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DESIGN AND DEVELOPMENT OF A COMPUTER-BASED LEARNING ENVIRONMENT FOR TROUBLESHOOTING AND REPAIRS OF CELLULAR PHONES

[1] A.H. ONYEMACHI & [2]AK. JIBRIL (*PhD)*

1. Department of Electrical/Electronic Technology, Abia State College of Education (Technical) Arochukwu, Nigeria
2. Department of Electrical/Electronic Technology, Abia State College of Education (Technical) Arochukwu, Nigeria

Abstract

Cellular phone technology is relatively new to developing nations like Nigeria and as such there is paucity of resources for learning troubleshooting and repairing of cellular phones. Hence, the authors designed and developed a learning environment to help students learn how to troubleshoot and repair cellular phones. The developmental process began with conducting literature review on both principles of operation as well as fault symptoms and remedies associated with cellular phones. This was followed by consulting experts on the appropriate procedures for troubleshooting and repairs of various problems associated with cellular phones. In addition, the authors reviewed two computer-based environments developed for troubleshooting of equipment to guide the present research. The knowledge and experiences gathered were then used to develop the computer-based learning environment for troubleshooting and repairs of cellular phones. The developed learning environment has four main modules, namely, theory, practical, examination and database. The theory module contains principles of operation of cellular phones. The practical module provides environment where student will learn how to troubleshoot and repair various problems concerning cellular phones through problem solving strategy. The examination module is a multiple choice test which test students' understanding of various parts of cellular phone as well as its principles of operation. The database stores users' login details and students results. With this learning environment, student can view his/her examination result immediately after finishing the examination. Likewise, the lecturer can view students' results after the examination session. The computer-based learning environment was implemented using java programming language and developed under java netbeans integrated development environment (8.2). The database of the learning system was developed using MySQL The database and its tables were created using MYSQL Workbench (8.0).The database stores various data such as students' results and users' login details. The developed computer-based learning environment was tested and evaluated by students and the result of the evaluation shows that students were satisfied with the performance of the computer-based learning environment. Furthermore, the students recommended the use of the developed learning environment for learning the troubleshooting and repairs of cellular phones in the College.

Keywords: Cellular Phones, Mobile Phones,Computer-based Learning Environment, Troubleshooting and Repairing of Cellular Phones, Abia State College of Education (Tech) Arochukwu

1.0 Introduction

A cellular Phone is an electronic device with transmitter and receiver in a single package (transceiver). Cellular phones perform multiple tasks. They are used in communication, social activities, banking and learning to mention a few. In fact, cellular phones have become man's most immediate companion in that life, nowadays become uncomfortable without cellular phone. Therefore, the market for cellular phone in Nigeria and other developing countries is on the upward trend. As the market for cellular phones is in the upward trend, the market or demand for their maintenance and repairs is also on the increase. In view of the contribution of cellular phones to man's life and its potential maintenance and repairs market in Nigeria that National Board for Technical Education, NBTE (2007) integrate maintenance and repairs of cellular phones into the curriculum of National vocational certificate.

A course in maintenance and repairs of cellular phones is expected to expose students with knowledge of the principles of operation of cellular phones as well as various techniques of both fault diagnoses and repairs. As there are paucity of textbooks on the maintenance and repairs of cellular phones in Nigerian schools, the researchers found it necessary conduct a research that may eventually culminate into the design and development of a Computer-based environment for learning troubleshooting and repairing of cellular phones for students' of Abia State College of Education (Technical) Arochukwu.

2.0 Problem Statement/Justification

As the demand for cellular phones increase so is the demand, maintenance and repairs. This translates to need for integration of maintenance and repairs of cellular phones into the curriculum of educational institutions in Nigeria. Presently, maintenance and repairs of cellular phones course is integrated into curriculum of educational institutions such as technical colleges and trade centres. Recently, Abia State College of Education (Technical) Arochukwu joined the bandwagon by integrating maintenance and repairs of cellular phones into her new established skill acquisition programme. As a new course, many lecturers have little knowledge on the principles of operations of cellular phones as well as its repairs. Textbooks on maintenance and repairs of cellular phone that will be of immense help to lecturers are scarce. In fact, presently, there is no ready- made material for teaching maintenance and repairs of cellular phones course in the College.

One of the consequences of the above training problems will be the production of graduates who cannot only set up cellular repairs workshops, but also cannot work in such types of workshops. To solve this kind of training problem, the researchers proposed the development of a computer-based environment for learning troubleshooting and repairing of cellular phones for students of Abia State College of Education (Technical) Arochukwu. Such learning environment will supplement the liitle learning materials that lecturers possess.

3.0 Objectives of the Study

The objectives of the study are as follows:

1. Determine the software requirements for the learning environment
2. Design the learning environment.
3. Develop the learning environment
4. Test the learning environment
5. Determine user's satisfaction with the performance of the learning environment

4.0 Literature Review

The literature review for the development of a computer-based environment for learning troubleshooting and repairing of cellular phones was conducted under the following headings; Concept of cellular mobile radio communication, some mobile cellular technologies, advantages of cellular technology, cellular phones and operations, troubleshooting of cellular phones and previous developed learning environments for learning troubleshooting of electronic equipment..

Concept of Cellular Mobile Radio Communication

In cellular mobile radio communication system, large geographical area (eg. city) is divided into small radio areas or network coverage areas often called *cells* which are interconnected with each other. The cells and other communication equipments are collectively known as *cellular network*. The size of a cell depends on the area of coverage as well as the number of calls that are made in that area. The more the number of calls in a given area, the smaller the size of cells and the more number of cells as well. This explains why an area with more heavy population density and large buildings has many cells of small sizes. In other words, crowded urban areas have many cells with smaller sizes compared with rural areas with sparse population. A typical cell size is about 26 square kilometres (approximately 5 kilometres x 3 kilometres). The cells are overlapped (see figure 1) so that one cannot experience drop call when moving from one cell to another.

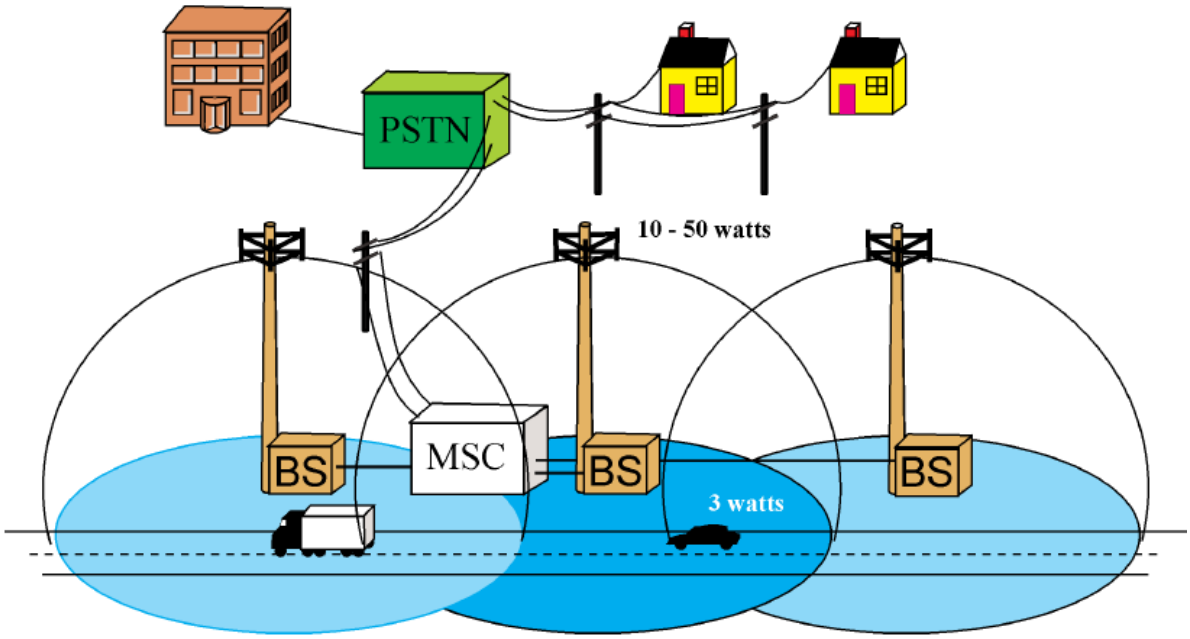

Figure 1: Cells in Cellular Network Source: Harte (2006)

Each cell coverage area has base station (BS) which consists of one or several transmitters, receivers, towers, buildings and other radio equipments that communicate with mobile telephones within its area. In specific, for communication between two mobile phones within a cell (simple call), the radio waves transmitted by an individual mobile phone is received by a base station which is then re-transmitted by the base station to other mobile phone. The transmission and reception between two individual mobile phones are carried out over two slightly different frequencies. In case of callers moving from one cell to another (roaming call), the base stations are connected to one another via mobile switching centers (MSC), which track calls and transfer them from one base station to another as callers move between cells. This process is known as *handoff* (handover). It should be noted that the handover is seamless and therefore, unnoticeable to the callers (Harte, 2006).

Each cell in a cellular network system has a number of voice channels. For example, in traditional analog cellular network system, there about 56 voice channels (frequencies) per cell. This implies that 56 people can be talking on their mobile phones simultaneously within a cell. However, the advent of digital cellular network system has greatly increased the number of such people to three folds. This is one of the many advantages of digital cellular network over its analog counterpart (Harte, 2006).

Cellular system is designed in such a way that both cellular phones and base stations have low-power transmitters. For example, the transmitters of many cellular phones have two signal strengths of 0.6 and 3 Watts. The low-power nature of the transmitters of both cellular phones and base stations make their transmissions not to go far outside the cells. This implies that two or more cells can re-use the 56 frequencies available for a cell. The implication of this trick is having multitude of people using the network as the more the number of cells in a network system, the more the number of subscribers. In fact, the number of subscribers in a cellular network system is limited with the number of cells in that network. Another advantage of making the transmitters of cellular phones to operate at low-power levels is that it permits them to be operated with small batteries. This indeed makes cellular phones to be handheld equipment (Harte, 2006).

Cellular Mobile System Technologies

The major technologies used in cellular mobile radio communication system include cellular frequency reuse, handover, speech compression, digital modulation, access multiplexing and packet data (Harte, 2006).

Advantages of Cellular Technology

The following are some of the advantages of cellular technology:

1. increase capacity
2. Reduced power usage
3. Larger coverage area
4. Reduce interference from other signals
5. Allows extensive frequency reuse

Cellular Phones and Operations

A cellular phone is a wireless handheld electronic device that allows the user to make and receive telephone calls while the user is on the move (or stationary) around a wide geographical area. Cellular phones (also known as mobile phones) provide additional functions such as short message service (SMS), multimedia message service (MMS), run applications (eg. money transfer), internet access, store files, remote control of other devices and GPS (Global Positioning System) functions among others. Modern cellular phones are equipped with digital camera, mp3 player and sensors among others.

Mobile or cellular phones are classified on different basis. For example, mobile phones can be classified based on software and hardware. Classification based on hardware is based on form factor. Form factor refers to the size, style and shape of a mobile phone, as well as to the layout and position of the phones major components. The following are the four form factors of mobile phones:

- The bar phone,
- The touch screen phone,
- The flip phone and
- The slider Phone.

Cellular phone has eight basic parts which include circuit board, antenna (aerial) microphone, speaker, liquid crystal display, keyboard, battery and SIM card. Figure 2 shows some parts of cellular phones.

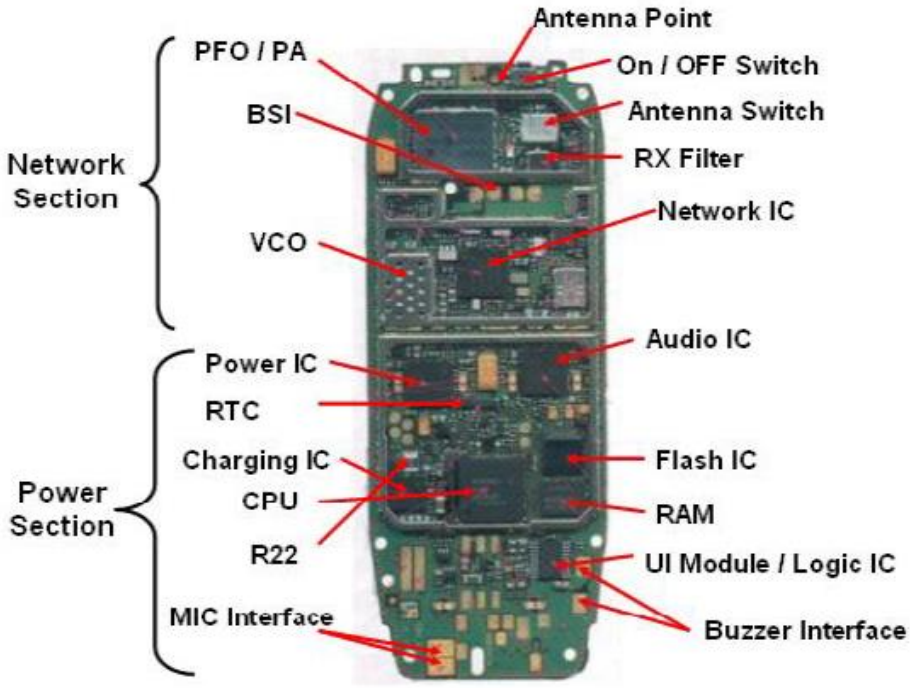

Figure 2: Parts of a Cellular Phone Source: Commonwealth of Learning (2015)
A cellular phone basically consists of two major parts; transceiver and baseband. The transceiver consists of transmitter and receiver as shown in figure 3. The baseband on the other hand contain DSP and Micro-Controller also shown in figure 3.

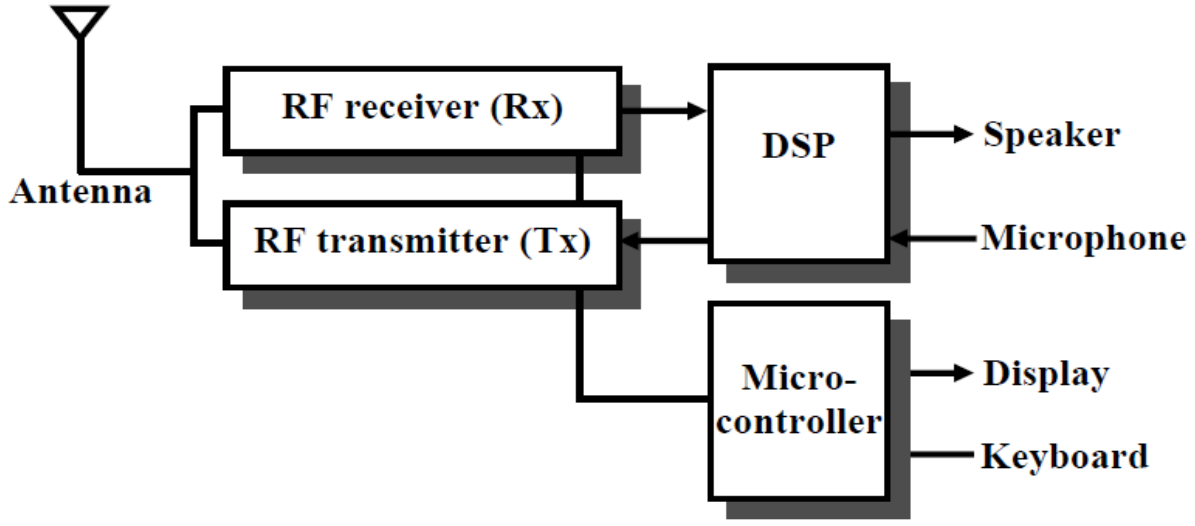

Figure 3: Block diagram of a Cellular Phone Source :Kharagpur(Undated)

As can be seen in the block diagram of figure 3, the transmitter transmits the audio speech. This is achieved through the flow of audio signal from the microphone, RF transmitter and finally to the antenna. For reception, the receiver accepts a radio signal from another cellular phone through the same antenna and then process the signal received into audio signal. The processed signal then passes through the speaker as sound.

Troubleshooting of Cellular Phones

This section presents one of the sample page for troubleshooting procedure (figure 4) of a cellular phone (Model : G5200/W5200) taken from LG electronics (2002)

Charging Troubleshooting

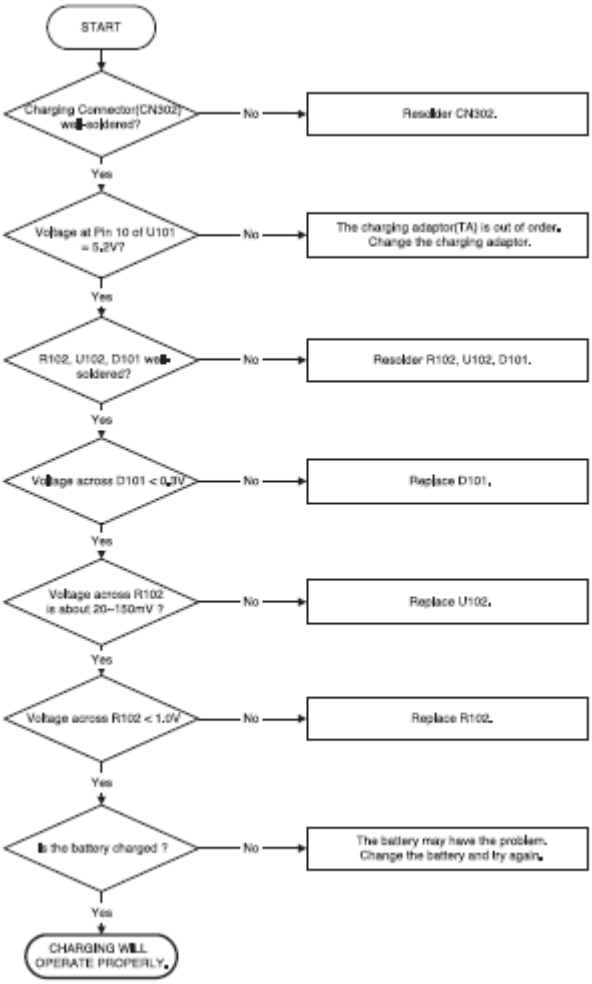

Figure 4: Troubleshooting Procedures

Some Developed Computer-based Troubleshooting Environments

Lesgold, Lajole, Bunzo and Eggan (1988) developed an intelligent tutoring system known as *Sherlock*. Sherlock teaches electronic troubleshooting procedure of F-15 manual avionics test station failures. Sherlock's knowledge base comprises of three components; the work environment, abstracted problem space for each problem and curriculum. The work environment consists of the test station, the unit from the aircraft that is currently being tested and a test package which connects that unit to the test station. Sherlock's work environment displays the simulation of the controls of the test station which are manipulatable (see figure 5). The control settings are monitored so that unsafe or inappropriate actions can be pointed out and blocked. Sherlock allows trainee to make measurements by pointing to the spots in a schematic diagram at which meter probes should be placed. In addition to the measurement devices built into the test station, a hand held multimeter is also simulated as an available device that can be applied to the schematic diagrams; and so is a wire since many tests can be performed by shorting across various points and observing the effects on over all test station (Lesgold, Lajole, Bunzo & Eggan,1988).

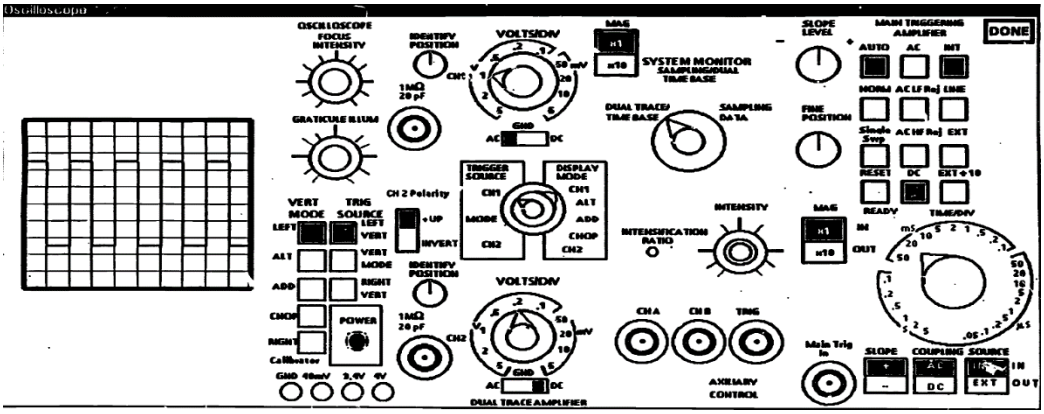

Figure 5: One of the Sherlock's Interfaces.

Abstracted problem space reduces the problem space to a manageable level. Each level represents a node in the abstracted problem space and the lines represents hierarchical relationships, nodes on the left subsume nodes on the right to which they are connected. That is, the nodes branching off to the right of a given node represent the wherewithal for completing the purpose of their "parent". This does not mean that every "offspring" of a node must be exercise before that "parent" is completed. Though, sometimes the actions and outcomes associated with a single "offspring make it clear that a whole region of problem space can be disconnected. Each node of the abstracted problems space is a computational object with specific data and procedure for handling the variety of circumstances that involved the part of the problem space it represents

(a) how to keep records of a trainees activity when he reached that part of the problem space (b) how to provide hints to trainee when he reached that part of the problem space (c) how to take account of the possibility that action elsewhere in the problem pace may have rule out this object's part of the space, and (d) how to assure that actions taken in this objects part of the space meet certain requirements for safety, efficiency, and possibility of being performable in the real world (Lesgold, Lajole, Bunzo & Eggan,1988).

Curriculum contains set of instructional goals and the sequence of activities that are meant to accomplish those goals. Sherlock is a holistic practice environment. What trainee do with Sherlock is to solve difficult test station diagnosis problems. Each problem exercises many of the needed skill components in the context of a complete naturalistic performance. This is very different from many instructional activities, such as courses, where different sessions treat different curricula goals. In Sherlock every session addresses almost every curricular goal. Nonetheless, Sherlock does have an explicit representation of the instructional goal structure it wants to achieve. The three main areas of its goal structure or curriculum are (a) troubleshooting strategy (b) mental models of test configuration that can be created with the test station, and (c) using test instruments to make measurements (Lesgold, Lajole, Bunzo & Eggan,1988).

Sherlock like other intelligent tutors has undergone evaluations. One of such evaluation was conducted in two separate Air force bases in United States of America. In such evaluation as reported by Shute (1991), pre-and post-tutor assessment was done using verbal troubleshooting techniques as well as a paper and pencil test. Two groups of subjects per Air force base were tested (1) subject receiving 20 hours of instruction on Sherlock, and (2) a control group receiving on-the-job training over the same period of time. Statistical analyses indicated the pretest (means = 56.9 and 53.4 respectively). However, on the verbal posttest as well as the paper and pencil test, the treatment group (mean = 79.0) performed significantly better than the control group (mean 58.9) and equivalent to experienced technicians having several years of on-the-job experience (mean = 82.2). The average gain score for the group using Sherlock was equivalent to almost four years of experience.

Zinn and Tenberge (2013) developed an anchored instruction learning module in the context of a computer-based simulation learning environment for acquiring troubleshooting skills in a production unit of an automotive industry. The learning environment consist of simulation of electrical, pneumatic and hydraulic systems. A trainee can contrl the plant, to test functions and request the status of PLC operands among others. The effects of the instructional modules was evaluated in a quasi-experimental evaluation study. During the study, 42 mechatronics apprentices were trained in two parallel experimental groups with

and without the anchored instruction module. The result of the evaluation shows that participants who trained with anchored instruction module improved performance and strategic behaviour expecially in similar and new task in the learning environment(Zinn & Tenberge,2013).

5.0 Methodology

This study adopted Model Driven Development (MDD) methodology. MDD methodology is suitable for the payroll management system. The Model Driven Development (MDD) methodology consists of seven phases like investigation phase, analysis of problem, requirement phase, decision analysis, Designs, Construction phase and implementation phase. The MDD methodology plays an important role in the success of the payroll project (Onyia, 2018).

5.1 Software Requirement Specifications

The following are some of the software and hardware requirements of the learning environment.

5.1.1 Hardware Requirements

(a) RAM: 1 GB or above
(b) Hard disk: 4 GB or above
(c)Processor: 2.4GHZ or above

5.1.2 Software Requirements

The following specification are needed

(a) Window 10
(b) MySql
(c) J.D.K
(d) J.R.E.
(e) Netbeans (eg. Version 8.2)
(f) Connector J 5.6

4.1.3 System Users

1.Admin
2. Lecturer
3.Students

5.1.4 Functional Requirement Specifications

Admin

1. Login and logout.
2. View, add, delete, update and print lecturer, students and admin usernames and passwords

Lecturer

1. Login and logout.
2. View and print students' results

Students

1. Login and logout.
2. Learn theory
3. Take examination
4. View and print results

5.1.5Non-Functional Requirement Specifications

1. Provide data security
2. Be efficient during operations
3. Be portable
4. Be reliable
5. Maintainable

5.2 Design

5.2.1 System Physical Architecture

The system follows client-server architecture with two layers; the application and the database layer. The application layer is the, Graphical User Interface (GUI) while the database layer is the database system (MySQL). The architecture is shown in figure 6.

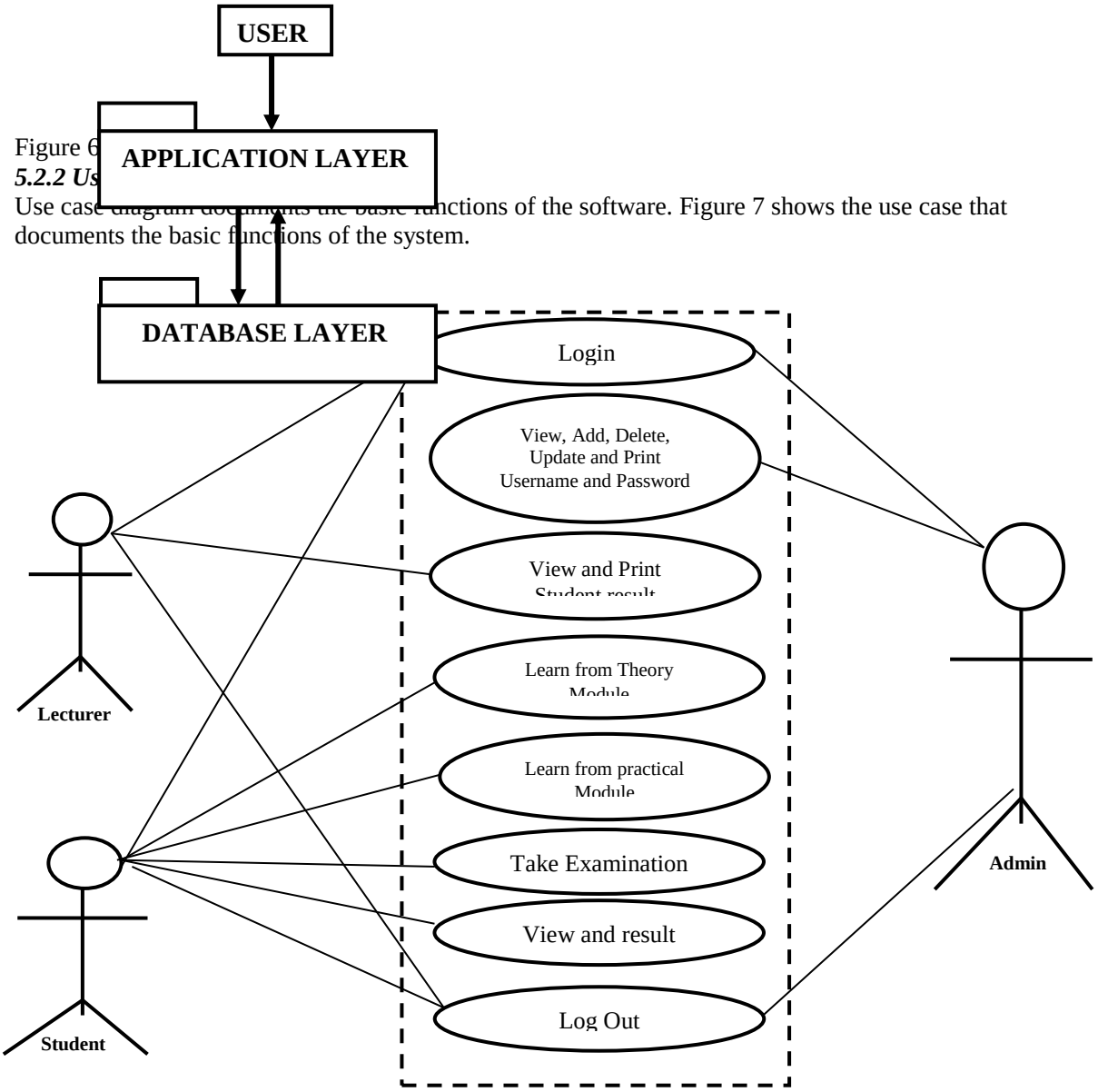

Figure 6

5.2.2 Us

Use case diagram documents the basic functions of the software. Figure 7 shows the use case that documents the basic functions of the system.

Figure 7: Use case

5.2.3 Input Forms Design

The software contains three login forms, namely, general login form, admin login form and lecturer login form respectively. Each of these login forms contains two input field; username and password where users can enter their respective usernames and passwords. In addition, they contain login buttons that send the data typed in the input fields to the database. Figure 9 shows a snapshot of the general login form while figure 10 depicts a data manipulation form in admin section that allow admin to add new usernames and passwords as well as changing them among others.

5.2.4 Main menu

The main menu contain admin login, lecturer login, theory, practical and examination, back and exit buttons as shown in figure 11. This enable user to navigate to different parts of the system.

5.2.5 Theory Module

The theory module contains two main units. The first unit contains component identification and function(s) as shown in figure 12. The second unit contains principles of operation of cellular phones.

5.2.6 Practice Module

The practical module contains five (5) troubleshooting problems. Each of the five troubleshooting problems provide student with an interactive environment that prompt and guide student during the troubleshooting process. Figure 13 shows the problem statement frame while that of figure 14 presented a scenario where student is troubleshooting a failure in a cellular phone.

5.2.7 Examination Module

The examination module is a multiple choice test environment. It contains textfields where students can enter their details. It also contains start exams, finish, submit and clear buttons. In addition, it contains countdown clock that start the exam module. When student click on the start button, the countdown clock start and at the same time the frozen radio buttons becomes active. The radio buttons become inactive when the clock reaches 0 seconds as shown in figure 15. Immediately after the examination student can view his/her result. The interface that shows student result is shown in figure 16.

5.2.8 Database Design

MySQL database was used to build the database of the software. Since the software has three login forms (eg figure 9 and 10), it implies that there must be three tables to store the data to be collected by such forms. Furthermore, since such forms contain two textfields each, it implies that the tables must have columns, namely, username and password as shown in figure 8. However, additional column of S/N is added. In addition, since students are to interact with multiple choice test module at the end of the learning process, there must be additional table that enable the storage of students result (score or total marks) along side with his/her details. Such table (Result-table) was designed after careful consideration of the textfields in the examination module interface shown in figure 15. In specific, the table should therefore have the following columns; S/N, name, Reg. Number, department, course code, level, semester, session and total marks as shown in figure 8.

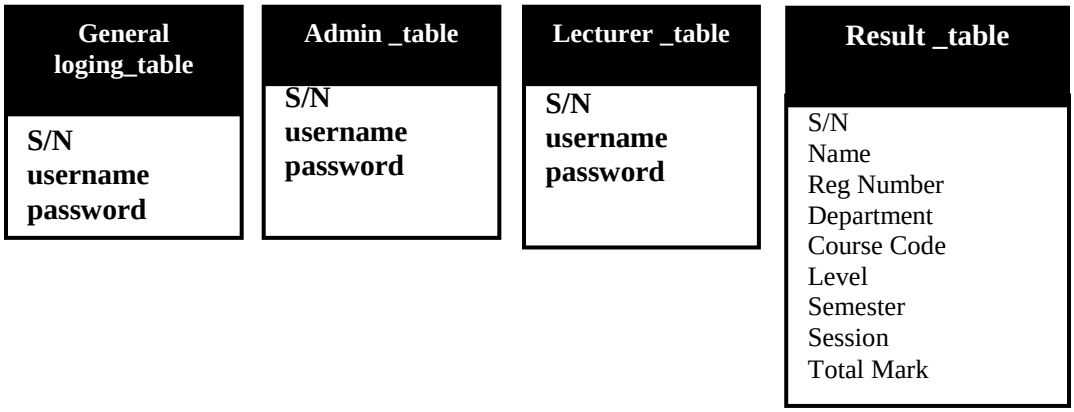

Figure 8: Database Tables

5.3 Implementation

The software was implemented using Java programming language under netbeans(8.2) IDE environment. All the database tables were constructed using workbench (8.0).

5.3.1 Outputs

The following are a sample of the outputs of the software when running.

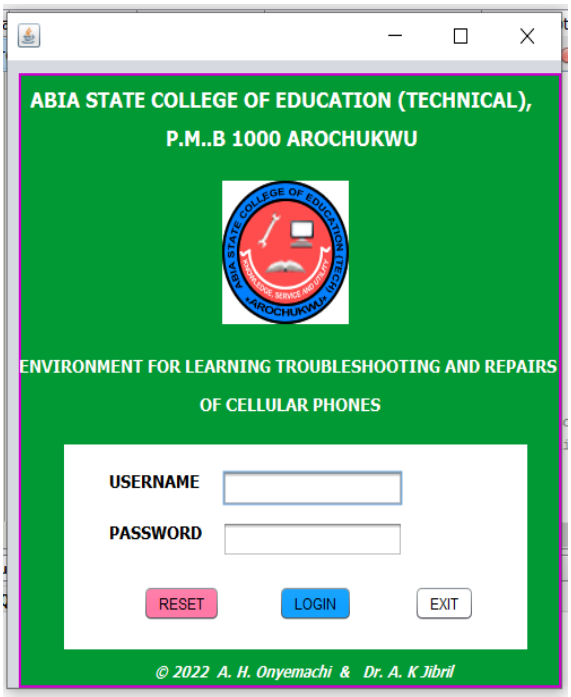

Figure 9: General Login form

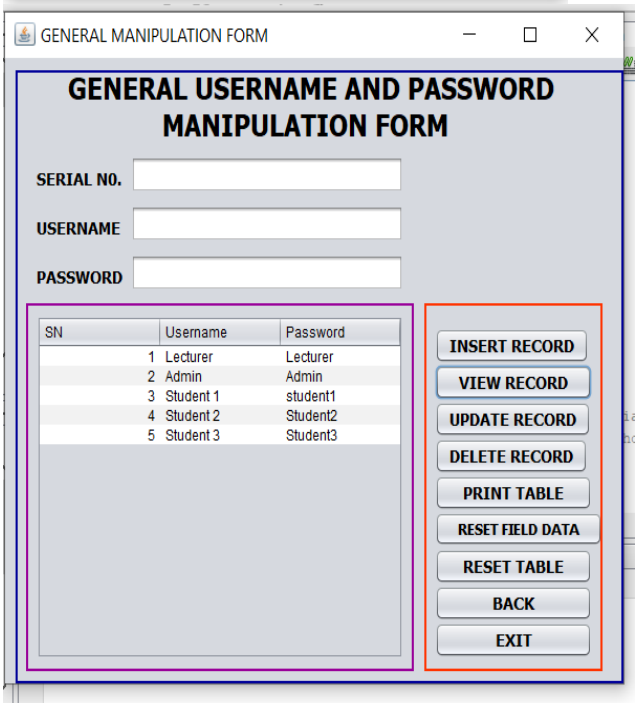

Figure 10: A view of user names and passwords stored in database

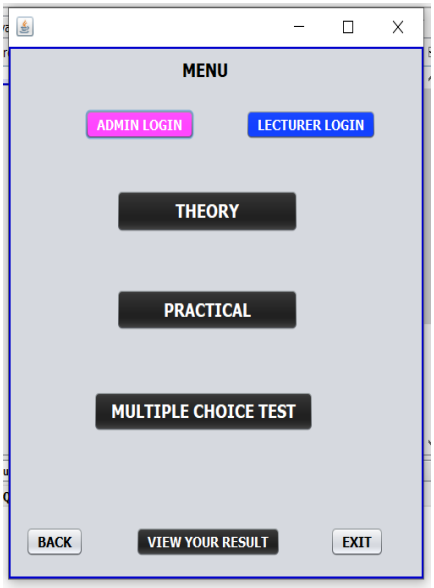

Figure 11: Main menu

Figure 13: Problem Statement Page

Figure 12: Components identification and functions

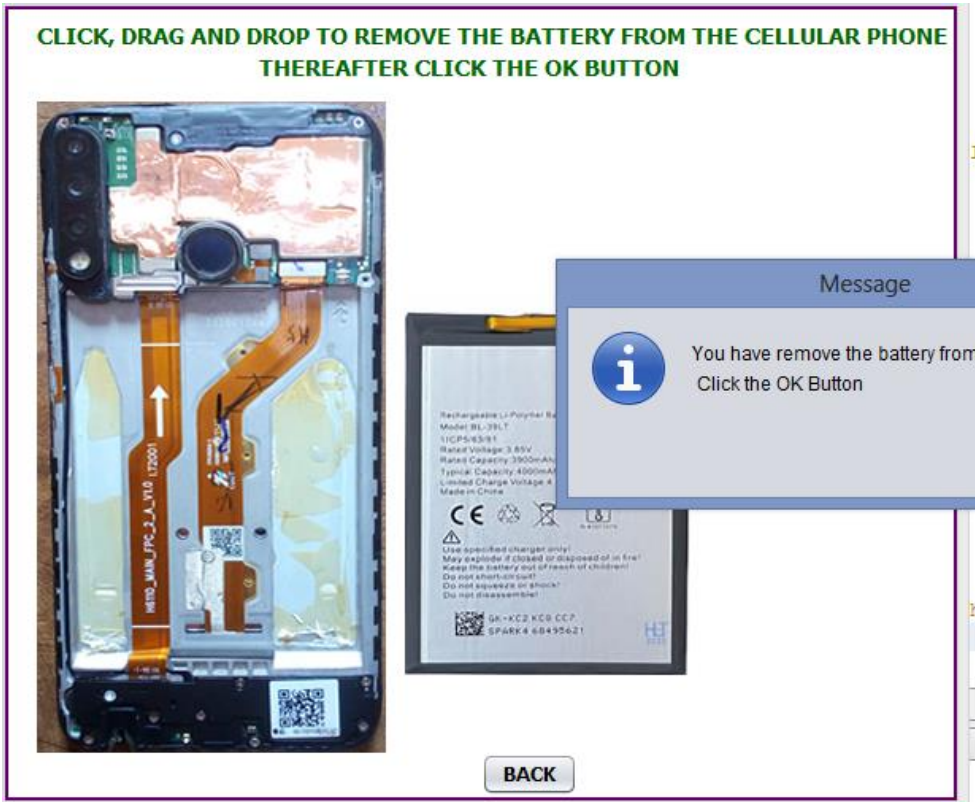

Figure 14: A sample of troubleshooting and repairs environment

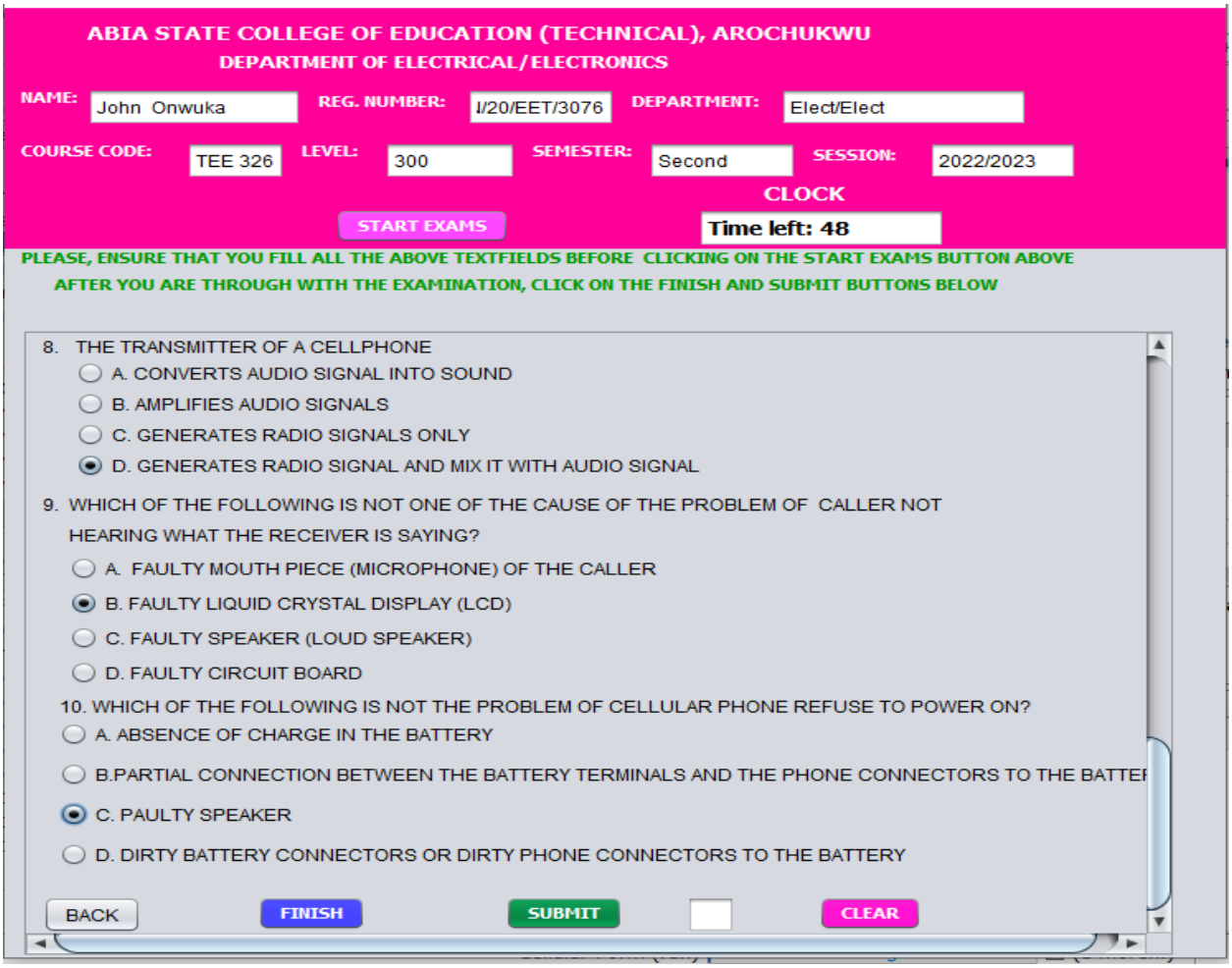

Figure 15: Multiple choice test on Cellular Phone

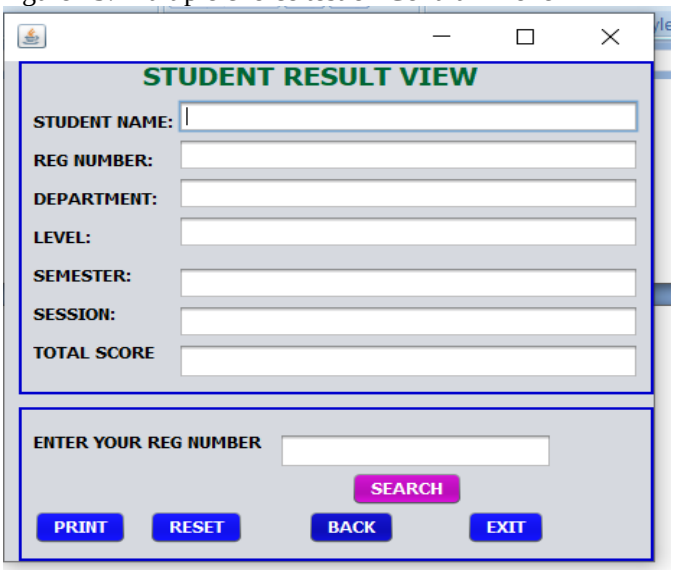

Figure 16: Student Result View

5.3.2 Testing and Evaluation

The system was tested at each of its developmental phase by the developers and corrections were made at the same time in order to conform to the software specification requirements of the project. Thereafter, the developed software was handed over to the potential users (students) for evaluation. Students interacted with the developed software and then filled copies of questionnaires designed to measure their satisfaction with the developed software. Table 1 shows the means and standard deviations of their responses to the four-point Likert scale questionnaire.

Table 1:*Mean and Standard Deviation of Responses of Students on their Satisfaction with the Performance of the new developed Software.*

N=11

S/N	Item	$\overline{X}$	SD	Remark
	Functional Software Requirements			
	Admin			
1	The software enable admin to login and logout	3.72	0.90	Agree
2	The software enable admin to add new username and password	3.82	0.60	
3	The software enable admin to update username or password	3.72	0.88	Agree
4	The software enable admin to delete username and password	3.72	0.47	Agree
5	The software enable admin to view username and password	3.82	0.40	Agree
	Lecturer			
6	The software enable lecturer to login and logout	3.55	0.69	Agree
7	The software enable lecturer to add new lecturer username and password	3.00	1.26	Agree
8	The software enable lecturer to update lecturer username and password	3.91	0.95	Agree
9	The software enable lecturer to delete lecturer username and password	3.91	0.82	Agree
10	The software enable lecturer to view lecturer username and password	3.36	1.36	Agree
11	The software enable lecturer to view examination result	3.82	0.40	Agree
12	The software enable lecturer to print examination results	4.00	1.18	Agree
	Student			
13	The software enable student to login and logout	4.00	1.18	Agree
14	The software enable student to learn from theory module	3.36	0.67	Agree
15	The software enable student to learn from the practice module	3.72	0.47	Agree
16	The software enable student to take examination	3.72	0.47	Agree
17	The software enable student to view his/her examination result	4.00	1.18	Agree
18	The software enable student to print his/her examination result	4.00	0.84	Agree
	Non-Functional Software Requirements			
19	The software is well organized	3.64	0.66	Agree
20	The Software window environments are attractive	3.64	0.50	Agree
21	The software buttons are responding to mouse click quickly	3.64	0.50	Agree
22	The feedback massages provided by the software through dialog boxes are self- explanatory	3.64	0.50	Agree
23	I felt comfortable when using the developed software	3.72	0.47	Agree
24	It is easy to navigate to different parts of the software	3.64	0.50	Agree
25	The software provided adequate data security	3.55	0.69	Agree
26	The software produce accurate calculated results	3.55	0.69	Agree
	Recommendation			
27	The developed learning environment can be used for learning troubleshooting and repairs of cellular phones	3.64	1.38	Agree

N=Number of respondent SD=Standard Deviation $\overline{X}$ *=Mean*

The data from table 1 above shows that students agreed that the software performed the functions that was designed to performed. This is evident from the fact that all the items in the table had mean values greater than the cut-off point of 2.50 on four-point Likert Scale. Furthermore, the values of the standard deviations

(SD) were very small. This signifies that the opinion of students were very close for all the items. Finally, the mean value of item 27 was found to be 3.64. This value implies that the student unanimously recommended that the developed software can be used for teaching troubleshooting of cellular phones in the College.

Conclusion and Recommendation

Cellular phone technology is relatively new to developing nations like Nigeria and as such there is paucity of resources for learning troubleshooting and repairing of cellular phones. Hence, the authors designed and developed a learning environment to help students learn how to troubleshoot and repairs. The developed learning environment has four modules; theory, practice, examination and database. The theory module contains component identification and functions as well as principles of operation of cellular phones. The practice module provides environment for learning the troubleshooting and repairs of cellular phones. The examination module test students' understanding of the principles of operation of cellular phones. The database stores users' login details and students' results as well. The developed learning environment was evaluated by students and the result of the evaluation showed that the developed learning environment is effective and efficient. Furthermore, students recommended the use of the developed software for learning the troubleshooting and repairs of cellular phones in the College.

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