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Development And Evaluation Of A Desktop Computer Fault Diagnosis And Repairs Tutor For Abia State College Of Education (Technical) Arochukwu

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***Abstract*—This paper presents the development and evaluation of an interactive computer-based tutoring system that mimic human instructors as realistic as possible in the area of desktop computer hardware fault diagnosis and repairs. To develop the tutoring system, the method of fact-finding known as knowledge acquisition was first used to extract facts from human experts and online resources in the area of desktop computer hardware fault diagnosis and repairs. The extracted facts were then presented as a set of if – then judgment statements, which were used to develop the tutoring system. The tutoring system (tutor) contains ten hardware problems and was developed using java netbeans platform. The tutor developed would enable students to disassemble simulated system unit, observe fault symptoms both visually and aurally. Student can use simulated test equipment to diagnose faults. In addition, student can remove simulated failed hardware, install new one as well as reassemble the simulated system unit after repairs. The tutor gives feedback for every fault diagnostic step taken by a student as well as guidance during diagnosis and repairs stages. The tutor provides opportunity for a student to test the repaired simulated computer. An initial evaluation study with the tutor revealed that students of Abia State College of Education (Technical) Arochukwu were satisfied with the performance of the tutor and the tutor is effective in teaching desktop computer hardware diagnosis and repairs. The students of the College recommended the use of the developed tutor in teaching fault diagnosis and repairs of desktop computer hardwares.**

***Keywords*— Development and Evaluation, Desktop computer, Fault Diagnosis and Repairs, Computer hardware**

1 INTRODUCTION

Computer is an electronic machine that that accepts user input (data) and processes it under the influence of set of instructions (programs) to produce the desired output as information [1]. In addition, computer store both user inputs and outputs. In this sense computer perform four basic functions, namely, i) accepts data, ii) processes data, iii) produce outputs and iv) stores both data input and output [2]. Computer has wide range of applications. Notably, computers are used in engineering, architecture, agriculture, transport, communication, healthcare, manufacturing, publishing , e-commerce, banking, inventory control, law and justice, military, education and research among others [3], In fact, there is hardly a field of human endeavour that has no computer application. Computer consists of two basic parts; software and hardware. Computer hardware is the tangible part of computer while the software is the intangible part. The two parts play complementary role as software controls hardware functions.

Computer hardwares such as mouse, RAM, processor, hard drive, adapter cards and power supply can fail at any time due to so many reasons. Computer hardware failures are mainly due to aging, electrical power upsurge, overheating, unfavourable environmental conditions, unauthorized operations among others [4]. Computer hardware failures cause various forms of malfunction ranging from intermittent

to complete system failure. PC (Personal Computer) technician requires a combination of the technician's knowledge, intuition, and experience to carry out PC diagnosis work. PC technicians always takes the quickest and easiest way when diagnosing PC failures and problems [5] . In addition, PC technician applies diagnostic procedures to repair malfunctioning computers. The steps in such diagnostic procedures include observation of faulty symptoms, diagnosis, repair and test [6].

Computer is one of the most widely used machines in the world and use by people of all works of life. This makes computer to be ubiquitous which translates to increase in demand for computer maintenance and repairs. Consequently, many tertiary educational institution integrated computer hardware maintenance and repairs into their educational programmes while others are on the way. Abia State College of Education (Technical) Arochukwu has already included computer hardware maintenance and repairs into her academic programmes. But such inclusion is accompanied with many challenges ranging from lecturers' lack of expertise in computer hardware maintenance to insufficient training time.

The existing expert systems developed in the area of troubleshooting (fault diagnosis) of computers that could have solved the training problems enumerated above have low training value. Low training value in the sense that they only contain the knowledge base without having components that reflect the understanding of students, explain decision making process in a manner which is easily understood by students particularly novice students (student module) as well as application of various teaching strategies (instructional module) to aid students understanding [7]. Furthermore, such expert systems do not take students through all the four basic fault diagnosis and repairs steps used by computer PC technicians during fault diagnosis and repairs. Such steps include observing fault symptom, diagnosing, repairing and testing. Unfortunately, the intelligent tutors that contain both students and instructional modules with knowledge base which could address the low training value of expert systems are mainly developed in avionics and automobile. In other words, there is paucity of computer-based training systems in the area of computer hardware troubleshooting that engage students through the four basic fault diagnosis and repairs steps during problem solving as well as providing students with feedback and guidance on every action performed they during repairs. It is against this backdrop that the author set out to develop a computer-based interactive tutoring system that teach students fault diagnosis and repairs using four basic troubleshooting steps.

The rest of this paper is organised as follows. Section 2 presents the training challenges facing department of Electrical/Electronic technology, Abia State College of Education (Technical) Arochukwu as a result of introduction of computer hardware maintenance and repairs programme and the need for the development of a new computer-based training system to tackle the challenges. Section 3 presents types of computer hardware failures, fault diagnosis steps as well as method of teaching fault diagnosis. Section 4 describes the methodology for the research work. Next was section 5, the implementation which describes how the tutoring system was implemented using java netbeans. Section 6 describes how the developed tutoring system was tested and evaluated and Section 7 provides conclusion and recommendation.

2 PROBLEM DEFINITION

Abia State College of Education (Technical) Arochukwu offered NCE (Nigeria Certificate in Education) programmes in different fields of specializations. Electrical/Electronic technology is one of the NCE programmes offers by the department of electrical/electronic technology in the College. In such

programme, students are exposed to only fault diagnosis and repairs skills in areas related to electrical installation, radio and television. However, the recent introduction of certificate programme in computer hardware maintenance and repairs in the department presents new challenges to the lecturers and technicians in the department in many ramifications. Firstly, the lecturers and technician have little knowledge and skills in computer hardware maintenance. Secondly, students must be exposed to the knowledge and skills for computer hardware maintenance and repairs within one year. Clearly, one year will not be enough to achieve such objectives. Thirdly, the training on computer hardware maintenance and repairs should not be based group task and evaluation which is the usual practice in the department, fourthly, the department has very little number of desktop computers which students can use to practice fault diagnosis and repairs.

One of the obvious solutions to the above enumerated training problems is the use of computer hardware fault diagnosis expert system to develop students fault diagnosis and repairs skills (troubleshooting skills). Certainly, the expert systems developed in the area of troubleshooting of computers are very effective in developing students' troubleshooting knowledge, but their training is low as they do not contain both students and instructional modules which are necessary for effective teaching. Such expert systems neither enable students to observe fault symptoms both visually and aurally nor take students through all the four basic troubleshooting steps followed by PC technicians during troubleshooting (observation of fault symptom, fault diagnosis, repair and test) .The intelligent tutoring systems developed in equipment maintenance training which incorporate instructional and student's modules are mainly developed in avionics and automobiles areas. In other words, there is paucity of computer-based training systems in computer hardware maintenance and repairs that take students through all the four basic steps of troubleshooting during problem solving phases. Hence, this paper presents the development and evaluation of an interactive computer-based training system that can mimic human instructors as realistic as possible in the area of desktop computer hardware fault diagnosis and repairs to address the training challenges facing department of electrical/electronic technology.

3 METHODS OF TEACHING COMPUTER HARDWARE FAULT DIAGNOSIS AND REPAIRS

Computer consists of many hardwares that work in conjunction with softwares to produce desired functions. Such hardwares can fail at any time. A hardware (or component) is said to have failed when it can no longer perform its required function [8].Hardware failures cause various forms of malfunctions ranging from intermittent to complete system failure. System hardware failures are broadly categorized into generic and specific. Generic failure is a type of failure that is not specific to a particular component while specific failure as the name implies is specific to a particular component. Generic failure can occur on any components in a system. Generic failures most often are not caused by actual electrical or mechanical failure, but are often the results of some other factor such as heat, age, poor assembly, or impact [9]. Generic failures are divided into intermittent generic failure and complete generic failure. Intermittent generic failure allows intermittent electrical contact to exist while no electrical contact in complete generic failure. While bad solder joints cause intermittent generic failures, bad trace on the other hand is responsible for complete generic failure. However, cable fault, connector fault and short circuit can cause both intermittent and complete generic failure. Authors in [9] observed that problems associated with generic failures can often be among the most difficult to isolate because their

nature is frequently erratic and sometimes not easily reproduced. Generic failures are responsible for a considerable number of problems with computer systems [9, 10].

Computer problems as result of both generic and specific failures occur during one of the three stages of computer operations, namely, during (i)POST (Power-On-Self-Test), (ii) loading and initialization of the required operating system files, (iii) after the logon and running the services and application software [5]. A problem which occurs during POST is most likely to be a hardware failure (eg RAM) as at POST stage, no operating system software has been loaded. The problems that occur during operating system loading and initialization are most likely due to corrupt operating system file or a driver as well as hard drive failure. The problems related to the third stage of operation are usually due to corrupt or incompatible drivers and files. Therefore, PC technician's knowledge on the principle of computer operation at these three stages to a large extent guides him during fault isolation or diagnostic process.

Fault diagnostic process and repairs consists of systematic steps for isolating or locating the cause of system malfunction and effecting correction. The systematic steps in diagnostic process and repairs according to [11] include; i) fault detection, ii) fault location and iii) fault rectification. Author in [12] expanded fault diagnosis and repairs to; i) preparing, ii) observing, iii) identifying problem sub-system, iv) suggesting possible causes and testing and repairing. . Author in [13] on the other hand considered the following as the fundamental steps in the logical diagnostic process for all type of equipment :i) symptom analysis, ii) equipment inspection, iii) fault stage location, iv) circuit checks, v)repair or replace and perform test. Regardless of the number of steps to be followed by a PC technician during fault diagnosis and repairs, the following remain the four universal basic steps for fault diagnosis and repairs; i) defining symptom, ii) identifying and isolating the potential source of problem, iii) replacing the suspected faulty component or part and iv) testing the repaired system to ensure that the problem has been solved [6]. PC technicians perform the job of fault diagnosis and repairs using fault-finding aids which includes: a) service and maintenance manuals and instruction manuals; b) test and measuring instruments; and c) special tools [8].

Fault diagnosis and repairs knowledge and skills are teachable and as such can be taught using various teaching methods. One of the methods of teaching diagnosis and repairs of computer is the algorithm method. An algorithm is a set of instructions designed for solving problems in a finite number of steps. Algorithms usually have one entrance or starting point although they may have several exits or finishing points corresponding to the possible solutions or outcome of the problem [14]. Algorithms in form of flowcharts (diagnostic flowchart) are used in teaching of not only fault diagnosis and repairs of electrical or electronic equipment but also mechanical ones. Diagnostic flowchart depicts the logical and step by step method of eliminating suspected culprits down to a place where the real culprit is found. Figure 1 shows a diagnostic flowchart for fault diagnosis of a computer CPU, RAM and Motherboard [15]

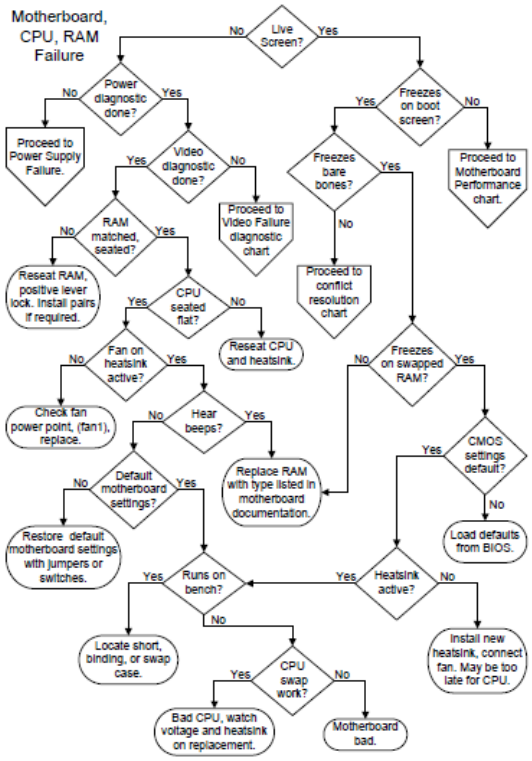


Figure 1: Fault Diagnostic Flowchart for CPU, RAM and Motherboard

Another excellent method of teaching fault diagnosis and repairs is the use of expert systems. An expert system or knowledge-based system is a computer program that is designed to mimic the decision-making ability of human experts in a particular domain of expertise [16]. Expert systems are mainly used in problem solving areas and contain the problem solving knowledge of human experts in those areas. Expert systems were developed in medical, automobile and computer diagnosis fields among others [17]. The expert system developed in the area of computer fault diagnosis and repairs (troubleshooting) are very efficient and effective in developing students' fault diagnosis and repair skills [18].

Authors in [18] developed an expert system for PC desktop troubleshooting. The expert system contain user interface, knowledge base, explanation system, knowledge based editor, inference engine and case specific data. The expert system specialized in the diagnosis of seven hardware problems in desktop PC: power supply failure, processor CPU error, RAM problems, Error VGA, hard disk failure, blue screen memory dump, and CMOS battery for motherboard. CLIPS knowledge based system language was used for designing and implementing the proposed expert system. The PC desktop troubleshooting expert system was evaluated by IT students and they were satisfied with its performance.[19] developed a self learning expert system which provides troubleshooting information about problems occurring in the computer system for information and communication technology technicians and computer users to solve problems effectively and efficiently. Domain knowledge was acquired using semi-structured interview technique, observation and document analysis. The conceptual model of the expert system was designed by using a decision tree structure which is easy to understand and interpret the causes involved in computer troubleshooting. Based on the conceptual model, the expert system was developed by using 'if – then' rules .The developed system used backward chaining to infer the rules and provide appropriate recommendations. According to the system evaluators, 83.6% of the users were satisfied with the prototype.[. Author in 20] designed and developed an expert system for fault diagnosis and troubleshooting of computer that assists personal owners in dealing with their computer problems especially when the time is limited and human expert is not available. The data for the expert was extracted from human expert and stored in the knowledge-base of the expert system shell. The expert system contained seven module; CD/DVD problems, system's boot failure, monitor/screen problems, power problems, sound problems, printer problems and other miscellaneous faults. The system's graphical user interface, the expert system shell and the database of the model were developed by integrating Netbeans, java language, MySQL database tool and the dynamic library (DLL) file. The methods used in the above studies guided the present study.

3. METHODOLOGY

The design model adopted for the project is the object-oriented analysis and design (OOAD) with Unified Modeling Language (UML) explaining the behaviour of the tutor. Figure 2 shows the use case for the system.

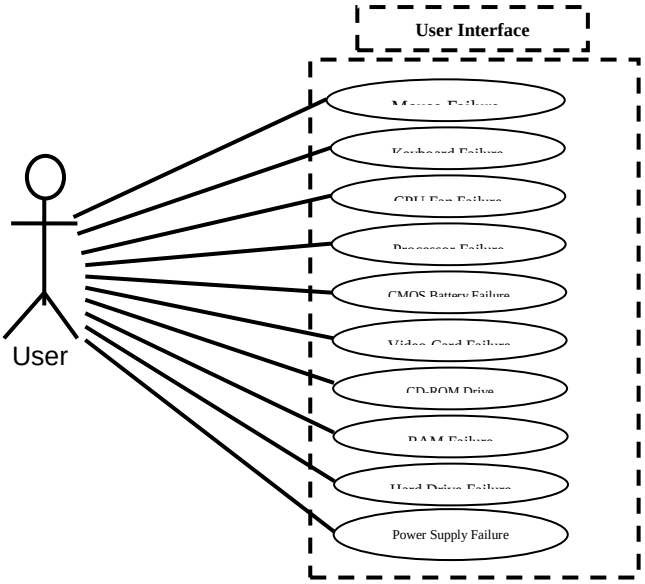
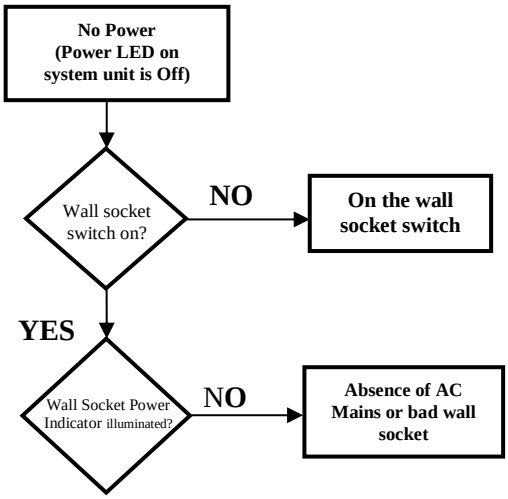
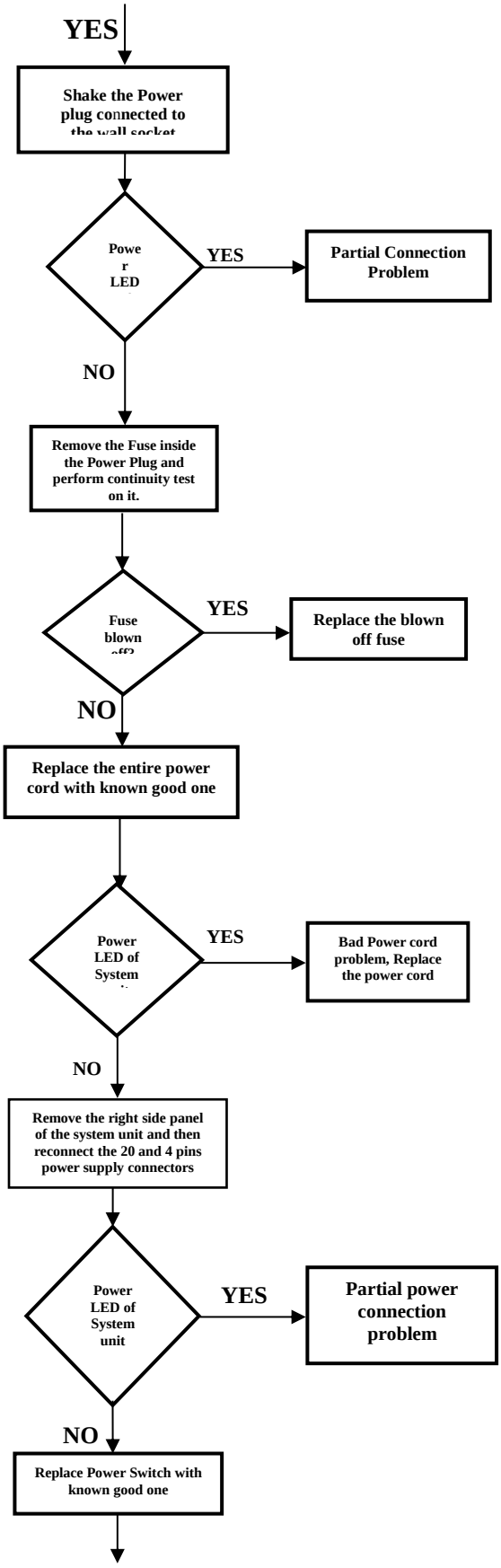


Figure 2 : Use case for the System

Figure 3 on the other hand shows an activity diagram for fault diagnosis and repairs concerning one of the ten problems in the tutoring system; power supply failure problem.





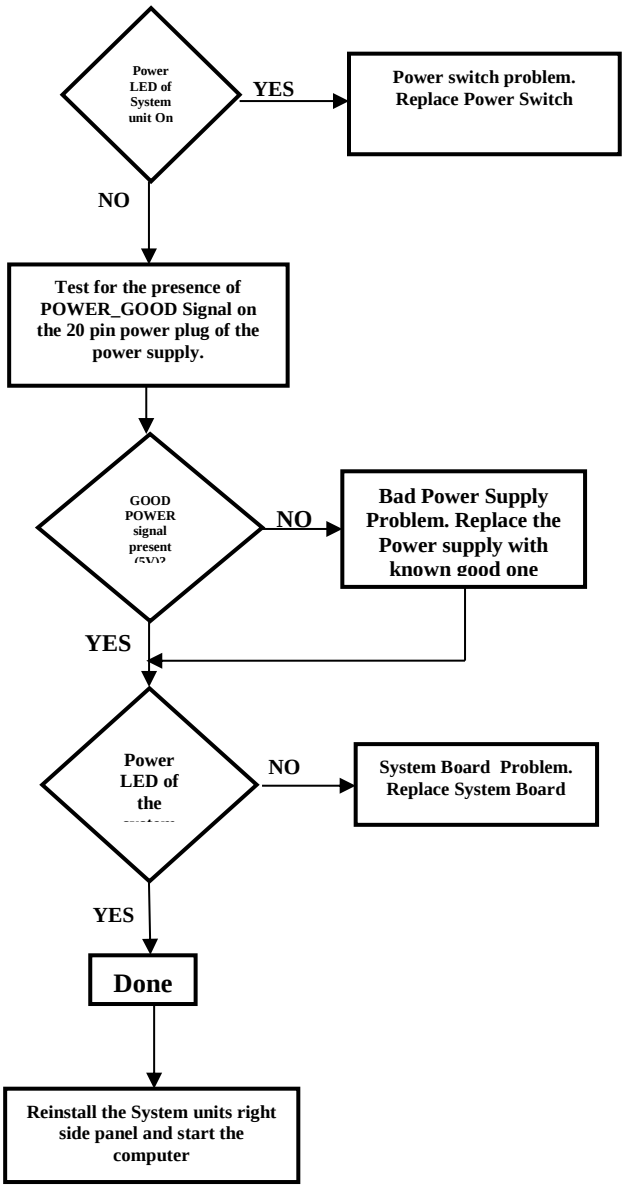


Figure 3: Activity diagram for fault diagnosis and repairs of power supply failure problem

The tutor consists of four components, namely instructional environment, functional expert module, procedural expert module and instructional expert module as shown in figure 4.

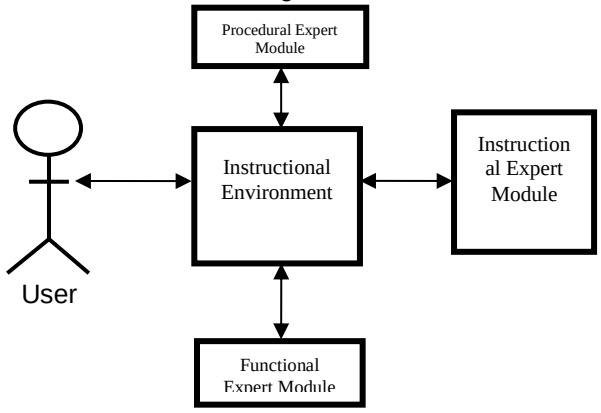


Figure 4: Tutor's Architecture

Instructional environment consist of all the photographs of computer hardware parts, hand tools, test instruments, prompts, buttons explanations, observations, deductions feedbacks guidance to be presented during problem solving sessions. The procedural expert module associates a given fault symptom to a particular suspected hardware component or part using some of the if-then statements (rules) extracted from human experts and online resources during knowledge acquisition phase. The procedural expert also provides approach and complete sequential steps for the solution of a problem .The functional expert module is concerned with the connectivity among the system components. It is responsible for giving advise such as "if the LED light on the front panel of a desktop computer is on, then, the power cord is good and therefore, no need of checking the power cord". Instructional expert module is responsible for sequencing instruction and selecting appropriate teaching methods and techniques for a particular problem. It detects trainee's errors during fault diagnosis and repairs and provides feedback immediately. In addition, it provides guidance to trainee (student).

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4.2.1 Main Menu Design of the Fault Diagnosis and Repairs Tutoring System

The main menu consists of ten items. The items are as follows: mouse failure, keyboard failure, CPU fan failure, processor failure, CMOS battery failure, Video card failure, CD-ROM drive failure, RAM failure, hard disc drive failure and power supply failure, Each of these ten items is clickable so that when an item is selected or clicked, the system will display series of interfaces with photographs of desktop computer parts, prompts, buttons, feedback and guidance until the trainee (student) solved the problem. Figure 5 shows the tutor's main menu.

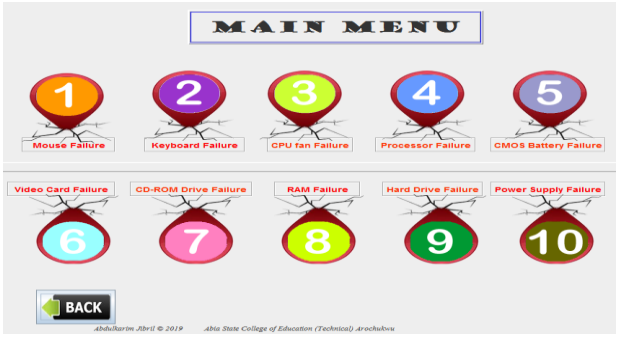

Figure 5: Tutor's Main Menu

5 IMPLEMENTATION

The desktop computer fault diagnosis and repairs tutor was implemented using java programming language under java netbeans platform. In specific, java netbeans was used in the development of all the user interfaces. Java netbeans is efficient, effective and reduces time used in designing user interface [20].

User interaction with the Tutor

Figure 6 shows the user login page developed under java netbeans platform.

Figure 6: Login Page for the Tutor

The user simply types the words "asceta and nce" into registration number and password text fields. On typing "asceta and nce" into the text fields, the tutor displays a frame with tutorial and examination buttons. On clicking the tutorial button, the tutor displays the main menu shown in figure 5. Each of the sub-menu on the main menu page contain one problem and at the same time clickable so that when a student clicked on it, it display series of sequential frames with buttons, prompts, photographs, observations, deductions, corrections, feedback and guidance until trainee solve the problem in that sub-menu. Figure 7 show a snapshot of a training environment where the tutor is correcting trainee's mistake during plugging of red test lead (red probe) in preparation to the testing of a suspected fuse in the power plug.

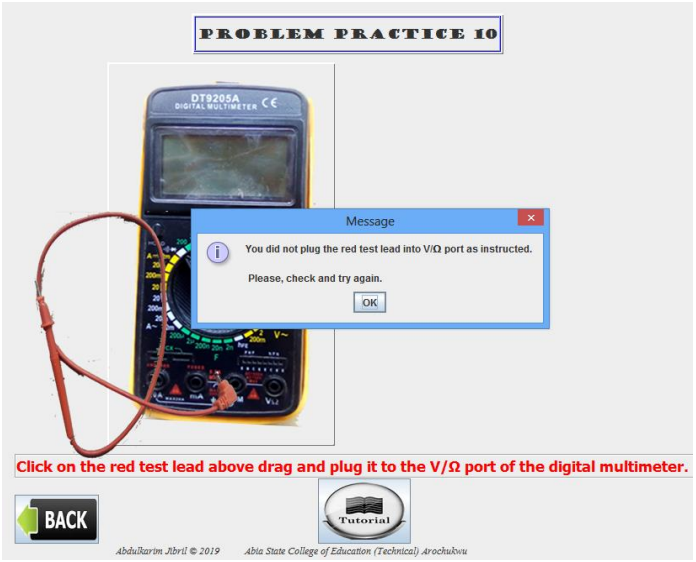

Figure 7: Tutor correcting trainee's (student) mistake in instructional environment

6TESTING AND EVALUATION

The developed tutor was deployed to Abia State College of Education (Techical) Arochukwu for testing. Students from school of technical education and department of computer science interacted with the tutor. Thereafter, a questionnaire tagged "User's Satisfaction with the Tutor's Performance (USTP) was administered to the students for evaluation. Table 1 shows the means and standard deviations of students' responses on their satisfaction with the performance of the Tutor.

Table 1: Mean and Standard Deviation of Students' responses on their Satisfactions with the Performance of the Tutor N= 21

S/N	Item	$\overline{X}$	SD	Remark
1	The tutor is organized in systematic order	4.33	1.18	Agree
2	The tutor's instructional environments are attractive	4.14	0.65	Agree
3	The tutor's buttons respond to mouse click quickly	4.57		Agree
4	Dragable objects are responding to mouse click and drag quickly	4.33	0.97	Agree
5	The pictures of the desktop computer and its parts are clear for identification and training	4.33	0.58	Agree
6	The feedback and guidance massages provided by the tutor are self- explanatory	3.90	1.14	Agree
7	The feedback massages provided by the tutor help me to complete various tasks	4.38	0.67	Agree
8	I felt comfortable when using the tutor	4.81	0.92	Agree
9	I enjoy learning with the tutor	4.62	1.16	Agree
10	It is easy to navigate to different parts of the software	4.62	0.50	Agree
11	When performing fault diagnosis using the tutor , I feel as if I am performing fault diagnosis and repairs using real desktop computer	4.14	1.08	Agree
12	I feel that I have learned something about hardware fault diagnosis of a desktop computer	4.38	0.92	Agree
13	I feel that I have learned something about repairs of a desktop computer	4.67	1.55	Agree
14	The tutor I used can be used in teaching desktop computer fault diagnosis and repairs in Abia State College of Education (Technical) Arochukwu	4.76	0.91	Agree
	Grand Mean	4.42		Agree

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

Table 1 shows that all the items in the table had mean response values of greater than the cutoff point of 3.50 on five point Likert scale. Furthermore, the grand mean response value of 4.42 is also greater than the cutoff point of 3.50. These results collectively indicate that students are satisfied with the performance of the developed tutor. The mean response value of 4.42 for item 14 in table 1 indicates that students recommended the use of the developed tutor in teaching desktop computer hardware fault diagnosis and repairs in Abia State College of education (Technical) Arochukwu. Tale 1 also shows the small values of standard deviation within the range of 0.50 to 1.18. The small values of these standard deviation indicate the closeness of students responses with regard to their satisfaction with the performance of the developed tutor.

7 CONCLUSION AND RECOMMENDATION

The paper presented the development and evaluation of desktop computer hardware fault diagnosis and repairs tutor. In specific term, the paper presented the tutors architecture, main menu and sub-menus. A brief description of the development of the tutor using java netbeans and how users interact with the tutor were also presented. Students' views on their satisfaction with the performance of the developed tutor were collected and analyzed. The result of the analysis shown in table 1 revealed that students were satisfied with the tutor's performance and recommended the use of the developed tutor in teaching desktop computer hardware fault diagnosis and repairs. Based on the impressive performance of the tutor, the author also recommended that the developed desktop computer hardware fault diagnosis and repairs tutor should be used in teaching computer hardware maintenance and repairs course not only in Abia State College of Education (Technical) Arochukwu, but also in other institutions that offer computer hardware maintenance and repairs course.

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