DEVELOPMENT OF A COMPUTER-BASED INSTRUCTIONAL ENVIRONMENT FOR TROUBLESHOOTING AND REPAIRS OF ELECTRONIC IGNITION SYSTEM OF A FOUR-CYLINDER CAR ENGINE

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Abstract

This paper presents the procedure for the development and evaluation of a computer-based instructional environment for troubleshooting and repairs of the electronic ignition system of a four-cylinder car engine. The development effort began with the conduction of literature review using both print and online resources. This followed by physical examination of electronic ignition system of a variety of four cylinder car engines as well as consulting experts concerning the procedures for troubleshooting of electronic ignition systems. Two computer-based instructional environments developed for troubleshooting of tactical telephone switchboard and aircraft power distribution system were reviewed to get an insight on how the new computer-based instructional environment will be developed. The knowledge and experiences gathered were then used to develop the computer-based instructional environment for troubleshooting and repairs of electronic ignition system. The developed instructional environment has four main modules, namely, theory, practical examination and database. The theory module contains principles of operation of electronic ignition system. The practical module on the other hand provides instructional environment where student will learn how to troubleshoot and repair various problems concerning electronic ignition system through problem solving strategy. The examination module is a multiple choice test which test students' understanding of various parts of electronic ignition system as well as its principles of operation The database stores users' login details and students results. 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 instructional environment was implemented using java programming language and developed in java netbeans integrated development environment (8.2). MySQL database was incorporated into the developed system for storage of various data, such as users' login details and results. The database and its tables were created using MYSQL workbench (8.0).The developed system was tested by students and they expressed their satisfaction with the performance of the developed training system. The students recommended the used of the developed computer-based instructional environment for teaching the troubleshooting and repairs of electronic ignition system in the College.

Keywords: Computer-based Instructional Environment, Ignition system, Troubleshooting and Repairing, Electronic Ignition System, Four-Cylinder Car Engine , Abia State College of Education (Technical) Arochukwu

1.0 Introduction

A motor car is a device and system that moves from one place to another using either electrical or chemical energy as input energy. The purpose of motor car is to convey passengers and/or goods from one place to another .A motor car as a system consists of many sub-systems which includes transmission, starting, steering, braking, charging, lighting, fuel, cooling, suspension and ignition among others (Singh,2007). These sub-systems and more work together to produce the desired functions of a car. For a car having four cycle engine to start and run for example, the car key switch has to be turn to start position. The battery then supply electric current to the starter motor which then turns the car's engine and cause the movement of the pistons. At the same time, the battery also supplies current to the primary windings of the ignition coil. The making and breaking of the contact breaker generates electric pulses that induce high voltage across the secondary windings of the ignition coil. The high voltage in the secondary winding is led to the distributor which then distributes currents to each of the four spark plugs in correct firing order.

At the fuel sub-system, the fuel in the tank is push by the fuel pump to the carburettor which then atomizes, vapourizes and mix it with air in proper proportion to form a combustible mixture at all speeds. The charge mixture is then drawn through the open intake valve into the cylinder chamber. Then as the piston nears the top of its compression stroke, the distributor signal the spark plug to fire. The firing (electric spark) of the spark plug lead to the ignition of the compressed mixture making combustion to take place that in turn drive the piston down(power stroke). Momentum then drives the piston upward expelling the exhaust gasses through the open exhaust valve to the exhaust pipe (exhaust stroke). These four strokes; air-fuel intake, compression, power and exhaust form the basis of operation of internal combustion engine. The four struck cycle continues as long as the engine is ON and there is fuel in the car.

The linear motion of the pistons in the four cylinders as result of repeated four stroke cycle are then transmitted to the crankshaft via connecting rods, resulting to a rotary crankshaft movement. The rotary movement of the crankshaft is then transmitted to the wheels of the car through the transmission, drive shaft, differential and axle (Giri, 2007).

Ignition sub-system consisting of ignition coil, distributor and plugs as a part of car's system therefore, plays a vital role in cars' starting and running. An ignition sub-system in its simplest form consists of a battery, ignition switch (ignition key), ignition coil, distributor, spark plug and cables. The purpose of an ignition sub-system is to provide a spark of sufficient heat intensity to ignite the charge mixture of air and petrol at predetermined position in the engine cycle under all speed and load conditions (Heisler, 2001). Each of the components that make up of ignition system can fail at any time due to its continuous usage, operating conditions or ageing among others. A failure in one or more components of the ignition system can result non starting or malfunction of a motor car. Restoring to the normal operating condition of a motor car requires troubleshooting and repairs.

Troubleshooting in simple terms is the process of locating fault. However, some authors broaden this definition to include repair in addition to locating the fault. In this context, troubleshooting is the process that involves taking logical, systematic approach to identify the source or cause of the problem in a system and then apply a solution so that the system will work normal again. The use of logical and systematic approach to troubleshooting lead to solving problem in cheaper way and shorter time as compared with haphazard approach that is often costly in terms of wasted time and unnecessary parts replacement. Morrison, Wells and Ruffolo (2012) identified four steps involved in troubleshooting. The four steps are 1) defining the problem, 2) identifying possible causes, 3) determining the most likely cause 4) and applying solution. Successful troubleshooting endeavour involves the knowledge of principles of operation of a system at both normal and abnormal states. It also involves knowledge of selection of test instruments and repair tools along side with the skills of using them.

The curriculum of technical education as well as some engineering technology disciplines contains courses that expose students to the troubleshooting and repairs of various devices (equipment) and systems. The traditional method of teaching troubleshooting of equipment is using the real equipment during teaching and learning. However, teaching troubleshooting of equipment using real equipment alone is time consuming which usually leads to non completion of troubleshooting courses with a semester. To solve the above problem, the teaching of troubleshooting of equipment often supplemented with computer-based instruction. A computer-based instruction for troubleshooting equipment is a computer simulation instructional package that teaches student how to diagnose and rectify fault in malfunctioning equipment using computer. Computer –based instructional instruction for troubleshooting equipment has a number of advantages over the traditional ones. Computer-based instructional environment is cheaper than real instruction as it does not requires the use of real equipment. With computer-based instructional package students can learn troubleshooting at anytime, anywhere and with little help from teacher. Furthermore, computer-based instruction with simulation enable students to develop critical and strategic thinking skills (Taher & Khan,2015). It is based on these benefits and more that the authors set out to develop a computer-based instruction for teaching the troubleshooting and repairing ignition system of a Four-Cylinder Car Engine.

2.0 Problem Statement

In school of technical education, all NCE II (Nigeria Certificate in Education II) students offer a course titled 'Auto-electrical Systems, Repairs and Computer'. The course is designed to provide students with knowledge and skills that will in turn enable them to troubleshoot and repair the electrical sub-systems of various cars. Lecturer and students are to complete the course within one semester. It is clear that one semester is not enough for the lecturer and students to complete the course as the course touches various electrical sub-systems of automobile (car) and has practical component as well. The insufficient time allocated for the course may be one of the factors responsible for poor performance of the students in the course and by extension students' inability to establish auto-electrical repair workshop after graduation. Presently, the course is still taught under one semester and there is no sign of increasing the time allotted for the course.

One solution to the above instructional problem may to provide students with self instructional system that will supplements lecturers' teaching effort so that the lecturer can complete the course effectively within one semester. To achieve this objective, the researchers set out to develop a computer-based instructional environment for troubleshooting and repairing electronic ignition sub-system of a car engine. The computer based instructional environment will enable students to acquire knowledge and skills in troubleshooting and repairing car ignition sub-system at anytime, at their own pace and anywhere. Such computer-based training system in car ignition sub-system along side with computer based training systems in other car's sub-systems(e.g charging sub-system, lighting sub-system) would likely supplements lecturers teaching effort, thereby enabling them to complete the course effectively within one semester.

3.0 Objectives of the Study

The objectives of the study are as follows:

1. Determine the software requirements for teaching troubleshooting and repairing of electronic ignition sub-system of car engine
2. Design the software for teaching troubleshooting and repairing of electronic ignition sub-system of car engine
3. Develop the software for teaching troubleshooting and repairing of electronic ignition sub-system of car engine
4. Test the developed software
5. Determine user's satisfaction with the performance of the software.

4.0 Literature Review

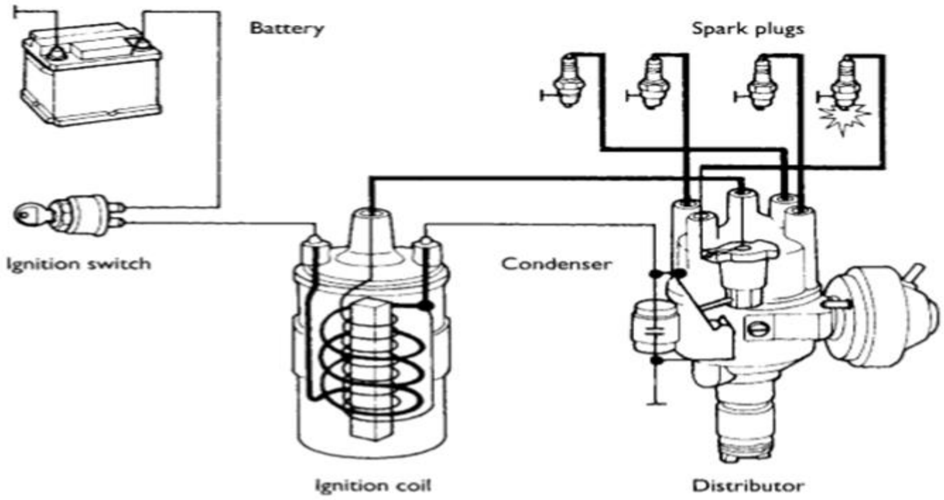
The literature review was conducted under the following headings; principles of operation of ignition sub-system, troubleshooting and repairs of electronic ignition sub-system. The review ends with the presentation of computer-based tutors developed for teaching troubleshooting and repairs of tactical telephone switchboard and the aircraft power distribution system respectively. The reviews guide the researchers in the design and development of the present system.

Ignition Sub-system

The ignition sub-system consist of various components working together to provide a spark inside the cylinder near the end of the compression stroke. The heat of the spark then ignites the compressed air-petrol vapour. Ignition sub-system falls into two categories; the conventional (point-type) and electronic type.

Conventional Ignition Sub-system

Figure 1 depicts a simple circuit diagram of a conventional ignition sub-system.



Source: Denton (2004)

Figure 1: Conventional Ignition Sub-system of a four-cylinder Engine

The circuit of a conventional ignition (also known as mechanical or non-electronic ignition) sub-system is divided into two circuits; the low and high voltage. The low voltage circuit (sometimes called the primary circuit) consists of battery, ignition switch, primary winding of the ignition coil, ignition resistor (ballast resistor), condenser (capacitor), contact breaker (breaker points or contact points) , low voltage connecting wires and the earth return respectively. The high voltage circuit (also known as secondary circuit) on the other hand contains secondary windings of the ignition coil, distributor rotor arm, central electrode, plug cable electrodes, spark plugs, high voltage cables and the earth return. Although in some designs, both contact breaker and condenser are located in distributor, it does not mean that they are part of it. In fact, there is no electrical contact between the contact breaker and condenser with distributor. However, in some designs the condenser and the resistor are place outside the distributor. Furthermore, in practice the distributor housing, the contact breaker, condenser and the distributor its self are all referred as distributor. Distributor, as the name implies distributes current to each plug in multi-cylinder engines. The operation of the mechanical ignition sub-system is usually explained via low and high circuits.

High Voltage Circuit

When the ignition switch is turn to 'ON' position (RUN position), the contact breaker close and current from the battery flows in the low voltage circuit through the primary windings of the ignition coil and contact breaker and back to ground. The flow of the current in the primary windings of the ignition coil cause magnetic field to build up around the coil. When the contact breaker open, the current in the primary windings of the ignition coil cease and this leads to the collapsing of the magnetic field. The change in the magnetic field (magnetic flux) induces an emf (electromotive force) at the secondary windings of the ignition coil. The induced emf (voltage) is of high value. The value of the voltage ranges from 25-30kV.

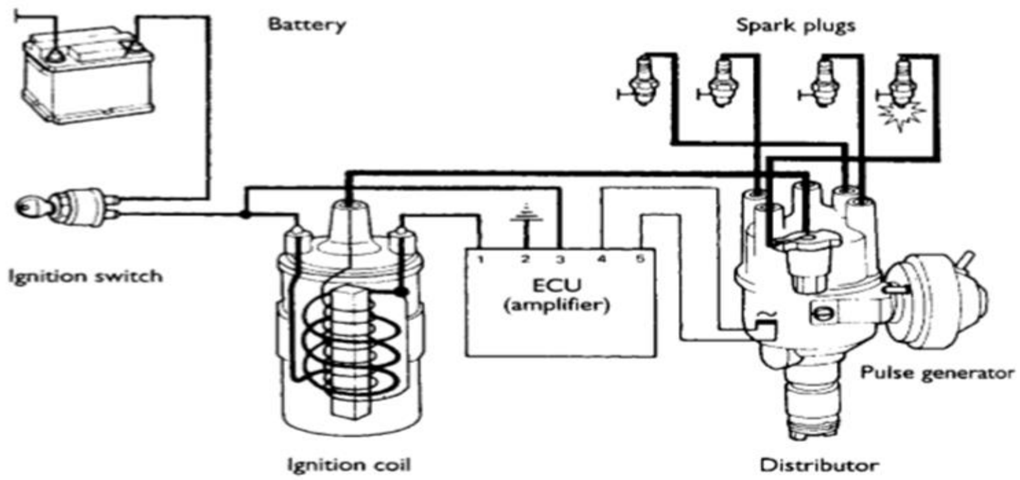
High Voltage Circuit

The high voltage (of about 25kV) across the secondary windings of ignition coil in form of pulses passes through distributor high voltage cable to a rotor (a revolving contact) located at the center of the distributor . As the rotor revolves, the high voltage is distributes or connects each spark plug. When the high voltage (High Tension,(HT)) appears across the small air gap of the spark plug, the air gap 'breaks down' (dielectric breakdown) and a spark 'jumps' across the gap. The heat of the spark ignites the air-petrol mixture in the combustion chamber of an engine cylinder. As the burning gasses expand, they drive a piston (inside cylinder) downward and this action provides the power that propels the car (Doyle, 1983). The value of the high voltage (breakdown voltage) that cause spark depends on a number of factors which include the plug gap, polarity and the condition of the plug electrodes, condition of plug insulation, moisture on the distribution cap and spark plug and pressure, temperature and the type of the combustion chamber (Singh,2007).

Electronic Ignition Sub-System

As stated earlier, the closing and opening of the contact breaker in the primary circuit of the conventional ignition sub-system result to building and collapsing of the magnetic field around the primary windings of the ignition coil. Indeed, the building and collapsing of the magnetic field induces high emf in the secondary winding of the ignition coil. Conventional ignition sub-systems are therefore called conventional mechanical contact breaker point type ignition systems. Although conventional mechanical ignition system are simple and common, but they have some drawbacks and limitations. Firstly, the contact breaker points have to operate with a heavy current which causes them to get pitted, burnt or worn out, thus necessitating their servicing and resetting at smaller periods. Secondly, because the contact breaker is only a mechanical device, it cannot operate precisely at higher speeds because of inertia. Moreover, at higher speeds, the dwell period is not sufficient for building up the magnetic field to its full value. Furthermore, it is found that the satisfactory performance of ordinary contact breakers has been limited to about 400 sparks per second, which corresponds to an engine speed of 800 r.p.m (in case of 6-cylinder engine). Thus, it is seen that for modern high speed car engine the conventional ignition system cannot work satisfactorily (Singh, 2007). To solve these identified problems, electronic ignition systems were introduced and have since replaced conventional mechanical ignition systems. The major difference between conventional mechanical ignition and its electronic counterpart is that while the former use contact breaker to make and break primary circuit which result to electric pulses, electronic one use solid state device (e.g transistor) to achieve the same objective. Hence, the name *solid state ignition* or simply *electronic ignition*.

It should be noted that the objective of both conventional and electronic ignition systems are the same. But the way and the manner in which the two systems accomplished the objective of igniting the mixture of air and petrol differs. Then this implies that there exist differences in components that both used in operation. However, despite such differences both have components that are similar. For example, both two systems have similar components such as battery, ignition coil, ignition switch, resistor and high voltage cables. At the same time some of the components found in electronic ignition system were modification of those in conventional ignition system. Figure 2 shows the diagram of an electronic ignition system with ECU (Electronic Control Unit) containing transistors.



Source: Denton (2004)

Figure 2: Electronic Ignition System

Troubleshooting of Electronic Ignition Sub-system

Engine troubles associated with ignition system manifested in a variety of ways. Irregular firing or stoppage of firing is typical examples of faults associated with ignition system. A steady engine miss confined to one or two cylinders is another fault associated with ignition system. The fact that other plugs fires well in the remaining cylinders implies faulty plugs(s). A faulty plug can be checked by the use of plug scope or by substituting suspected faulty one with known good one. A faulty spark plug found can be replaced with a new one or cleaned and/or re-gapped and finally installed if it is not badly damaged. A faulty spark plugs high voltage cable can be a culprit as regard to having engine miss confined to one or two cylinder. Replacement of a suspected spark plug's high voltage cable with known good one will reveal whether the fault is from the cable or not.

Engine dead problem can also associated with ignition system and can be troubleshoot as follows ;(1) remove the lead from one of the spark plugs to check for presence of a spark to the engine block when the engine is cranked. If a spark occurs, the ignition system is not at fault. The problem may be from the absence of petrol in the fuel tank, faulty carburettor or fuel pump. If however, there is absence of spark, then the problem is within the ignition system. (2) Check the primary and secondary windings of the ignition coil. The primary windings of the ignition coil can be checked for an open condition by connecting an ohmmeter across the two primary terminals. An infinite reading indicates an open. The secondary windings of the coil can be checked for an open by connecting an ohmmeter from the high-voltage centre tower to either of the primary terminals. An infinite reading indicates an open. (3) Check the distributor pick up coil. The distributor pick up coil can be checked by separating the wiring harness connector and the connecting an ohmmeter across the coil. The resistance of the coil should be from 5550 to 650 ohms. If the reading is infinite, the coil is open, but if the reading is low, the coil is shorted. The pickup coil may be checked for grounds by connecting the ohmmeter from either coil lead to the distributor housing. The reading should be infinite. If it is not, the coil is grounded. (4) check ignition-pulse amplifier. This can easily be done by substituting the ignition-pulse amplifier with known good one. If the engine works, it implies that the problem is from the ignition-pulse amplifier. If the problem is not from the ignition-pulse, (5) check the electronic control module. This of course, can be done by swapping it with a known good one. If the problem is solve, you can then attribute the problem to electronic control module. It should be noted that the above troubleshooting steps were carried out with assumption that fuel pump, carburettor, switch key and low voltage wires are all in normal working condition while the battery is in good enough condition to crank the engine over at its normal rate.

Methods of Teaching Troubleshooting of Electro-Mechanical Devices

Electro-mechanical devices are those devices that consist of both electrical and mechanical parts. Electro-mechanical devices include electric generators, electric motors and automobiles (cars) among others. There are two main approaches to teaching the troubleshooting of electro-mechanical devices; face-to- face approach and computer-based training.

1. *Face-to-Face Equipment Maintaining Training Approach*

Face to face equipment maintenance training approach training (real training) is accomplished via three phases; theory, practice and evaluation. In theory phase, the teacher introduce the device to students and then identify its major parts and functions. Thereafter, the teacher explains the working principle of the device, fault symptoms, causes and remedies. The theoretical phase is followed with practical phase where the teacher insert a fault in the training equipment (in the absence of students) and then show the students the step by step technique of finding the fault using instructional materials such as hand tools, test equipment and troubleshooting flowcharts. The teacher then test students and make corrections until the students are able to troubleshoot all the possible faults associated with the equipment under training.

Although face-to-face equipment maintenance training approach has a number of advantages such as using sense of sight, smell, hearing and touch as well as the use of real test equipment (eg. multimeter) to find fault, it has a number of disadvantages. Such disadvantages include instructors and trainees spend quite considerable amount of time in assembling and disassembling equipment that should be spent experiencing variety of faults (Welchel, Purcell, Freedy & Lucaccini,1980), inadequacy of equipment for training students, access to potential dangerous high voltage and bottlenecks occurred when students waited to be evaluated while others finished training on the available equipment(Bolyld & Clark,1983). To reduce the above training problems, computer-based equipment maintenance training systems were introduced.

2. Computer-based Equipment Maintenance Training Approach

Computer-based equipment maintenance training is a type of equipment maintenance training where a student perform the practice troubleshooting and repairing of simulated equipment via computer. The simulated equipment and teaching elements are referred to as troubleshooting tutor. Some computer-based troubleshooting tutor are developed around four instructional steps. Such steps includes familiarize, acquire skill, practice skill and validates skill.

1. *Familiarize**:*** Acquire knowledge about equipment, its capabilities, and its location by observing a presentation or taking a guided tour. This is a relatively passive process for the student.
2. *Acquire Skill:* Learn techniques and procedures by being tutored. The tutor guides the student through each step of the process, prompting the student to perform the action required for each step. If a student makes a mistake, the tutor provides immediate feedback.
3. ***Practice skill**:* Internalize techniques and procedures by doing the skill with access to help from a tutor. The student performs the actions of the procedure without prompting from the tutor. At any point, the student may ask the tutor for help. If the student makes a mistake, the tutor provides feedback shortly after the incorrect action. The delay before feedback varies from application to application. For example, dangerous or expensive mistakes usually produce immediate feedback, while incorrect but harmless actions may not provide an immediate response.
4. ***Validate skill**:* Test the ability to perform the skill without help from a tutor. The student is on his / her own until either the task is successfully completed, or it is determined that the student cannot complete the task successfully. For example, if the student performs a dangerous or expensive mistake, then the test may be aborted immediately. When the performance test has ended, either with success or failure, the tutor provides an After- Action Review (AAR), interacting with the student to determine what went right, what went wrong and how to improve the performance. If the task was not performed to standard, the AAR includes a prescription for remedial training (Helms, Frank & Field, 1999).

Computer-based Troubleshooting Tutors

A number of computer-based tutors for troubleshooting various types of equipment were developed. This sub-section presents computer-based tutors for teaching troubleshooting of tactical telephone switchboard and aircraft power distribution system. Johnson and Fath (1985) designed and developed a computer-based simulation tutor that supplements technician training for troubleshooting tasks on a tactical telephone switchboard. The tutor simulation enable student to first gather information concerning the symptoms of the switchboard failure. Having this information, the student can proceed to check components in suspect subsystems until the problem is solved. The menu of choices a student has with the simulation are;1) review instructions, 2) program work sheet information, 3) back of switchboard, 4) printed circuit cards, 5) front panels, switches and alarms,6) the program, 7) operational checks, system troubleshooting and 8) part replacements. The pilot evaluation involving 30 experimental users suggested that computer-based simulation can be effectively used to supplement practice with real equipment.

Towne (1997) developed an intelligent tutor for diagnosing faults in an aircraft power distributing system. The following are the steps used in the developmental process: Step 1. Obtain improved views of the dual generator power distribution system. Step 2. Produce a graphical representation of dual generator power distribution system. Step 3. Tag the Objects with their DIG types.Step 4. Make the Graphical views into a fully Operational System model for normal operation.Step 5. Define the exercise faults and extend the indicator rules to incorporate abnormalities.Step 6. Define the modes of operation.Step 7. Define the training curriculum.Step 8. Generate DIAG's symptom knowledge base. The dual-generator AC/DC power distribution is represented by three unit; front panel, replaceable unit and test points as shown in figure 3.

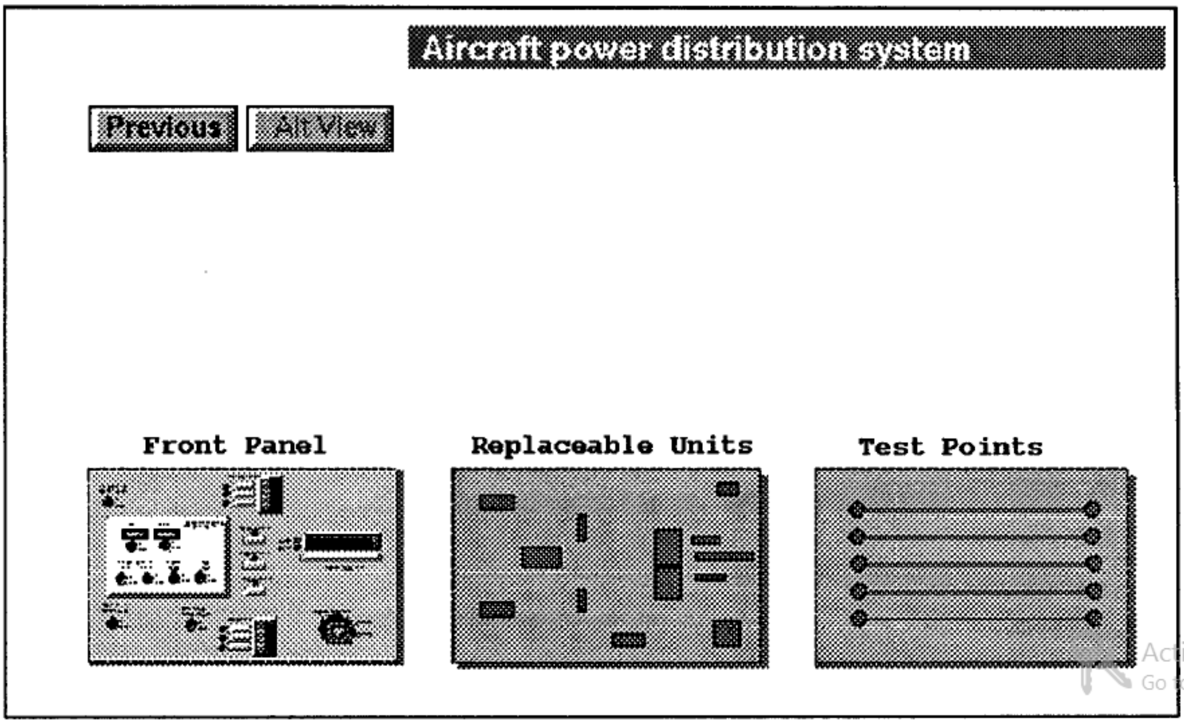


Figure 3: Top level representation of dual-generator AC/DC power distribution

5.0 Methodology

Rational unified process model was used as a guide to the development of the software. Rational unified process according to Virou and Tsiriga 2001) is an object-oriented methodology, which suits better the development of graphical user environment. Using the rational unified process, the software lifecycle is broken into cycles, each cycle working on a new generation of the product. The process divides one development cycle in four consecutive phases; the Inception, the elaboration, the construction and the transition phase.

In inception stage, users are focused on the problem domain, where the systems features are the primary concern, whereas developers are focused on the solution domain. That is meant to be usable in real world situation, it is crucial to describe users requirement in a way that all participants can comprehend. The purpose of the elaboration phase is to analyze the problem domain, establish a sound architectural foundation and produces a first prototype system to serve as a basis for the iterative development of the final product. In this stage, architectural decisions have to be made with an understanding of the whole system. In addition, while the process of the development must always accommodate changes, the elaboration phase activities ensure that the architecture, requirements. During the construction phase, all remaining components and application features are developed and integrated into the product. In addition, the resulting software is thoroughly tested among all aspects. The outcome of the construction phase is a product ready to be used by its end-user (Virou&Tsiriga, 2001).

5.1 Software Requirement Specifications

The authors studied various types of car electronic ignition systems, consulted experts concerning troubleshooting of electronic ignition in addition to study of tutors developed in the domains of computer-base equipment maintenance training and then come up with the following requirements:

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 4.

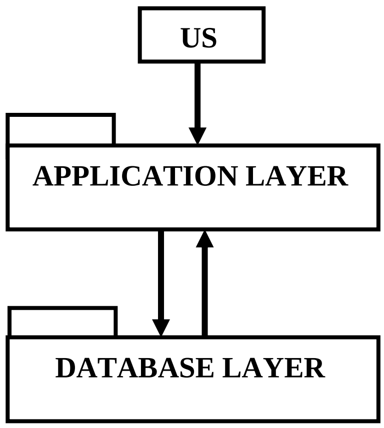


Figure 4: Two Layer Architecture

5.2.2 Use Case

Use case diagram documents the basic functions of the software. Figure 5 shows the use case that documents the basic functions of the system.

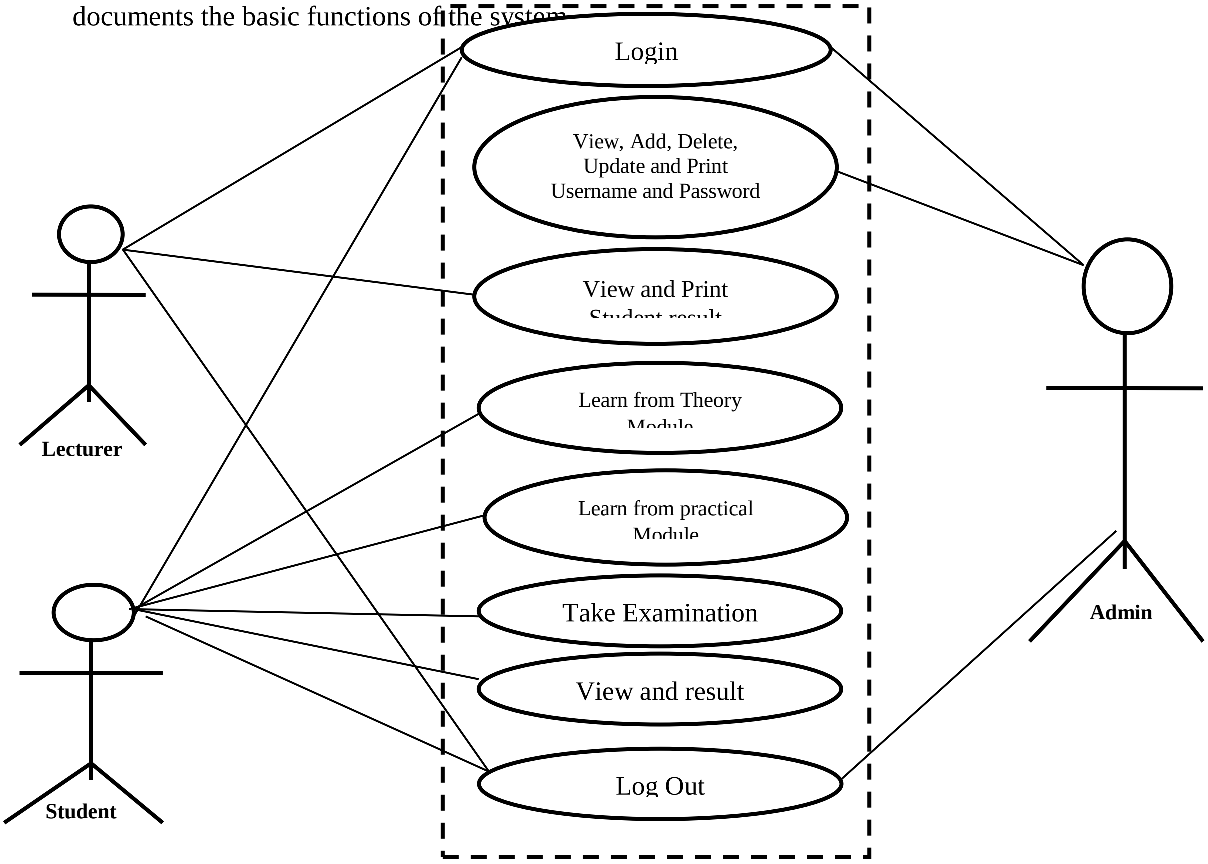


Figure 5: Use case

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 7 shows a snapshot of the general login form while figure 8 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 9.

5.2.5 Theory Module

The theory module contains two main units. The first unit contains component identification and function shown in figure 10. The second unit contains principles of operation of electronic ignition system.

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 11 shows the problem statement frame while that of figure 12 presented a scenario where student is troubleshooting a failure in electronic ignition system.

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. The radio buttons become active as soon as the exams button is clicked. At the same time, the countdown clock starts. The radio buttons become inactive when the clock reaches 0 seconds as shown in figure 13. Immediately after the examination student can view his/her result. The interface that shows student result is shown in figure 14.

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 6), it implies that there must be three tables to store the data to be collected from such forms. Furthermore, since such forms contain two textfields (2) each, it implies that the tables must have columns, namely, username and password. Howevermm S/N column was considered as shown in figure 6. 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 12.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 6.

General loging_table	Admin _table	Lecturer _table	Result _table
S/N	**S/N**	**S/N**	S/N
username	**username**	**username**	Name
password	**password**	**password**	Reg Number
			Department
			Course Code
			Level
			Semester
			Session
			Total Mark

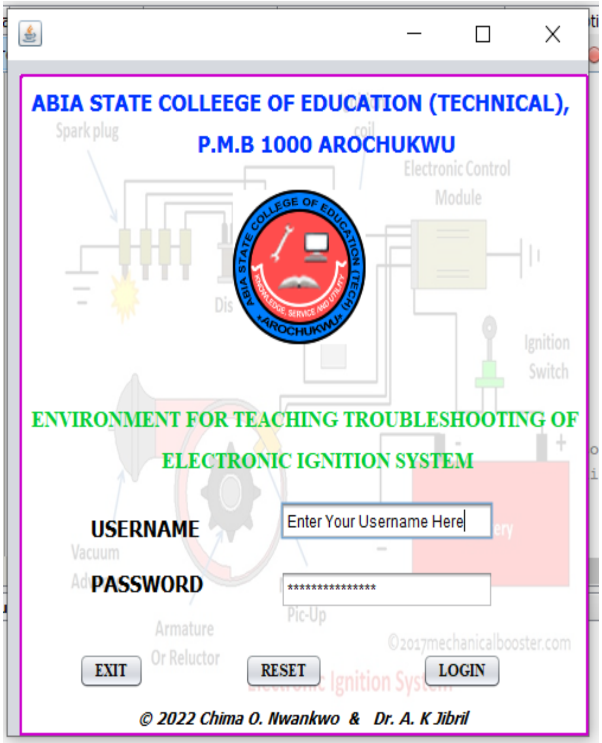
Figure 6: Database Tables

5.3 Implementation

The computer-base instructional environment was implemented using Java programming language under netbeans(8.2) Integrated Development Environment(IDE). The database and its tables were constructed using MYQL Workbench (8.0).

5.3.1 Outputs

The following are a sample of the outputs of the developed system when running.



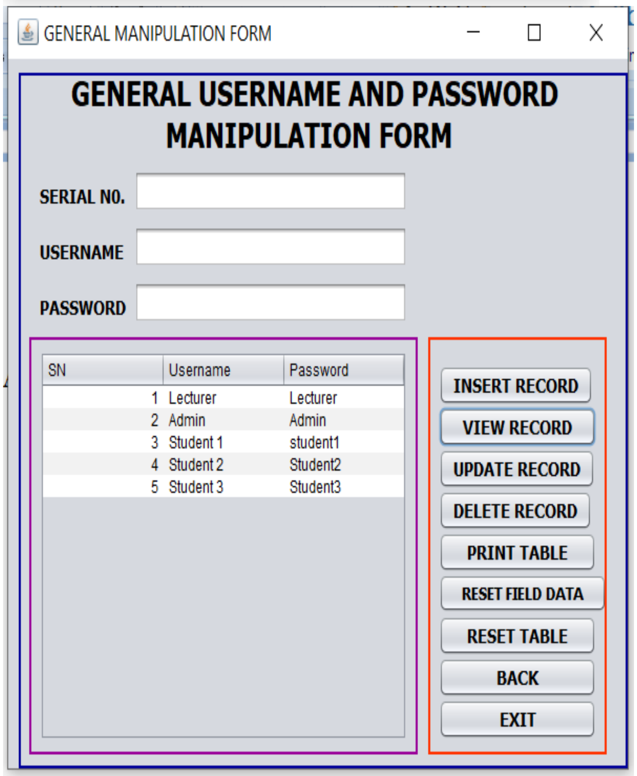
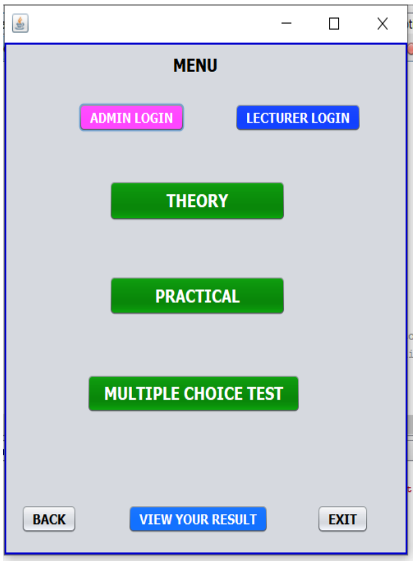


Figure 7: General Login form

Figure 8: A view of user names and passwords stored in database



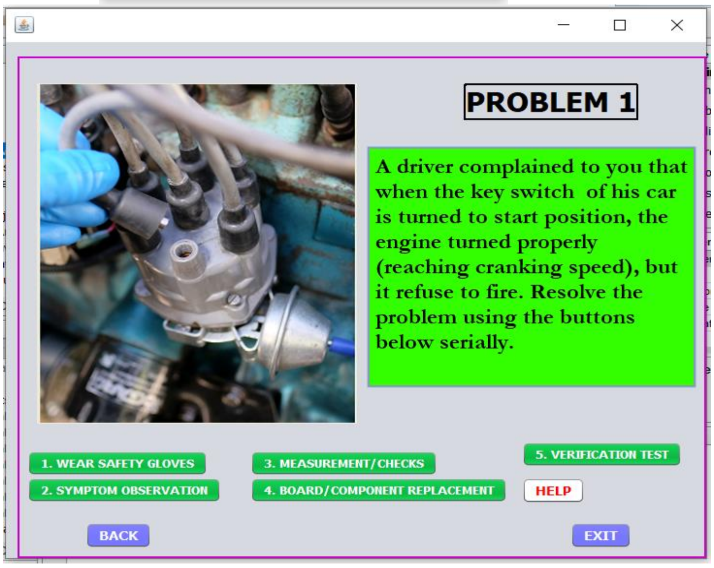


Figure 9: Main menu

Figure 11: A Problem Page

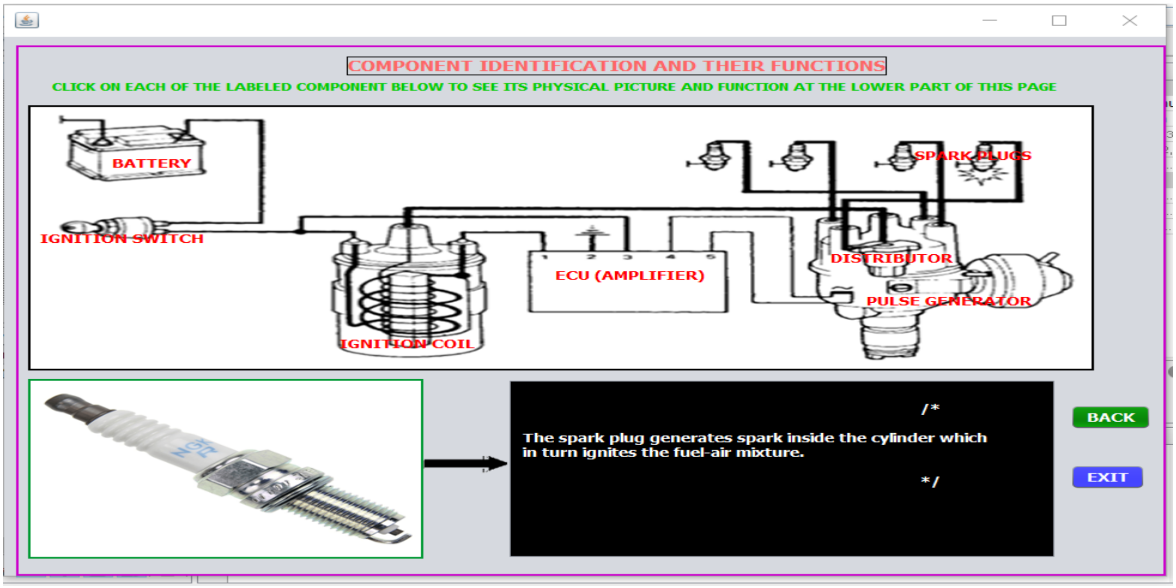


Figure 10: Screenshot of the system showing the picture of a spark plug and its function in the bottom windows when spark plug is selected in the diagram above

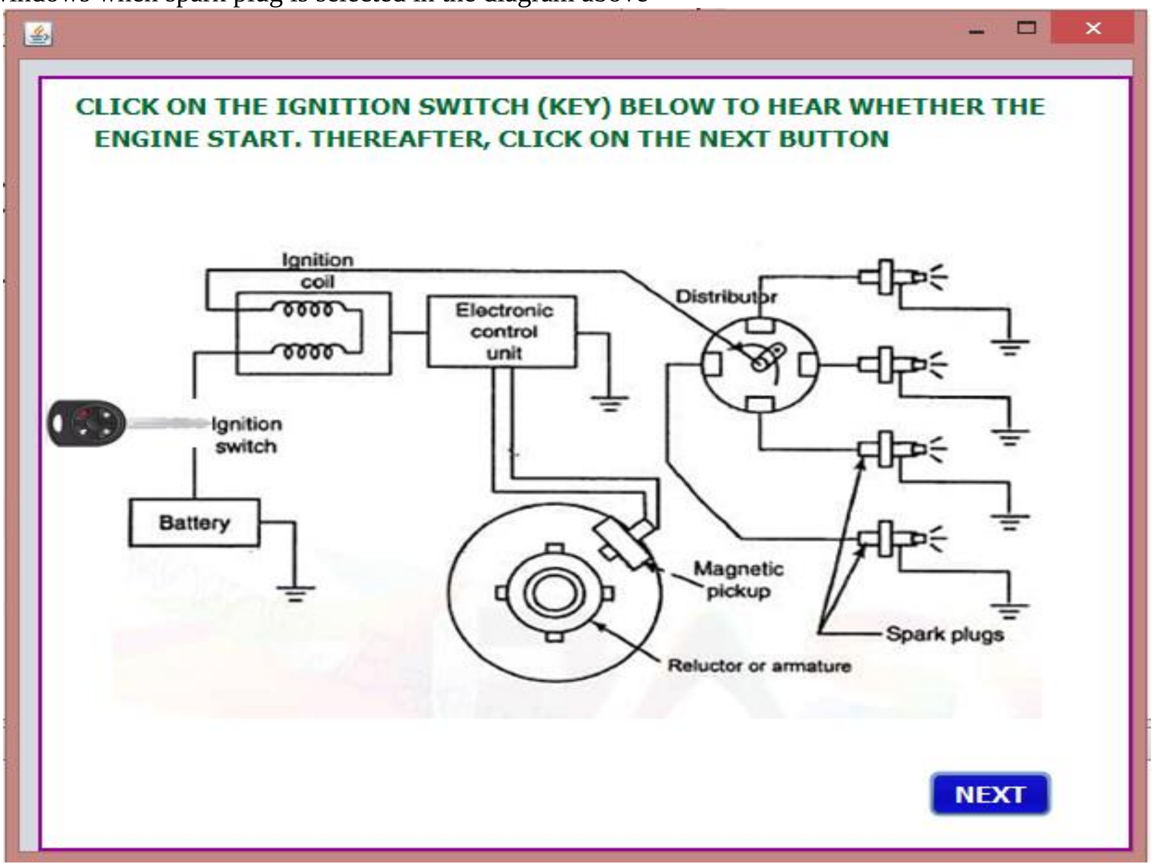


Figure 12: A sample of troubleshooting and repairs environment

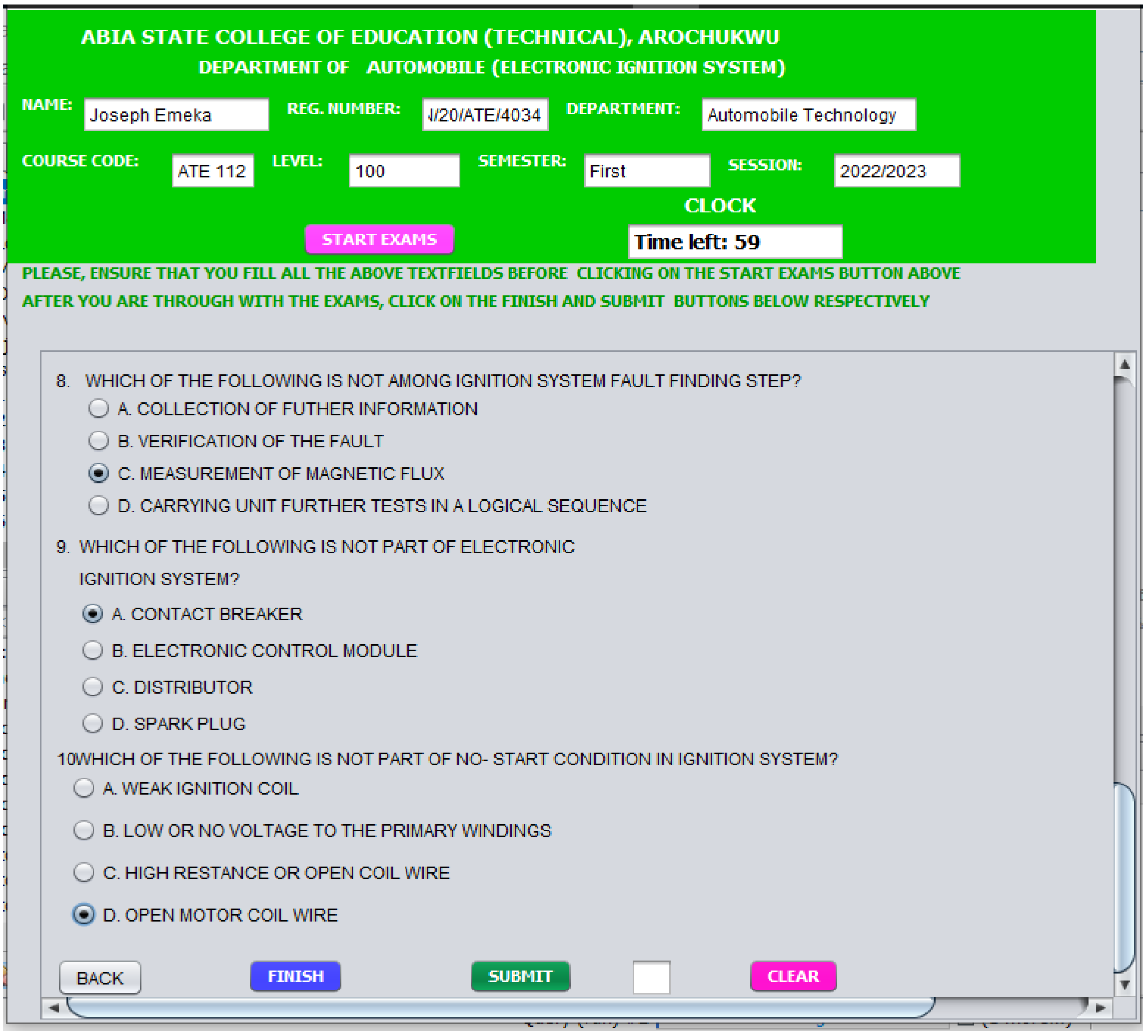


Figure 13: Multiple choice test on electronic ignition system

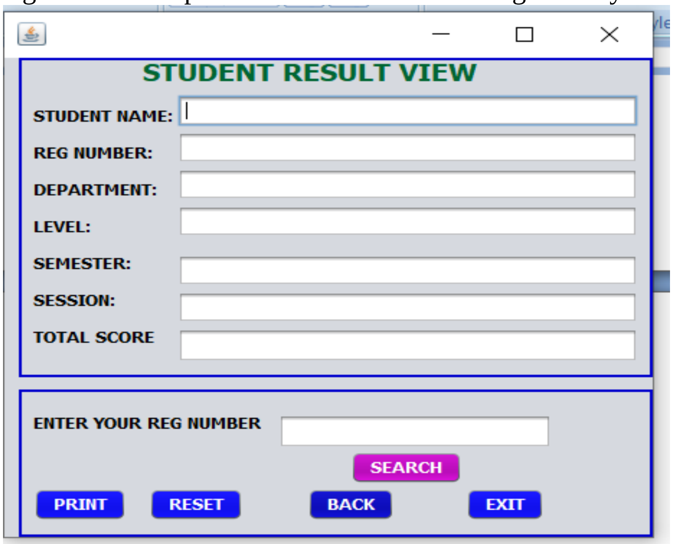


Figure 14: Student Result View

5.3.2 Testing and Evaluation

The system was tested at each step 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 software. Thereafter, the developed software was handed over to the potential users (students) for evaluation. Students interacted with the developed system and then filled copies of questionnaires designed to measure their satisfaction with the developed system. Table 1 shows the means and standard deviations of their responses to the questionnaire.

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

N=10

S/N	Item	$\overline{X}$	SD	Remark
	Functional Software Requirements			
	Admin			
1	The software enable admin to login and logout	3.80	0.41	Agree
2	The software enable admin to add new username and password	3.70	0.48	
3	The software enable admin to update username or password	3.90	0.31	Agree
4	The software enable admin to delete username and password	3.70	0.48	Agree
5	The software enable admin to view username and password	3.80	0.63	Agree
	Lecturer			
6	The software enable lecturer to login and logout	3.60	0.70	Agree
7	The software enable lecturer to add new lecturer username and password	3.40	0.21	Agree
8	The software enable lecturer to update lecturer username and password	3.70	0.48	Agree
9	The software enable lecturer to delete lecturer username and password	3.70	0.11	Agree
10	The software enable lecturer to view lecturer username and password	3.50	0.97	Agree
11	The software enable lecturer to view examination result	3.80	0.42	Agree
12	The software enable lecturer to print examination results	3.80	0.42	Agree
	Student			
13	The software enable student to login and logout	3.80	0.63	Agree
14	The software enable student to learn from theory module	3.80	0.63	Agree
15	The software enable student to learn from the practice module	3.80	0.63	Agree
16	The software enable student to take examination	370	0.48	Agree
17	The software enable student to view his/her examination result	3.80	0.63	Agree
18	The software enable student to print his/her examination result	3.70	0.48	Agree
	Non-Functional Software Requirements			
19	The software is well organized	3.70	0.58	Agree
20	The Software window environments are attractive	3.10	1.21	Agree
21	The software buttons are responding to mouse click quickly	3.30	1.22	Agree
22	The feedback massages provided by the software through dialog boxes are self- explanatory	3.60	0.53 0.58	Agree
23	I felt comfortable when using the developed software	3.70	0.48	Agree
24	It is easy to navigate to different parts of the software	3.70	0.71	Agree
25	The software provided adequate data security	3.50	0.52	Agree
26	The software produce accurate calculated results	3.60	0.42	Agree
	Recommendation	0.42		
27	The developed instructional environment` can be used for teaching troubleshooting and repairs of car ignition system	3.80		Agree

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

The data from table 1 above shows that all the mean values of the items are greater than the cut-off point of 2.50 on four-point Likert S. This implies that the students are satisfied with the performance of the developed system. 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 3.80. This value implies that the student unanimously recommended that the developed computer-based instructional environment can be used for teaching the troubleshooting and repairs of electronic ignition system in the College.

6.0 Conclusion and Recommendation

Students of school of Technical Education in Nigerian Colleges of Education are expected to acquire knowledge and skills for troubleshooting and repairs of various systems of a motor car. Electronic ignition system is one of the systems that students need to acquire its troubleshooting knowledge and repairs. To make teaching and learning of troubleshooting of electronic ignition system easier, the authors developed a computer-based learning environment for teaching troubleshooting and repairs of electronic ignition system. The learning environment has four module; theory, practice, examination and database respectively. The developed learning environment was tested and evaluated by selected students. The result of the students' evaluation shows that the system is effective and efficient. Based on these results, students recommended the use of the developed computer-based environment for learning the troubleshooting and repairs of electronic ignition system.

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