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Development of an Interactive Expert System for Self-Learning of Computer Hardware Maintenance: A tool for technical skills acquisition

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Abstract

Learning the numerous procedures needed for the maintenance of different computer hardware devices, especially in universities requires not only in-class tutoring and laboratory practical but also an interactive guide that students can refer to in order for them to learn on their own. One of such interactive guide or tool is an expert. This research took and in-depth study of computer hardware faults and symptoms displayed by each fault, as well as the maintenance procedures for resolving the faults, which were used for the development of an expert system for self learning of computer hardware maintenance. The study adopted Research and Development (R and D) design. The study was carried out in two phases as follows: Phase I: Computer hardware maintenance needs assessment and Phase II: Design of an expert system. The study was conducted in University of Nigeria, Nsukka. The population for the study was 48, which comprised of three categories of respondents. These respondents were 17 lecturers, 13 technologists and 18 final year undergraduate students of computer and robotics education department. There was no sampling due to manageable size of the population. An instrument titled computer hardware maintenance assessment questionnaire (CHMAQ) was used for data collection. Mean and standard deviation were used to analyze the data collected on the research questions. The findings showed that there are: 20 computer hardware faults, 77 symptoms of the faults and 121 procedures for resolving the faults. Based on the findings, an expert system was developed. It was recommended among others that both computer users and students should make maximum use of the expert system for self learning of computer hardware devices.

Keywords: computer hardware, corrective maintenance, expert system, Knowledge base, learning

I. INTRODUCTION

One of the most vital tools for driving educational development today is computer. According to [1] computer is a machine that accepts data as input, processes it and outputs the result. Therefore, computer can be viewed as an electronic machine that accepts data, processes it, prints out the result and stores it for future retrieval with the help of software and hardware components. However, the hardware components of the computer are prone to having faults and needs maintenance.

Computer hardware maintenance/repair is an essential area in the field of computing is taught as a course in tertiary institutions. According to [2] maintenance may be preventive, predictive or corrective. [3] argued that preventive maintenance is the type of maintenance that is carried out on scheduled basis in order to prevent total breakdown of equipment that may need repair. On the other hand, [4] noted that predictive maintenance is the unscheduled activities and steps undertaken so as to prevent computer breakdown when abnormality is noticed in the operation of any of the parts. However, [5] asserted that corrective maintenance is also referred to as computer repair and can be defined as the type of maintenance that is carried out only when the computer breaks down completely or fails to work as expected. Therefore, corrective computer maintenance may be regarded as the repair of broken-down or faulty computers through different procedures. Thus, Computer hardware maintenance/repair been an essential area in the field of computing is taught as a course in computer education and related programmes in tertiary institution in Nigeria and beyond.

In tertiary institutions in Nigeria and some other developing countries, the periods allotted to this hands-on course is limited with the challenge of limited facilities, resulting to students going through the course without having a grip of the required skills. In view of this, [6] stated that through the ages there has been limited time and facilities for the teaching and learning of skills in universities, since the student-lecturer relationship has been the only basis for the education of one generation to the other. [7] noted that in universities in Nigeria and other developing countries, there is limited time and resources for use in enhancing the learning processes, as well as improving the basic skills of students in practical areas such as computer hardware maintenance. Since computer hardware maintenance is a practical course, and the time/period allocated to it in most universities in Nigeria is not enough and the facilities are also li mited for sufficient hands-on exercise, it is necessary to develop an expert system based on the curriculum used in the Nigerian universities to enable students learn on their own and acquire more skills.

An expert system is referred to as computer software that is designed to act like a human expert. [8] defined expert system as knowledge base system and computer software that emulates the decision-making ability of a human expert. [9]

also defined expert system as an intelligent computer program that uses models and theories such as waterfall model, rule based theory and decision tree model to develop applications that solve problems which are difficult enough to require significant human expertise. In other words, expert system is defined as a computer program that acts like a human expert and which can aid students in learning the solutions for resolving different computer hardware faults.

Consequently, in universities in Nigeria, computer hardware maintenance is a course offered by students of computer education. This is an area of specialization where maintenance skills are most needed. Given the challenges of teaching and learning of computer hardware maintenance, it is therefore necessary to develop an expert system. Developing an expert system no doubt will facilitate the learning of computer hardware maintenance among undergraduate students of computer education. Therefore, the development of an expert system for learning of computer hardware maintenance is the focus of this study.

II. STATEMENT OF THE PROBLEM

In learning of computer hardware maintenance in universities in Nigeria, there ought to be adequate time and learning resources to boost students' level of understanding of what is taught in the classroom, as well as enhance their skill development and motivation to learn

Unfortunately, in Nigeria, the time/period allocated for the teaching and learning of computer hardware maintenance is not enough for sufficient hands-on exercises. Additionally, there are inadequate facilities for students to learn at their own pace and in turn boost their level of understanding of the course and motivation to learn. These issues results to students going through the course without a grip of the required skills.

A wide gap therefore exists between the present situation of learning computer hardware maintenance in Nigeria and the ideal situation, with regards to time, facilities and personnel skills requirement. Consequently, there is need to develop a self learning expert system based on the universities' curriculum to enable students learn on their own and acquire more skills.. The problem of this study therefore is that, there is no expert system to guide university students of computer education and other related programmes in self learning of computer hardware maintenance. Therefore, the main purpose of this study is to develop an expert system for self learning of computer hardware maintenance in universities in Nigeria, specifically, the study seeks to:

1. examine the faults associated with different computer hardware devices,
2. determine the symptoms associated with each fault,
3. find out the procedures for resolving the faults associated with different computer hardware devices,
4. developed an expert system for self learning of computer hardware maintenance based on specific purposes 1- 3,

III. METHODOLOGY

The study adopted Research and Development (R and D) design. [10] explained that Research and Development is an institutional-based development approach involving the use of research findings to design and develop new systems, programmes and materials which will assist in improving knowledge and skills. Similarly, [11] explained that R and D design involves the preparation of new educational materials, the introduction and use of procedures or programmes, and systematic try out, in which feedback gathered can lead to a perceptible improvement in the education of students. According to [12], there are eight steps in R and D research design which involve: Identification of goal of instructional program, Identification of specific skills, Identification of learning tasks and procedures, Translating goals into specific objectives, Development of assessment instrument, Development of instructional strategy, Development of instructional material and Evaluation.

[13] indicated that all the steps must not all be used in a study, but could be modified to suit the conditions peculiar to the study. Thus, the 8-phased R and D model of [14] were modified into 2-phased cycle which fits into this study. The two modified phases include:

Phase I: Computer hardware maintenance need assessment: Needs assessment was conducted through the use of the CHMAQ to determine the faults, symptoms and procedures for resolving the faults associated with different computer hardware devices.

Phase II: Development of an expert system: This phase involved the design of the user interface by drawing the flowchart, sketching the user interface, knowledgebase and the administrative panel and then designing the actual interface using Cascaded Style Sheet (CSS), designing the knowledgebase/database and associated tables using Structured Query Language (SQL), coding with Hypertext Pre-processor (PHP) and testing the expert system. The development of the expert system was based on the waterfall model of system/software development life cycle (SDLC): initial investigation, system design, coding, testing, implementation, operations and support.

The instrument that was used for data collection was titled: Computer Hardware Maintenance Assessment Questionnaire (CHMAQ). The questionnaire was used to identify the faults associated with different computer hardware devices, symptoms of the faults and procedures for resolving them. The findings were used to develop an expert system for self learning of computer hardware maintenance. The instrument was structured on 4 point rating scale developed based on literature reviewed and interactions with computer experts. The instrument was grouped into three clusters, namely; cluster A - computer hardware faults, cluster B - symptoms and cluster C - procedures for resolving the faults. Cluster A was comprised of 20 items that sought information on the faults associated with different computer hardware devices. Cluster B contains 77 items which seeks information on the symptoms associated with each fault, while Cluster C contains 121 items which sought information on the procedures for resolving the faults. The response options and the numerical

values that were assigned to each section of the instruments are as follows:

- Strongly Agree (SA)- 4 points,
- Agree (A) -3points,
- Disagree (D) -2 points,
- Strongly Disagree (SD - 1point.

IV. RESULTS AND DISCUSSIONS

Results of Data analysis

Research Question 1

What are the faults associated with different computer hardware devices?

TABLE 1

Mean and standard deviation of responses of lecturers and technologists on the faults associated with different computer hardware devices (*NL=17, NT=13, NS: 18)*

S/N	Questionnaire items	Lecturers $\bar{x}$	SD	DEC	Technologists $\bar{x}$	SD	DEC	Students $\bar{x}$	SD	DEC
1.	Keyboard fault	3.50	0.67	A	3.70	0.46	A	3.60	0.54	A
2.	Mouse fault	3.65	0.57	A	3.59	0.55	A	3.73	0.44	A
3.	Touchpad fault	3.75	0.49	A	3.54	0.55	A	3.43	0.69	A
4.	Touch Screen fault	3.55	0.63	A	3.64	0.48	A	3.54	0.60	A
5.	Screen fault	3.60	0.49	A	3.75	0.43	A	3.66	0.53	A
6.	Speaker fault	3.62	0.49	A	3.56	0.50	A	3.66	0.47	A
7.	Motherboard fault	3.57	0.63	A	3.56	0.50	A	3.54	0.50	A
8.	Processor fault	3.52	0.55	A	3.67	0.47	A	3.68	0.48	A
9.	Fan fault	3.75	0.54	A	3.54	0.69	A	3.63	0.52	A
10.	Network card fault	3.67	0.47	A	3.70	0.57	A	3.48	0.57	A
11.	Heat-sink fault	3.62	0.54	A	3.67	0.52	A	3.61	0.56	A
12.	Sound card fault	3.50	0.75	A	3.64	0.53	A	3.67	0.50	A
13.	Graphics card fault	3.70	0.51	A	3.72	0.50	A	3.66	0.49	A
14.	Hard disk drive fault	3.66	0.60	A	3.48	0.60	A	3.38	0.77	A
15.	Random Access Memory (RAM) fault	3.67	0.47	A	3.64	0.48	A	3.53	0.57	A
16.	Optical drive fault	3.50	0.67	A	3.70	0.46	A	.60	0.54	A
17.	Charging adapter/battery fault	3.65	0.57	A	3.59	0.55	A	3.73	0.44	A
18.	Universal serial bus (USB) Port fault	3.75	0.49	A	3.54	0.55	A	3.43	0.69	A
19.	CMOS battery fault	3.55	0.63	A	3.64	0.48	A	3.54	0.60	A
20.	Charging port fault	3.60	0.49	A	3.75	0.43	A	3.66	0.53	A
	Cluster Means	**3.64**	**0.23**	**A**	**3.52**	**0.19**	**A**	**3.28**	**0 .23**	**A**

Associated with different computer hardware devices (NL=17, NT=13, NS: 18)

Keys: NL=Number of Lecturers, NT= Number of Technologists, NS= Number of students, x =Mean, SD= Standard Deviation, Dec=Decision, A=Agree

Table 1 shows the mean and standard deviation of the responses of lecturers and technologists on the faults associated with different computer hardware devices. The result revealed that the mean scores of both the responses of lecturers and technologists on the 20 identified items are all above the cut-off point of 2.50. The standard deviation of the lecturers for the 20 items ranges from 0.42 to 0.90, while that of the technologists ranges from 0.37 to 0.85, which shows that both respondents do not differ greatly in their responses. The 3.64 cluster mean of lecturers with standard deviation of 0.23, 3.52 cluster mean of technologists with standard deviation of 0.19 and 3.28 cluster mean students with standard deviation of 0.23 explains that both respondents agreed on the 20 identified items. This means that the 20 items are the faults associated with different computer hardware devices

Research Question 2

What are the symptoms associated with each fault?

TABLE 2

Mean and standard deviation of responses of lecturers and technologists on the faults associated with different computer hardware devices (*NL=17, NT=13, NS: 18)*

S/N	Questionnaire items	Lecturers			Technologists			Students		
		$\bar{x}$	SD	DEC	$\bar{x}$	SD	DEC	$\bar{x}$	SD	DEC
1.	Keyboard fault symptoms	3.26	0.52	A	3.30	0.54	A	3.60	0.56	A
2.	Mouse fault symptoms	3.01	0.65	A	3.43	0.87	A	3.73	0.47	A
3.	Touchpad fault symptoms	3.02	0.37	A	3.55	0.78	A	3.43	0.33	A
4.	Touch Screen fault symptoms	3.16	0.78	A	3.84	0.49	A	3.54	0.21	A
5.	Screen fault symptoms	3.26	0.83	A	3.36	0.74	A	3.66	0.45	A
6.	Speaker fault symptoms	3.09	0.27	A	3.43	0.55	A	3.66	0.34	A
7.	Motherboard fault symptoms	2.98	0.34	A	3.64	0.97	A	3.54	0.24	A
8.	Processor fault symptoms	2.96	0.46	A	3.76	0.83	A	3.68	0.42	A
9.	Fan fault symptoms	3.14	0.37	A	3.87	0.57	A	3.63	0.51	A
10.	Network card fault symptoms	3.12	0.53	A	3.73	0.72	A	3.48	0.55	A
11.	Heat-sink fault symptoms	3.21	0.76	A	3.34	0.41	A	3.61	0.56	A
12.	Sound card fault symptoms	3.26	0.87	A	3.56	0.90	A	3.67	0.50	A
13.	Graphics card fault symptoms	3.23	0.14	A	3.52	0.46	A	3.66	0.44	A
14.	Hard disk drive fault symptoms	3.47	0.53	A	3.38	0.64	A	3.38	0.34	A
15.	Random Access Memory (RAM) fault symptoms	3.28	0.70	A	3.47	0.87	A	3.53	0.65	A
16.	Optical drive fault symptoms	3.36	0.34	A	3.81	0.33	A	.60	0.69	A
17.	Charging adapter/battery fault symptoms	3.16	0.88	A	3.62	0.69	A	3.73	0.42	A
18.	Universal serial bus (USB) Port fault symptoms	3.18	0.35	A	3.55	0.58	A	3.43	0.23	A
19.	CMOS battery fault symptom	3.26	0.44	A	3.62	0.64	A	3.54	0.69	A
20.	Charging port fault symptoms	3.21	0.53	A	3.73	0.59	A	3.66	0.64	A
	Cluster Means	**3.25**	**0.29**	**A**	**3.92**	**0.49**	**A**	**3.88**	**0 .29**	**A**

Keys: NL=Number of Lecturers, NT= Number of Technologists, NS= Number of students, x =Mean, SD= Standard Deviation, Dec=Decision, A=Agree

Table 2 shows the mean and standard deviation of the responses of lecturers and technologists on the symptoms associated with each computer hardware fault. It is evident from the result that the mean scores of the respondents on the 77 identified items are all above the benchmark of 2.50. The standard deviation of the lecturers and technologists on the 77 items ranges from 0.49 to 0.90 and 0.37 to 0.95, respectively, which shows that both respondents do not differ greatly in their responses. The 3.94 cluster mean of lecturers with standard deviation of 0.22, 3.92 cluster mean of technologists with standard deviation of 0.44 and 3.88 cluster mean of students and standard deviation of 0.27 explains that lecturers, students and technologists agreed on the items. This also explains that the 77 identified items are symptoms associated with each computer hardware fault.

Research Question 3

What are the procedures for resolving the faults associated with different computer hardware devices?

TABLE 3

Mean and standard deviation of responses of lecturers and technologists on the faults associated with different computer hardware devices (*NL=17, NT=13, NS: 18)*

		Lecturers			Technologists			Students		
S/N	Questionnaire items	$\bar{x}$	SD	DEC	$\bar{x}$	SD	DEC	$\bar{x}$	SD	DEC
1.	Procedures for resolving Keyboard fault	3.20	0.37	A	3.43	0.49	A	3.45	0.54	A
2.	Procedures for resolving Mouse fault	3.45	0.53	A	3.57	0.57	A	3.45	0.44	A
3.	Procedures for resolving Touchpad fault	3.65	0.65	A	3.54	0.58	A	3.78	0.69	A
4.	Procedures for resolving Touch Screen fault	3.35	0.78	A	3.33	0.46	A	3.45	0.60	A
5.	Procedures for resolving Screen fault	3.50	0.39	A	3.67	0.47	A	3.34	0.53	A
6.	Procedures for resolving Speaker fault	3.32	0.50	A	3.78	0.54	A	3.35	0.47	A
7.	Procedures for resolving Motherboard fault	3.67	0.31	A	3.46	0.54	A	3.24	0.50	A
8.	Procedures for resolving Processor fault	3.12	0.42	A	3.76	0.48	A	3.89	0.48	A
9.	Procedures for resolving Fan fault	3.05	0.62	A	3.78	0.63	A	3.88	0.52	A
10.	Procedures for resolving Network card fault	3.37	0.82	A	3.45	0.54	A	3.48	0.57	A
11.	Procedures for resolving Heat-sink fault	3.92	0.44	A	3.20	0.59	A	3.98	0.56	A
12.	Procedures for resolving Sound card fault	3.30	0.56	A	3.66	0.58	A	3.83	0.50	A
13.	Procedures for resolving Graphics card fault	3.40	0.48	A	3.76	0.56	A	3.98	0.49	A
14.	Procedures for resolving Hard disk drive fault	3.56	0.79	A	3.24	0.64	A	3.96	0.77	A
15.	Procedures for resolving Random Access Memory fault	3.67	0.34	A	3.56	0.43	A	3.69	0.57	A
16.	Procedures for resolving Optical drive fault	3.30	0.46	A	3.89	0.48	A	3.09	0.54	A
17.	Procedures for resolving Charging adapter/battery fault	3.25	0.74	A	3.68	0.59	A	3.69	0.44	A
18.	Procedures for resolving Universal serial bus Port fault	3.75	0.87	A	3.58	0.52	A	3.79	0.69	A
19.	Procedures for resolving CMOS battery fault	3.15	0.44	A	3.58	0.47	A	3.68	0.60	A
20.	Procedures for resolving Charging port fault	3.80	0.58	A	3.35	0.44	A	3.78	0.53	A
	Cluster Means	**3.74**	**0.66**	**A**	**3.22**	**0.16**	**A**	**3.24**	**0 .27**	**A**

Keys: NL=Number of Lecturers, NT= Number of Technologists, NS= Number of students, x =Mean, SD= Standard Deviation, Dec=Decision, A=Agree

Table 3 shows the mean and standard deviation of the responses of lecturers, technologists and students on the procedures for resolving the faults associated with different computer hardware devices. The result indicates that the mean scores of all the respondents on the 121 identified items are all above the cut-off point of 2.50. The standard deviation of the lecturers and technologists on the 121 items ranges from 0.47 to 0.92 and 0.37 to 0.85, respectively, which show that both the lecturers and technologists do not differ greatly in their responses. The 3.74 cluster mean of lecturers with standard deviation of 0.26, 3.22 cluster mean of technologists with standard deviation of 0.16 and 3.24 cluster mean of students with standard deviation of 0.27 clarifies that both agreed on the 121 items. The grand mean of 3.79 also explains that the 121 identified items are the diverse procedures for resolving the faults associated with different computer hardware devices.

V. RESULTS OF THE DEVELOPED EXPERT SYSTEM

User interface of the expert system / Introductory page of the expert system

This is the introductory page that display the name of the system, details of the developer, name of the supervisor and button that takes the user to the next page. The page also displays a slider of different pictures that explains the expert system.

Instruction: Click the "click to proceed" button to go to the home page

Home page

This is the page where students can click the menus to read about the following: computer hardware overview, computer assembly/disassembly, computer software installation and computer hardware maintenance. Users can as well use keywords to search for information on computer hardware maintenance.

Instruction:

1. Click the "computer hardware maintenance" button to see a list of faults, or
2. Type a computer hardware maintenance keyword on the search box and click the submit button to find everything concerning the keyword.

Computer hardware maintenance menu

This is a menu that contains the faults, symptoms and solutions for the maintenance of different computer hardware faults. Therefore, the symptoms of a fault appear when the fault is clicked. While the solutions for resolving the fault appears when a symptom is clicked.

Instruction: Click a fault in the computer hardware maintenance drop-down list

Computer Hardware maintenance page

This is the page where the user interacts with the expert system to find out the procedures for resolving computer hardware faults.

Instruction: Select a fault and any of the associated symptoms to view the procedures for resolving the fault

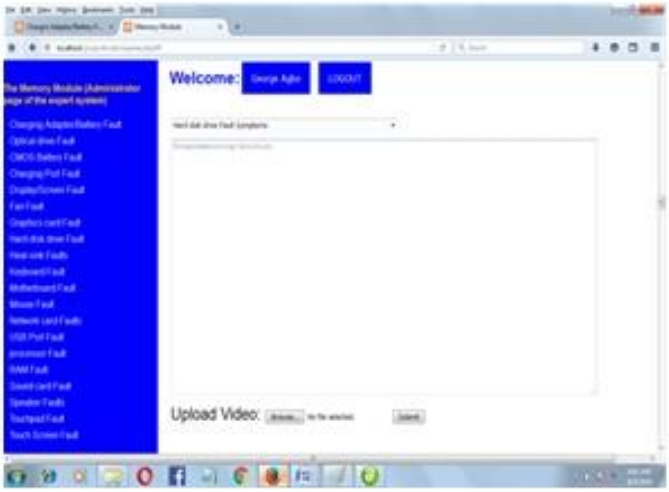
Administrator's Login page

Instruction: Login with an existing username and password and click the "login" button to proceed

Administrator's home page (Working Memory)

This is the page where the system administrator/ hardware maintenance experts update the knowledge base of the expert system

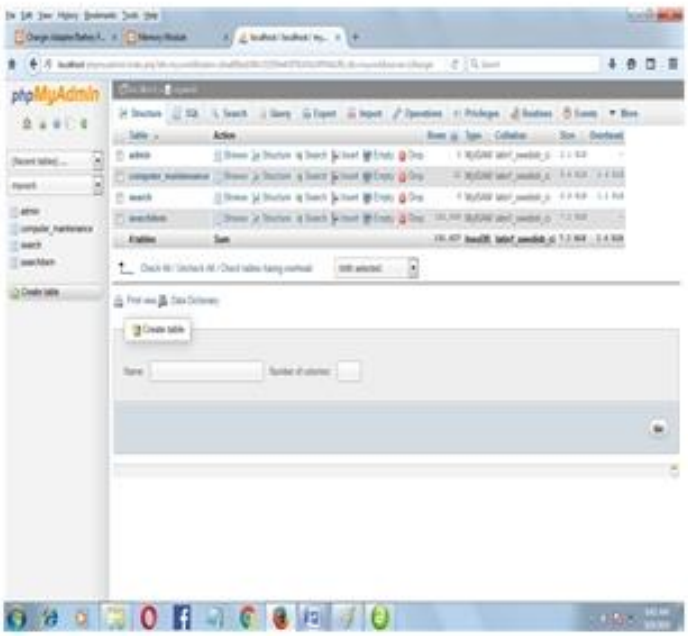
Instruction: Select a fault, select a symptom, write the procedures for resolving the fault, browse to the location of the video of the solution for the maintenance of the fault and click submit button.



VI. KNOWLEDGEBASE OF THE EXPERT SYSTEM

This is a database where all the information in the expert system is stored

Instruction: Click any of the table to view the stored information in the database. Example: click the "hardware_maintenance" table to view the stored information on computer hardware maintenance.



CONCLUSIONS

From the findings of the study, it is evident that a computer system can develop different computer hardware faults, while each fault displays different symptoms; each symptom requires different procedures for resolving the fault. As a result of the technical nature of computer hardware maintenance, mastering the symptoms and procedures for resolving the faults of any computer hardware device always require constant practical exercises. Thus, learning the numerous procedures needed for the maintenance of different computer hardware devices especially in universities requires an interactive expert system such as the one developed in this study, so that students can learn on their own outside the classroom, amidst the limited amount of time that lecturers and technologists devote in teaching them.

Consequently, this study has determined the faults, symptoms as well as procedures for the maintenance of different computer hardware devices. Based on the findings, an expert system was developed for individual learning of computer hardware maintenance by students of computing and other related fields. Therefore, to ensure an effective and efficient skill acquisition in computer hardware maintenance by students of computer education and related fields, there is need for them to always make effective use of the developed expert system for self learning of computer hardware maintenance. This is because the expert system will help boost their level of understanding of what is taught in the classroom, as well as enhance their skill development and motivation to learn. Lecturers, technologists and private computer users are also expected to make use of the expert system for either initial training or periodic training and retraining on the computer hardware devices and their maintenance requirements.

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