)} \leq 24, \begin{cases} k=1,3,5,\ldots 2n-1 \\ k=2,4,6,\ldots,2n \end{cases} \quad (6)$$

where O is a function that determines total outstanding load units from $F(x_{kj})$.

(d) Instructional Management Module

Instruction management module allows the web-based educational system staff to archive digitised courses offering materials while allows also the maintenance of the course offerings metadata collections in the digital library database. Participating lecturers could as well build their own personalised digitised courses offering materials to be archived on the digital library server for web-based educational system students.

The courses offering materials were digitised into digital libraries as building of collections. Just like any digital library to be viable, it must have a digital collection with the critical mass to make it useful. Metadata is the data that describes the contents and attributes of any particular item in a digital library, it is very essential as a key to resource discovery and use of any document. The scheme adopted was based on a generic format for organising metadata. This format supports representation of metadata's intellectual content; content expressions; physical embodiments; and structural component. The metadata structure is created using the above bibliographic details to describe digital objects, together with several keywords and other search parameters for efficient and effective searching such as course_material[course_code, staff_code, abstract, session, date, filename], where the course_material is the digital collection or file as referred to relational database and course_code...filename are the digital objects or fields in relational database. The organisation of the digital objects into a relational database management system was done using MySQL, a popular open source database running on windows operating system.

The field course_code denotes the identification number of the digital object and it is automatically assigned to the new digital collection. This identification number is based on the *course_code* for each course, *session* in which the collection built. This scheme of naming metadata object is very simple and avoids clashes with existing collections. For instance, for CSC101, in 2006/2007 session, the internal identification number would be *csc101_2006_2007*. Furthermore, user identification number is automatically stored in the creator field of the metadata table. This is the same as the username and is obtained during the login process. This is so important and it is used to determine who can modify what in the digital library system. Date field is likewise stored automatically for each of the collections with the date the collection is built. The naming of the files stored in the repository with the naming of directories is another issue considered in the system. Names are strings that uniquely identify digital objects and are part of any document's metadata. Therefore, the naming of the files stored in the repository of this system depends on the identification number of the digital collection built by the users. This naming convention is achieved through a simple algorithm designed to automatically assign name to digital object depending on whether the digital object is composed physically single file or set of files. In case of digital object composed of a single file, the algorithm adopts the digital object's *ID* number plus a *dot* and the extension of the document format otherwise it adopts the digital object's *ID* plus an increasing serial number for each of the files for naming such digital object and a *dot* with the extension of the document format. For instance, a course code *CSC101* that is physically formed by a set of *5* files would have names in the digital library server as csc101_2006_2007_01.pdf, csc101_2006_2007_02.pdf, ..., csc101_2006_2007_05.pdf where *csc101_2006_2007_01* is the first access link to the course material and hyperlinked to other serial files. Also, directory structures are created for each of the *courses* automatically at the first occurrence of the digital object. For *CSC101*, a directory *CSC101* is created during the first time the digit object of the *course* is submitted and subsequent similar digital object will be stored automatically into this directory.

To facilitate interactive, efficient and effective interfaces between the users (learners and instructors) and the system for global searching and retrieving, an automated aid as shown in fig. 3 was modelled for capturing lecturer's data structure organisation of the study materials and tools by which students could use these resources in creative ways so as to increase the effectiveness of teaching and learning in web-based educational system courses as well as tools for searching and retrieval based upon terms familiars to lecturers such as lectures notes, assessments, syllabus, and the like and as well as the preservation of the content.

Figure 3: Hierarchical Course Structure Model

6. Architecture of Artificial Neural Network of the System

Neural network is interconnection of network of information-processing elements that mimics the connectivity and functioning of the human brain. The application of neural networks addresses problems that are often difficult for traditional computers to solve; such problems include that of speech and pattern recognition.

Figure 4 above shows the architecture of the neural network web-based towards promoting rural education in Nigeria, in the figure, the neural network architectures have three (3) layers. The first layer, which is the only layer exposed to external signals iscalled the input layer. The layer accepts signal (such as students' qualifications s_i, courses c_{ij}, and subjects' combination admission requirement, x_i) and transmits them to the neurons in the next layer, which is called a hidden layer. Each of these layers is linked to several other hidden layers between the input and output layers of the network. The layer, which may be several layers of hidden nodes, performs a calculation on the signals reaching it and sends a corresponding output signal to other layers. The layer will extracts relevant features or patterns from the received signals. The final outputs are highly processed version of the input, which are then directed to the output layer -the final layer of the network.

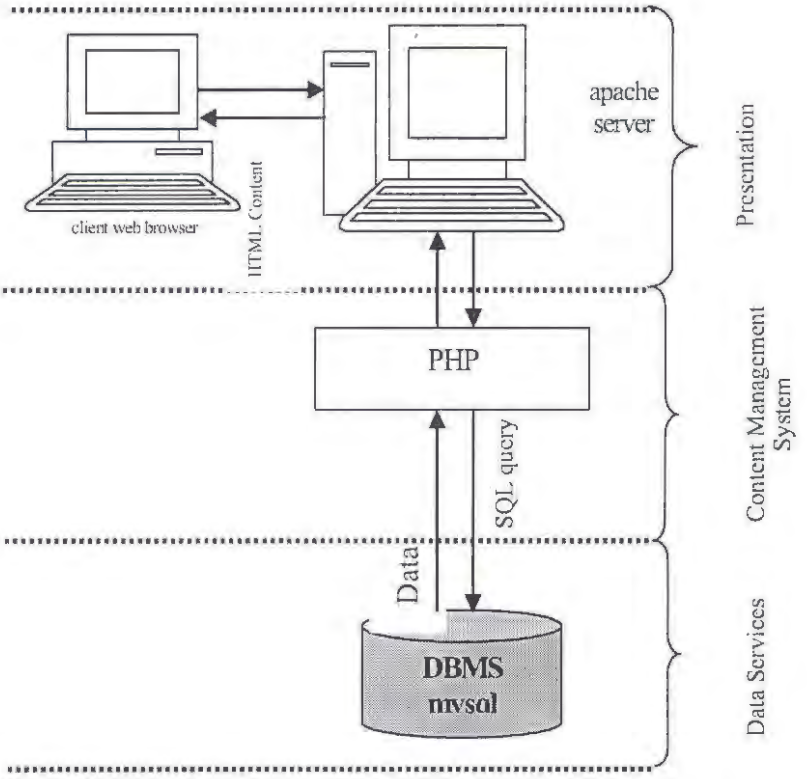

Fig. 1: Conceptual Diagram of Web-based Educational System

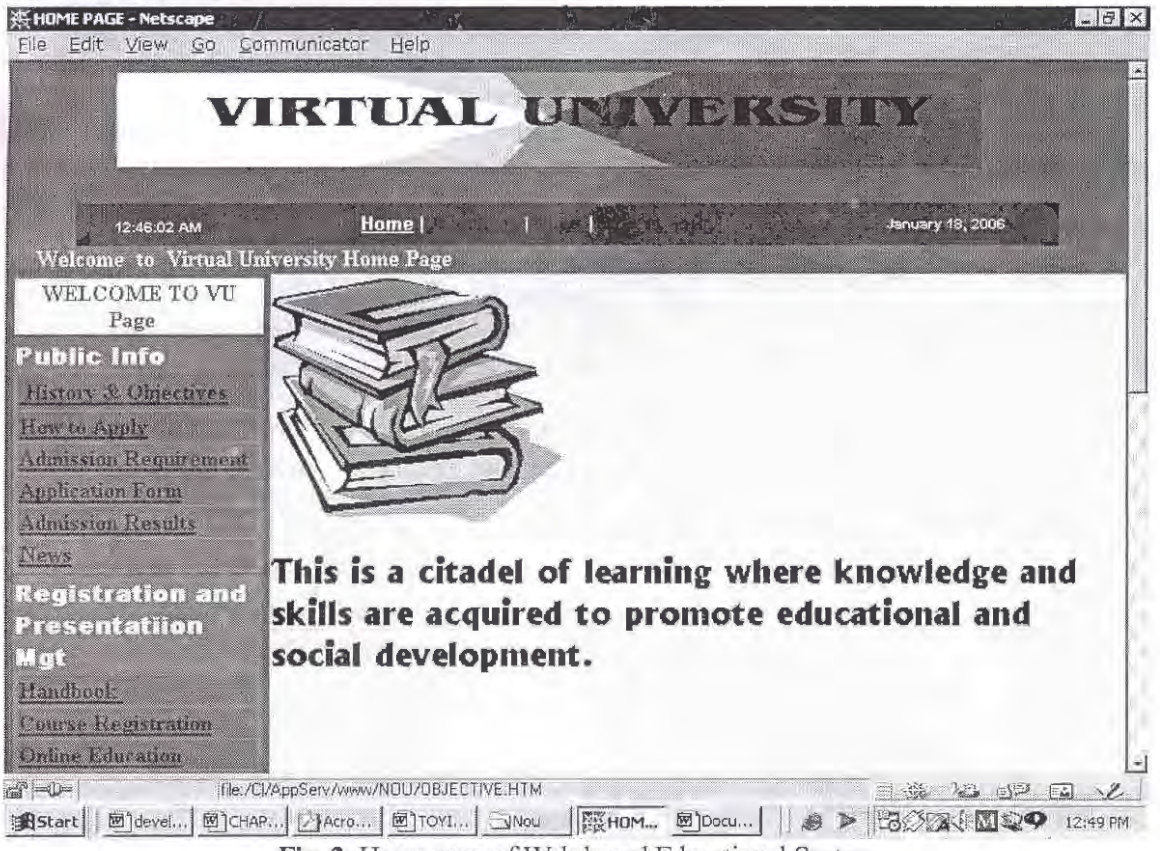

Fig. 2: Home page of Web-based Educational System

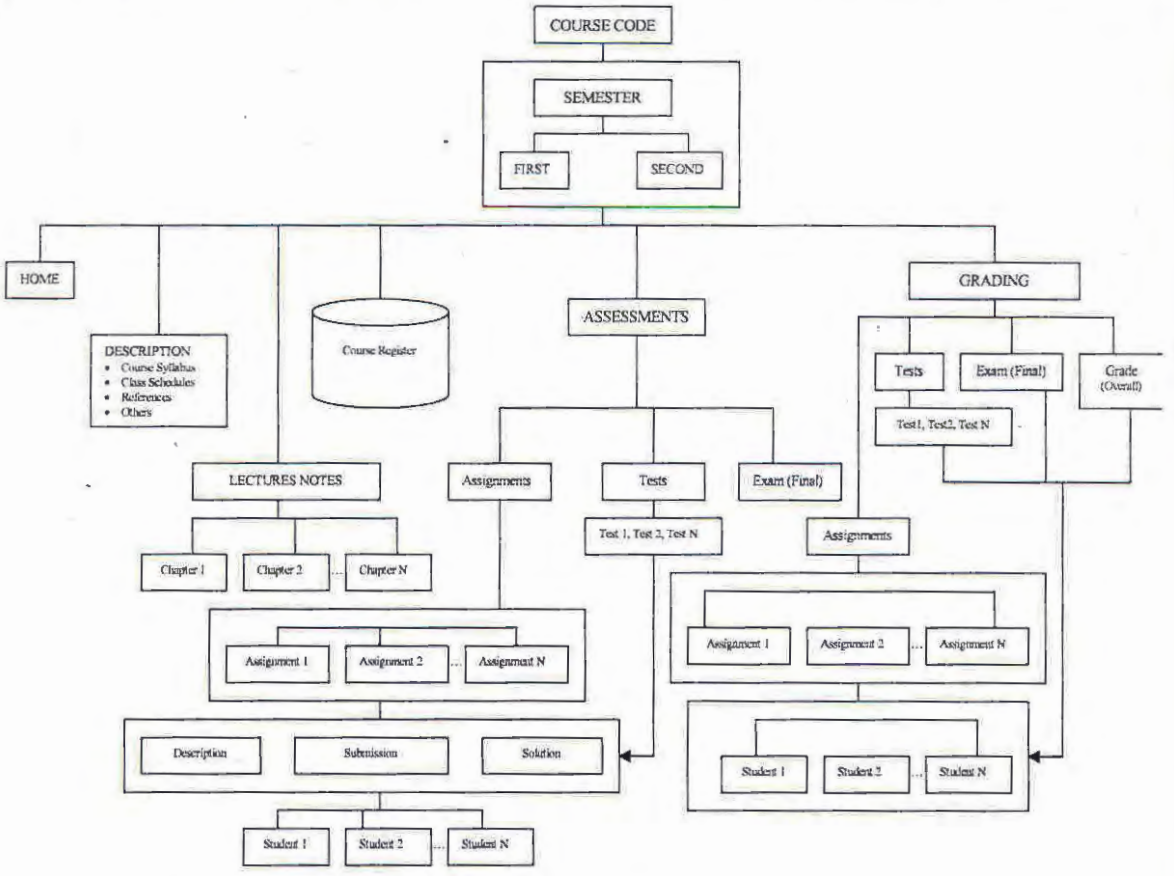

Fig. 3: Hierarchical course structure model

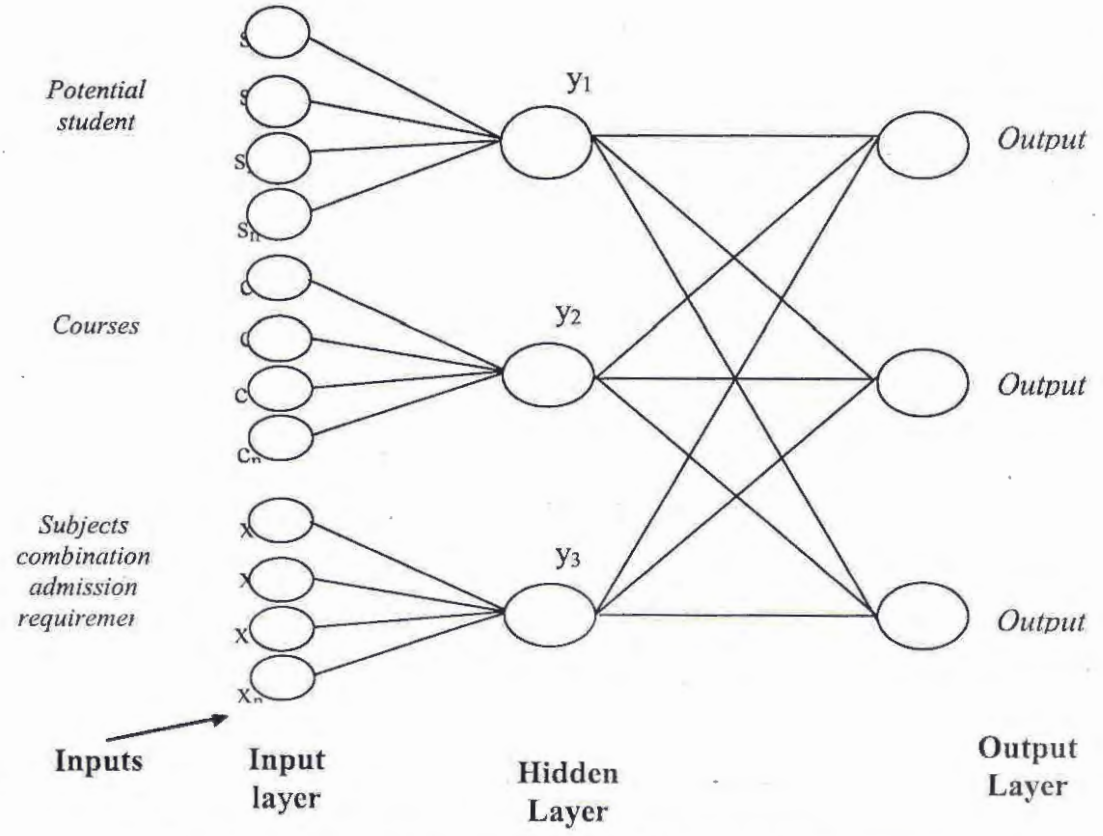

Fig. 4: Artificial neural network model of the web based educational system

7. The Challenges for Proper Implementation of the System

The general challenges of implementing this system in rural areas are enlisted below:

(i) Basic Infrastructure: The telecommunication and electricity infrastructure especially needed in rural area are still lacking. Satellites and wireless technologies are now in use but these are largely developed in urban areas and even in these areas, the infrastructure is often inadequate. If the government can look critically into this, by making available funds, it will go a long way in promoting increase access to rural education.

(ii) Policy Considerations: Most countries lack policies and strategies that facilitate the harnessing of new ICTs for rural development and where policies have been implemented, proper implementation plans are often needed. In addition, review strategies are often lacking. At present, the regulations are rigid and telecommunications tariffs and import duties on ICT equipment are high. The situation is compounded by lack of political will. Implementation infrastructure needs to be established to meet expectations raised by the ICT policy (Aliga et. al., 2006).

(iii) High rate of illiteracy in rural areas: Illiteracy is a fundamental barrier to participation in knowledge societies. The level of computer literacy is still low in Nigeria especially in rural areas, just because there is little or no ICT awareness. So, government, stakeholders and non-governmental organizations should create this awareness in order to increase the level of computer literacy. It will be impossible for interested working staff and students that are computer illiterate to enroll online as learners. Therefore, adequate training that would enable them to take full advantage of the new technologies should be made available at the local level in order to make rural communities fit into global Information Technology (IT) world.

8. Conclusion

ICT has revolutionized the world into global village, where everything takes place almost at a faster rate, at the same time, as the dividing wall of partition is broken and open for all kind of socio-cultural, economic, political, entertainment, educational activities etc. to promote for competitive and positive developmental growth and to keep abreast the latest technology on the part of developing countries to developed countries, so also on the part of rural areas to its urban counterpart.

With the era of ICT, a web-based educational system is designed to provide a learning process that will take care of the educational needs of those that are qualified for university education but could not be accommodated for lack of facilities and shortage of personnel in the tertiary institutions of urban areas and so also in the rural areas where most often tertiary institutions are not situated because of not having enabling environment; provide access to professional and upgrading opportunities that do not remove learners from the workplace and serve as easy access to education to those people in the rural areas. The system will assist in tapping the potential of new technologies to allow increased access to rural education without comprising the quality and standard of education.

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