Cases on Successful E–Learning Practices in the Developed and Developing World: Methods for the Global Information Economy

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Chapter 7
Application of VoiceXML in e-Learning Systems

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EXECUTIVE SUMMARY

This chapter examines the learning environment of visually impaired students in the school for the blind. The level of Information and Communication Technology (ICT) utilization and adoption is reported with specific interest in VoiceXML and its application areas. As a case study, a prototype voice-based e-Learning application for course registration and examination was developed and reported. The system was evaluated using ISO 9241-11 usability criteria. The outcome of the usability evaluation is also presented. The voice-based e-Learning technology described in this chapter will improve accessibility to education, including distance learning for learners who are visually impaired in the school for the blind.

BACKGROUND

The use of the Internet and web based instructional aids is now viewed as an integral part of the learning environment. As a result, students now have real-time online access to e-Learning contents and opportunities, and most tertiary institutions now offer courses through distance learning. Although some people would argue against the merits of e-Learning, it is clear that with the pace of e-Learning implementation, students such as those with visual impairments have been left behind due to the lack of an accessible content delivery system to ameliorate their disabilities.

The various options available for most learning environments are face to face, telephone, electronic mail, chat room, instant messaging, etc. However,
this becomes a more difficult task for those with disabilities. A blind person cannot see or communicate through mail or electronic means that require ability to see the screen. Lack of provision for voice in the existing learning methods has excluded support for people with limited capabilities such as the visually impaired that affect either data entry, or ability to read (and therefore check) what they have entered, since these applications are visual in nature and require sight to see the blackboard or computer screen and manipulate the computer keyboard.

Several e-Learning design methodologies have been proposed in literature. However, not too many works were dedicated to the design and implementation of e-Learning for the disabled (Sirithumgul et al., 2007, p. 1). The blind and vision impaired students, who are particularly affected by the technological change, face a range of difficulties from the act of typing a letter to the use of computers in educational institutions. The increasingly widening gap between the people who are technologically able and those who are not gives cause for great concern.

This is the case of a particular school for the blind, a privately owned educational institution located in Lagos, Nigeria, that provides a learning environment for the blind and partially sighted children at primary and secondary school levels. The school also admits people who became blind in the course of their life, for rehabilitation at higher education level (at university level). The school is headed by a principal assisted by a vice principal. There are thirty five teachers in the school and they all report directly to the school administrator while the school administrator reports to the principal.

The school’s foundation was laid by the Catholic Church on the 16th of June, 1960 and it was officially opened in 1962. The total number of pupils in 1962 was four, two boys and two girls in the primary school category. The population later increased to accommodate secondary school students. Thereafter, the federal government took over all schools in Nigeria but later handed over the ownership and management of the school back to Catholic Church missionaries, the original proprietor in the year 1970. The school provides the traditional form of learning, where the teachers meet physically with the students in class.

Presently, the school is managed by the Catholic Church of Nigeria and funded by charitable individuals and organizations. It operates the same primary and secondary school curriculum as other private and public institutions within its category in Nigeria. The school spends an average of six million, six hundred thousand naira (N6,600,000) annually on capital and recurrent expenditure while its annual income is an average of seven million, two hundred and fifty naira (N7,000,250). The total number of students is one hundred and six, and they are all accommodated in the school premises.

The report presented in this chapter examines the learning environment of vision impaired students in the school used as case study. The resulting information was used to provide an assistive voice-based e-Learning platform to support learning in the school. A number of challenges were identified after the implementation of the project. However, suggestions and recommendations were made on how to overcome them. The educational institution used as case study in this project is referred to as ‘the school’ in the subsequent sections of this chapter.

**SETTING THE STAGE**

This section examines the technology utilization of the school prior to initiation of the project. It also describes the application areas of voice technology that was used to provide a solution to the case studied.
The ICT Infrastructure of the School

The school has a total of ten of Personal Computers (PCs) running on Microsoft Windows XP operating system. There are ten Uninterrupted Power Supply (UPS) units attached to the PCs. There are two DeskJet printers available in the school. The school has an Information and Communication Technology (ICT) department. A computer technician normally comes around to carry out maintenance work on the computers and printers. The school neither currently uses any e-Learning application nor provides any e-Learning service to the students. The word processing software used is Microsoft Word. The school has one land line telephone and ten personal mobile phones owned by the members of staff. The phones are mainly used for communicating with the parents of the students, amongst others. Internet service is available for the teachers and students but was reported by the management of the school to be unstable most times.

The following ICT products and services are not available for use in the school: development/programming languages, computer network, Extranet and Intranet. However, the school’s management considers the importance of ICT as very high, particularly for the visually impaired. Their wish is to develop the ICT infrastructure further in the future if they have access to enough funds. For instance they would want to provide computer networks, replace all the PCs with new ones and computerize their examination processes.

The conventional learning methods for teaching the visually impaired students in the school include interaction between the teachers and the students which requires the physical presence of the teacher in the class. The equipment used for learning in the school are Slate and Stylus, Mathematics board and figures, Braille, Typewriters, Abacus, etc. The challenges with these resources are as follows: 1) they are very expensive to provide per child; and 2) they are imported into the country and cannot be sourced locally. The cost of maintaining the equipment is high and the technicians responsible for maintaining the equipment are very scarce.

Two major problems are associated with the utilization of the aforementioned equipment for teaching, learning and examination. First, the coordination of visually impaired students during course registration period at the beginning of the term or semester is cumbersome. As a result of the sight challenge of the students, the teachers in the school are most times not sufficient to guide the students for course registration that will lead to minimal errors by the students. Consequently, too much time is spent on the course registration exercise at the expense of pursuing other school activities. Second, the teachers are extremely busy during examination either invigilating in the classes or coordinating the logistics affecting examination. Sometimes, any of the equipment can fail during usage for lectures or examination.

More so, the hostel where the students are accommodated and the lecture halls are some distance apart. It normally takes the visually impaired students a lot of effort to navigate the foot path leading to the class rooms. They sometimes cause obstructions on the way to themselves and the teachers in attempt to locate their class rooms.

Voice learning means the use of mobile phones or landline telephone to access learning contents in the Internet or Intranet anytime and anywhere by dialing a telephone number. In determining the perception of voice learning provision to the management of the school, the school strongly agrees that: 1) a voice-based e-Learning application will complement existing supportive technologies to meet the needs of students with a range of disabilities such as visual impairment, etc, that make reading and writing difficult, and 2) voice-based e-Learning will be available on multiple platforms to all users as well as boosting access to education for the physically challenged, particularly the sight impaired in the developing countries of the world.
The management of the school was asked to rate the degree of their institution’s concern (as Least Concern, Concern or Most Concern) when considering providing telephone-based learning using mobile and land lines in terms of Reliability, Usability and Cost. These were their responses: Least Concern for Reliability, Most Concern for Usability and Concern for Cost. This shows that usability on the part of the students who are mainly from poor backgrounds may constitute a hindrance to having a 100% acceptance of the application. They also believe that the visually impaired student in their school will rely heavily on the application once it is fully deployed for access by the students and the necessary infrastructure provided by the school.

**Voice Technology and Areas of Application**

A VoiceXML (known as voice extensible markup language) platform is the foundation for developing and operating voice-based applications (Rouillard, 2007, p. 27). The VoiceXML platform also provides the speech processing capabilities (speech recognition, speech synthesis, voice authentication, etc). During the human-computer interaction, it executes the commands and logic specified by applications written in VoiceXML.

Voice-enabled e-Learning systems allow users to access information on the Internet or Intranet through a telephone interface. It uses technologies such as speech recognition and text to speech (TTS) conversion to create a user interface that enables users to navigate through a dialogue system using telephone and voice commands (Gallivan et al., 2002, p. 1).

A typical telephone web-based e-Learning application provides e-Learning materials that can be accessed via the web as well as via the telephone. Some students have used speech recognition systems successfully for their studies and for exams, and the use of this technology has helped them to overcome their difficulties and go on to higher education (Paul, 2003, p. 1).

Voice-based e-Learning systems are a system of learning that can take place anytime, anywhere with the help of a mobile or land phone by dialing a telephone number that connects users to an application that is resident in a web server. Voice-based learning is a type of “assistive technology”, used by the physically challenged. The World Wide Web Consortium (W3C) defines assistive technology as software or hardware that has been specifically designed to assist people with disabilities in carrying out their daily activities (Adaptive, 2005, p. 1). These technologies aid the learning process for learners with disabilities. People with partially sighted vision have difficulty accessing e-Learning systems due to small print or the inability to sufficiently see the position of text blocks on the screen. For blind people, e-Learning systems are often inaccessible due to the nature of the process requiring sighted information.

In addition to the provision of alternative platforms for normal users, voice-enabled e-Learning systems can be helpful for people with physical access difficulties (e.g. arthritis, high spinal injury) that make writing difficult (Donegan, 2000, p. 4). It can also be effective for students with reading, writing or spelling difficulties (e.g. dyslexia) and for those with visual impairment (Nisbet & Wilson, 2002, p. 1).

Development of voice applications using VoiceXML for higher institutions of learning has remained an open area of research all over the world. For instance, Gallivan et al., (2002, p. 4) presented a VoiceXML absentee system that enables students to report their class absence through a telephone call. The Absentee System was developed basically for Pace University students to report class absences and have them stored in the university database. The VoiceXML absentee system was designed to include record keeping of absentee calls from students, faculty and university staff. Voice-driven interfaces will also be of great benefit to people who are unable to leave their home due to disability, providing them with a learning portal using a telephone handset.
Chin et al., (2006) recommended that one can actually make use of VoiceXML technology to build speech applications that can serve educational purposes or in other words, build an online learning system that provides better accessibility to users. One of the e-Learning applications that can be provided using speech technology is one that delivers basic teaching by simply listening. For example, students can check their scores or other information by calling a particular telephone number and getting the information they want.

Voice-based applications have also been developed in several other areas such as in banking transactions (Azeta et al., 2008, pp. 59-72) and a lot more, to assist the visually impaired and provide an alternative platform for normal users.

**CASE DESCRIPTION**

A sample case of user interface description and implementation process of the application is described in this section.

**Sample Case (Call Flow) of the Application**

Below is a sample case (call flow) for the VUI of voice-based e-Learning system (see Figure 1) for the school.

**Implementation Process**

As a follow-up to providing a solution for the problems experienced involving use of the conventional learning equipment in the school, two application modules were identified. 1) Course registration, and 2) Examination. Although VoiceXML is easy to learn, building a successful VoiceXML application requires not only software development skills, but other skills like understanding human factors for the telephone interface, linguistics, speech recognition and audio production.

The implementation of a voice-based e-Learning system should contribute to the success of education for the visual impaired students in the school. The institution wants a solution based on technology that allows a student to learn independently. In order to meet up with this requirement, a voice-based application was proposed that allows access using a telephone. The project was accomplished using VoiceXML application development life cycle (VoiceXML, 2007, p. 1).

The VoiceXML application development life cycle is one of the software development models used for developing voice applications. It is similar to that of a web application development process but includes voice user interface (VUI) design and speech recognition system. The development cycle consists of five phases: They include: Problem Definition; Systems Design; Systems Development; Systems Testing; Pilot and Deployment. The life cycle was engaged in the implementation of a telephone-based e-Learning application for course registration and examination modules as follows:

**Problem Definition**

The existing learning methods in the school does not allow students to learn independently (i.e. on their own) irrespective of location. Students have to be physically present in the class room. The process of guiding/directing visually impaired students from their hostel to the class room is cumbersome.

It is the opinion of management of the school that a system that allows the students to learn on their own would minimize the problem of scarcity of teachers in the area of teaching in a classroom setting, among others.

**Systems Design**

A Unified Modeling Language (UML) class diagram was engaged to represent the data flow for the course registration and examination module. The
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Figure 1. A sample case (call flow) for the voice-based e-Learning application

IVR: Welcome to the School for the Blind e-Learning application.
IVR: What is your user name.
Caller: admin
IVR: What is your user password.
Caller: admin
IF NOINPUT then
IVR: I did not hear any user name. Please try again.
IF NOMATCH then
IVR: The user name you entered is not recognized.
Please try again.
IF NOMATCH then
IVR: The user name you entered is not recognized.
Please try again.
ENDIF
IF MATCH then
IVR: You have successfully login.
ENDIF
IVR: Select any of the following options.
say one for course registration.
say two for examination.
say three to exit.
IF one is selected then
IVR: for the following, listen and say select or deselect at the hearing of each subject.
Mathematics, Social studies, Government.
ENDIF

UML is a visual language that provides a means to visualize, construct and document the artefacts of software systems (Simeon et al., 2005).

Figure 2 contains the class diagram for the course registration and examination module. The Class diagram has five classes – Student, Course, CourseRegistration, ApproveRegdCourses and Examination. Each class has three compartments, the top compartment contains the class name, the second contains the attribute names and format, and the third compartment contains the operations to be carried out on the attributes.

The lines labelled with a directed arrow connecting two classes show associations between the classes as follows: (i) “* register 8”, means all students must register for 8 courses (ii) “* take part in 8”, means all students must take part in examination for 8 courses, (iii) “8 approve 1”, means 8 registered courses by students must get an approval from class teacher. (iv) “* must undergo 1”, means all registered courses by students must undergo an examination.

The Architectural Framework

Software Architecture

Figure 3 gives the logical overview of the architecture of e-Learning application. The software architecture shows the location of each of the modules in the application. It consists of the presentation tier, business logic tier and data tier. The database is separated from the client through the middleware, here referred to as the business logic tier.
The Presentation Tier

The presentation tier provides clients access to the e-Learning application through the middleware. The components of the clients’ interface are i) Course Registration, and ii) Examination. These components do not store or process any form of data. They only provide an interface for the middle tier and the data tier. Data or files or voice browsers are not stored on the mobile phones due to resource constraints associated with hand-held devices. The application is developed to use telephone and allows voice browsers (running in the voice gateway) to be used as the interface. The information from the database is presented in a compatible form to the client using voice. The voice browser simply receives any call into the application and submits them to the voice gateway for further processing.

The Business Logic Tier

The presentation tier communicates with the voice gateway component of the middle-tier through the voice browser. The middle-tier contains the voice gateway and the application/business logic. Users access the application from various mobile telephone devices and land line telephone, anywhere, anytime. Once a user has been authenticated, the user’s query is translated by the automated speech recognition (ASR) to text and passed to the database server for execution. The text-to-speech (TTS) does the reverse of translating text to speech. A user can only access the module for which he or she is authorized. The client application interfaces with the business logic tier using the voice gateway.
Data Tier

The data tier contains the application database. It provides data services and database management system function. The data tier is responsible for changing, adding, or deleting information in the database within the system. We have used MySQL database for the implementation of the data tier.

The Hardware Architecture

The hardware architecture consists of client devices; servers and database (see Figure 4). The client devices include the web and hand-held devices such as mobile phones and personal digital assistants and land telephones. In a situation where students are not allowed to carry mobile phones or where cost is an issue, an alternative for them is to use the PC phone such as Skype through Voice over Internet Protocol (VoIP). The servers contain the voice server and application server. The database contains MySQL database.

Systems Development

Every authenticated user of the application will pass through some questions and answers sections, which will be matched against the content of the grammar, and the result received by the user through voice. Figure 5 describes a pseudocode for course registration and examination module.

The prototype client application for the telephone was developed using VoiceXML for the VUI. PHP and Apache constituted the middle-ware and MySQL database as the back-end component. VoiceXML was chosen because it is a foundation platform for developing and operating voice automation applications (Rouillard, 2007). PHP, Apache and MySQL database were selected because of their benefit as free and open source software (Siemens, 2003, p. 4).
Systems Testing

Testing is a vital stage in the development of any application. The prototype VoiceXML-based application was deployed and tested using sample student data. The user logs onto the application using a “username” and “password” specific to their registration profile.

Pilot and Deployment

There are two methods for accessing the application: either on a local computer or the Internet. First, for a local computer, Voxeo Prophecy was installed to run on a local computer before connection and subsequent voice interaction could commence. A headset was connected to the local computer for the caller to get voice response and also be able to supply voice input. Clicking

Figure 4. A hardware architecture of the voice-based e-Learning application

Figure 5. Pseudocode for course registration and examination module

BEGIN
    SYSTEM PROMPT “Welcome to the School for the Blind e-Learning application
    //Caller supply a username and password
    SYSTEM AUTHENTICATES A CALLER;
    SYSTEM PROMPT menu selection;
    SYSTEM REPORT Student information from database;
    WHILE NOT EOF DO
        //Caller select a menu option;
        IF menu option is REGISTRATION THEN
            SYSTEM process and report registration information;
        ELSE
            IF menu option is EXAMINATION THEN
                SYSTEM process and report examination information/result;
            ELSE
                IF MENU option is EXIT THEN
                    SYSTEM report good bye message and exit;
                ENDIF
            ENDIF
        ENDDO
    END
END
the Dial button from the Voxeo Prophecy SIP Softphone keypad (www.voxeo.com/prophecy) provided connection to the application. The application was developed and tested using a local computer and latter deployed on the Internet when it was confirmed to be functioning without errors for access using a public telephone.

Second, on the Internet, Voxeo voice server (Voxeo, 2003) provided a free hosting service to deploy the prototype VoiceXML application, which can be accessed from any telephone using the format: <source country international dial-out number><destination country code><destination area code><generated voice network 7-digit number>. Dialing: 009-1-202-6849430 from any mobile or land phone from Nigeria (009) will connect and execute the application. The default username and password is “admin”.

Once connected, the application prompts with a welcome message and goes ahead to authenticate the user name and password before any transaction can take place. The application will ask for the services demanded by a student and goes ahead to process the request, either course registration or examination. A sample list of registered courses as stored in the database is depicted in Figure 6.

At the end of deploying the application, the teachers and students were given an oral guideline on how to connect to the application and use it for course registration and examination. One of the key points mentioned during the presentation of the application to the school was that the examination module only handles multiple choice examination (“objective”) questions only.

CURRENT CHALLENGES/PROBLEMS FACING THE ORGANIZATION

After developing and deploying the system, the application was evaluated for usability to determine the level of effectiveness, efficiency and users’ satisfaction. A set of questions was designed and administered through a questionnaire to the teachers and students mostly from secondary

Figure 6. A sample list of registered courses
school and higher education level (at university level). The questionnaire contains of five sections names: background information, user experience with mobile phone and the system, effectiveness of the system, efficiency of the system and user satisfaction with the system. The questionnaire aims at eliciting information from the school in order to measure the usability of the voice-based e-Learning application provided.

The system evaluation questionnaire was designed using the information acquired from 1) the analysis of requirement elicitation questionnaire, and 2) personal oral interview conducted during several visits made to the school. Some of the current challenges facing the school after deploying the application were also derived from the evaluation result. A sample of the questions from each section in the questionnaire is presented as follows:

**Question one**
Gender: Male [ ] Female [ ]

**Question two**
Would you be able to afford a mobile phone to call the e-Learning application?
[Yes] [No]

**Question three**
I was able to complete my task successfully and correctly using the application 1 2 3 4 5
Strongly Disagree Strongly Agree

**Question four**
I was able to complete my task on time 1 2 3 4 5
Strongly Disagree Strongly Agree

**Question five**
I am satisfied with the performance of the system in accomplishing my tasks 1 2 3 4 5
Strongly Disagree Strongly Agree

**System Evaluation**

The evaluation of a product is a fundamental requirement in determining the practical usability of a product (Ikhu-Omoregbe, 2007, p. 14). The usability of the e-Learning application was measured to specify the features and attributes required to make the product usable using ISO’s standard of usability (ISO 9241-11, 1998) as consisting of three distinct aspects:

- **Effectiveness**, which is the accuracy and completeness with which users achieve certain goals. Indicators of effectiveness include quality of solution and error rates.
- **Efficiency**, which is the relation between 1) the accuracy and completeness with which users achieve certain goals; and 2) the resources expended in achieving them.
- **Satisfaction**, which is the users’ comfort with and positive attitudes towards the use of the system.

**Data Analysis**

For all the learners, an overall score was computed for each of the usability dimension by averaging all the ratings on the questionnaire that was used. Microsoft Excel was used to generate the frequency distribution and mean and all the relevant charts for the ratings.

**Discussions**

With the assistance of some of the teachers, the respondents were taken through a short training on how to dial a telephone number from a mobile phone that will connect the learners to the application and how to navigation within the application. The ratings for the usability attributes as collected are presented below:
Table 1. Descriptive statistical analysis of questionnaire data

<table>
<thead>
<tr>
<th>Summary of study variable</th>
<th>Teachers</th>
<th>Students</th>
<th>Total # of respondents</th>
<th>Total Mean Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effectiveness</td>
<td>11</td>
<td>42</td>
<td>53</td>
<td>3.38</td>
</tr>
<tr>
<td>Efficiency</td>
<td>11</td>
<td>43</td>
<td>54</td>
<td>3.33</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>10</td>
<td>42</td>
<td>52</td>
<td>3.35</td>
</tr>
</tbody>
</table>

Effectiveness

The “effectiveness” was evaluated for each of the tasks performed by each learner. The mean rating for “Effectiveness” is 3.38. This is shown in Figure 7.

Efficiency

The rating for “Efficiency” indicates the time it takes to achieve a task, most of the learners were able to realize their task on time as indicated in Figure 8 with a mean rating of 3.33.

Figure 7. Effectiveness analysis

![Effectiveness graph]

Figure 8. Efficiency analysis

![Efficiency graph]
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Figure 9. Satisfaction analysis

![Satisfaction Analysis](image)

Figure 10. Usability Attributes Analysis

![Usability Attributes Analysis](image)

**Satisfaction**

The system has a mean rating of 3.35 for “Satisfaction”. Figure 9 shows the values for “Satisfaction” attribute.

Several studies on usability suggest the system with “Good Usability” should have a mean rating of 4 on a 1-5 scale and 5.6 on a 1-7 scale (Sauro, et al., 2005). Therefore, we can conclude that the prototype application developed for the school has an “Average Usability” based on the following mean ratings of the given usability scale of Table 2 and usability attributes of Table 3.

The voice-based e-Learning application provided to the school for the blind used as case study is a first trial which led to a bit of resistance from users. For this reason, on a total usability scale of 5 anything above 3 is considered successful, while less than 3 is a failure. Therefore, the case study presented in this chapter is successful.

The ratings for the three usability attributes are depicted in Figure 10.

**Navigation Analysis**

The mean overall ratings of “Navigation” is 3.62 as shown in Figure 11. This is expected since an IVR content (the words that make up the voice input and response) is required to be moderate at a particular time of call transaction.
The under listed challenges were faced by the school after completing the project and while the students were using the application. These challenges brought about the bit of resistance recorded from users and usability rating of approximately 3 out of 5 scale “Average Usability” depicted in Table 2 and Table 3.

- Most of the students in the school are from poor background and were not able to afford a mobile phone and the subsequent cost of calling the e-Learning voice application.
- Some of the students are under rehabilitation to be integrated into the society after their education. This set of students did not show much enthusiasm towards using the application.
- Poor ICT infrastructure and in particular slow Internet access that deter students from making use of free web-based PC phone such as Skype using VoIP for those who cannot afford to buy or maintain a mobile phone.
- Low financial and material donations from individuals, government, private and public organizations to cater for the general needs of the institution. This was also the case prior to the implementation of the project.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Very Bad Usability</td>
</tr>
<tr>
<td>2</td>
<td>Bad Usability</td>
</tr>
<tr>
<td>3</td>
<td>Average Usability</td>
</tr>
<tr>
<td>4</td>
<td>Good Usability</td>
</tr>
<tr>
<td>5</td>
<td>Excellent Usability</td>
</tr>
</tbody>
</table>

Table 2. Usability scale

<table>
<thead>
<tr>
<th>Usability Attributes</th>
<th>Mean Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effectiveness</td>
<td>3.38</td>
</tr>
<tr>
<td>Efficiency</td>
<td>3.33</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>3.35</td>
</tr>
</tbody>
</table>

Table 3. Usability attribute ratings

Summary and Recommendation

In this chapter, we have explored the learning experiences of students to bring to light the problems encountered by visually impaired learners for effective learning support. We have also developed a prototype voice-based e-Learning application using the VoiceXML application development life cycle to proffer a solution that will complement the existing learning methods in the school used as case study.

The voice-based e-Learning application provided for the blind has many implications. Learning can be realized faster and more efficiently than existing learning methods. The application can achieve just-in-time learning with greater reach irrespective of location (whether on the move, at home or work), speed of response and consistency of message. While claims that voice learning is an expensive form of education can be misleading, voice learning can reduce the traditional face-to-face related expenses such as lecture halls and other learning delivery facilities associated with physical presence between the students and teachers. It can also provide economies of scale at higher levels, as cost of each additional learner is negligible once the lecture materials have been developed and hosted in a central server.

The voice-based e-Learning technology will improve accessibility to education, including distance learning for learners who are visually impaired in the school for the blind. By doing so, the target group will not be completely neglected in the scheme of promoting ICT in education and learning. Loss of sight is one of the most difficult disabilities to come to terms with. The assistive
technology reported in this article has the ability to fundamentally change the way teaching and training is delivered to the students of the school for the blind used in this case study and other schools alike.

ICT driven revolutionary change in the education sector has created ever-changing knowledge and skills requirements, and traditional approaches to learning are struggling to keep up. The face-to-face method of learning has support from school teachers in the area of teaching. Meanwhile, there are growing staff shortage in the school while the demands for teachers continued to increase. Voice learning as a component of e-Learning has been deployed in the school for the blind as a means of fuelling the expansion in the school within resource constraints. The voice learning was able to provide the visually impaired learners with a more participatory educational experience.

This study has shown that there is a very low level of ICT development in the school for the blind used as case study as it is with so many other schools for the visually impaired. However, the school will appreciate any financial support towards improving their level of ICT to enable them fully embrace the new technology supported learning known as voice learning. This study also makes a contribution in the field of ubiquitous learning. Any researcher wishing to provide an assistive technology that is based on speech technology to complement existing learning methods in schools for the blind will have something to take from this article.

The voice-based e-Learning application provided to the school for the blind in this case study is the first trial of voice technology. It is also the first major technological revolution experienced after the installation of Internet services in the school. Hence, the bit of resistance recorded in the case study. Consequently, on usability scale of 5, between 3 and 5 is considered a success while anything less than 3 is a failure. Therefore, this case study is a successful e-Learning practice since the usability result recorded is approximately 3 out of a total of 5 scale.

Other e-Learning application developers trying to develop a similar voice application for the blind will need to consider several factors. To deliver and access (electronic-enabled) e-enabled voice-based learning materials will require a new

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*Figure 11. Navigation Analysis*
level of competence and awareness with ICT on the part of the users. There are the complexities of some users having to develop the basic ICT skills before using voice learning. There should be blended model with the face-to-face sessions at the initial deployment stage to prepare users for voice learning, a practice often referred to as parallel changing over from the existing learning methods to the new voice-based learning. This to some extent will minimize resistance from users. Resistance from students and teachers arise because they are used to attending classroom sessions physically. Such cultural expectations will change over time.

Another level of resistance may come from the perception of restrictions of mobile devices in terms of output and input capabilities. Mobile devices often have limited screen display sizes and limited capacity to support audio and video data. The remedy to this issue is the fact that voice application only requires dialing a telephone number to connect to an application, which does not require any additional resource overhead on a mobile phone. However, some visually impaired learners may still prefer to hear the teacher in a classroom setting. Generally, the problem of resistance may be more severe in developing countries where human resources and capacity development may be less robust and the economy less unstable. One further step to addressing the resistance issue is to understand why some learners and teachers resist. There may be a variety of reasons including 1) fear on the part of the teachers that the technology will make them obsolete and may lose their jobs, and 2) unfamiliarity with technology and fear that they will look stupid in front of others if they do not use it correctly.

While voice learning can appear to be the best option for specific learning requirements such as the visually impaired, cost of development can be prohibitive if provided through a service provider. The cost of developing the smallest voice-based e-Learning application is enormous, an amount that most schools for the blind may not be able to afford. A cost effective alternative would be to develop materials and content in-house and employ the services of an ICT administrator to manage the learning content that will be accessed by calling a telephone number. This will serve as a remedy to the issues of cost and skill since most schools for the blind in developing countries such as Nigeria does not have the required funds, skills and knowledge to make it work effectively.

There is need to increase training and development capacity for teachers in the school for the blind. It is unlikely that classroom-based delivery alone can provide sufficient capacity to bridge the gap between the developed and developing countries in the area of technology supported learning for the blind. Digital divide challenges facing developing countries in terms of ICT deployment and in particular the neglected populace such as the school for the blind are numerous. These include digital illiteracy, lack of adequate infrastructure such as electricity, etc, and lack of suitable ICT legal framework to support the visually impaired learners. In the developed and developing countries, several methodologies exist for implementing e-Learning applications. Meanwhile, not too many of them considers the plight of the visually impaired during the analysis and design stages of these applications.

Some of the challenges currently faced by the school for theblind used as case study can be overcome if individuals, Non Governmental Organizations (NGOs) and other charity organizations come to the aid of the school and render financial and material support to boost their income and asset level. This type of support will enable the management of the school to invest more on ICT including provision of mobile phones, computers and reliable Internet facility for the voice learning application that is developed and reported in this study.

The government of Nigeria should endeavour to provide the necessary ICT infrastructure in the country to support the deployment of the prototype VoiceXML-based application. Government
should also formulate policies that will reduce the tariff paid on importation of ICT products and other equipment used for learning by visually impaired students.

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