

## Comprehensive and Adaptive Computer-based Unified Tertiary Matriculation Examination (UTME) Tutorial System

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### ABSTRACT

Inadequate preparation and non-familiarity with question patterns are major causes of poor performance in Unified Tertiary Matriculation Examination (UTME). In that mix is also that candidates, still in secondary school, begin practice of past questions not earlier than a year to the exam, usually because they are put off by questions from yet-to-be treated topics. This work is a development an adaptive UTME practice system, which has proven useful in giving candidates knowledge of their areas of strength and weakness, and then configuring subsequent sessions to correct the weaknesses while consolidating on areas of strength. Since high practice scores do not necessarily translate into high performance in the actual exam, the system also gives an interpretation of candidate's performance history to give an estimated exam preparedness rating. The system was implemented using the Incremental software development model, in seven increments: database development using MySQL, HTML and CSS structuring, loading of questions and their navigation, and sorting of questions according to topics in the UTME syllabus, sorting of questions according to difficulty. In the later increments, capability of software to resume from where a user was last active if a user logs out or closes the software application without submission; and user's preparedness rating were built into the system.

**Keywords:** Adaptive, Modular Assessment, Difficulty levels

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### 1. INTRODUCTION

[1]'s finding that a greater percentage of Unified Tertiary Matriculation Examination (UTME) candidates succeed at their second, third, fourth or fifth attempt gives an indication of how candidates' competences tend to improve with more attempts or practice. This further means a UTME preparatory system that gives a several-year's amount of practice/experience but over a shortened period would improve the UTME pass rate. UTME is an entry examination for admission into tertiary institutions in Nigeria. With increased UTME question practice sessions sometimes comes with candidates' tendency to memorize and recall answers/options whenever they come across similar questions, instead of actually solving the questions.

Revision works best when you practice what you will be doing in the examination [6]. [6] States further that with the study of past questions, an examinee gets familiar with the topics in high demand, pattern of questions and examination condition. All of which helps a UTME candidate know what to expect – an important source of examination confidence. Question pattern for instance is better seen when past questions on a topic are collated from different years. The statistic of average number of questions per topic will reveal high demand topics, or topics a candidate should concentrate more on.

Early preparation for UTME increases success probability while late preparation has been identified as a platform for test anxiety which hinders proper preparation and, ultimately, performance in the examination [3]. [4] found that participation in The Early Assessment Program (EAP), a collaborative effort among the State Board of Education (SBE), the California Department of Education (CDE) and the California State University (CSU), reduces the average student's probability of needing remediation at California State University by 6.1 percentage points in English and 4.1 percentage points in mathematics, concluding that EAP appears to lead students to increase their academic preparation while still in high school. Administered in junior year in high school, the EAP provides students with opportunities to improve their skills during senior year [7]. Key to that success is that EAP is administered early – even before senior year, when in fact EAP is tests college-readiness. Quite conversely, practice UTME questions, or its early introduction to secondary school curriculum, tend to begin towards the end of secondary education or after completion, very often within a year to the examination date. Same can be said for use of UTME practice applications. Candidates are usually put off attempting them early because of the questions they cannot answer correctly; questions from yet-to-be treated topics. Modularized assessments has been a very helpful tool in fostering early relevance of school curriculum to students [5]. The system developed in this work offers such modular assessment in three levels.

Again, [1]'s finding that a greater percentage of Unified Tertiary Matriculation Examination (UTME) candidates succeed at their second, third, fourth or fifth attempt also gives an indication most candidates are secondary school leavers. This means that UTME preparation for them does not necessarily follow a graduation through secondary school curriculum, having already passed through it. Consequently, this fraction of UTME candidates would need to have a holistic evaluation of their topics of proficiency so there could be concentration on the areas of weakness. This work also presents a system that customizes a candidate's practice sessions to correct such deficiencies while reinforcing areas of strength.

## 2. RELATED WORKS

This section highlights UTME practice applications tested. SmartLearn JAMB 2015 for instance is non-adaptive with questions selected at random without examinee's performance being tracked. It also features step by step navigation and comes with a game. Another is JAMB Exam Practice 3.0, though also non-adaptive provides adjustable test time and allows user navigate to questions of choice. Links are provided for questions on the user interface. In E-Testpedia, neither scores nor solutions to questions and calculations are provided. On completion of test, questions are displayed with chosen option highlighted in green if correct, otherwise the correct option is highlighted in green, and the wrong choice in red. Quiz Faber is another example of non-adaptive UTME CBT software. Test duration is adjustable and the speed of the application is good. Question navigation is only done step by step; users cannot jump between questions. Scores review can be enabled or disabled. The application does not have in-built questions or answers but the examinee/user can input and customize questions to a very high degree. Common to UTME practice applications reviewed is that practice sessions are UTME year-centric.

## 3. METHODOLOGY

### 3.1 System Design

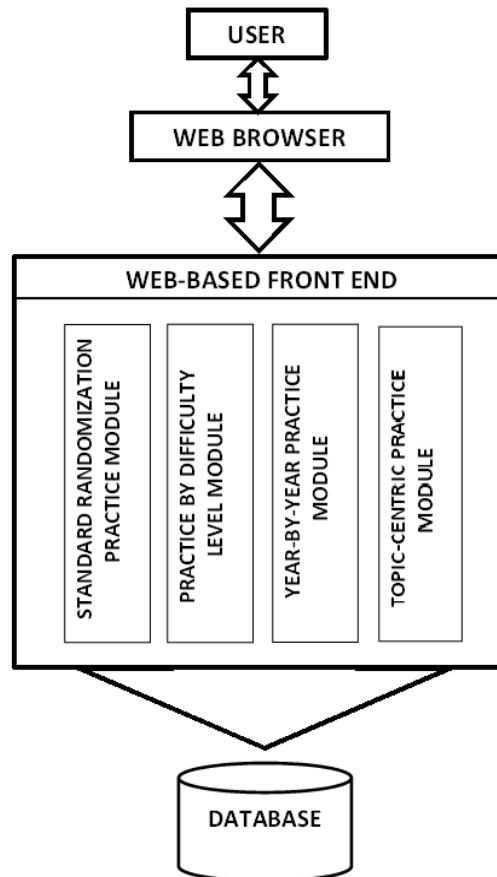
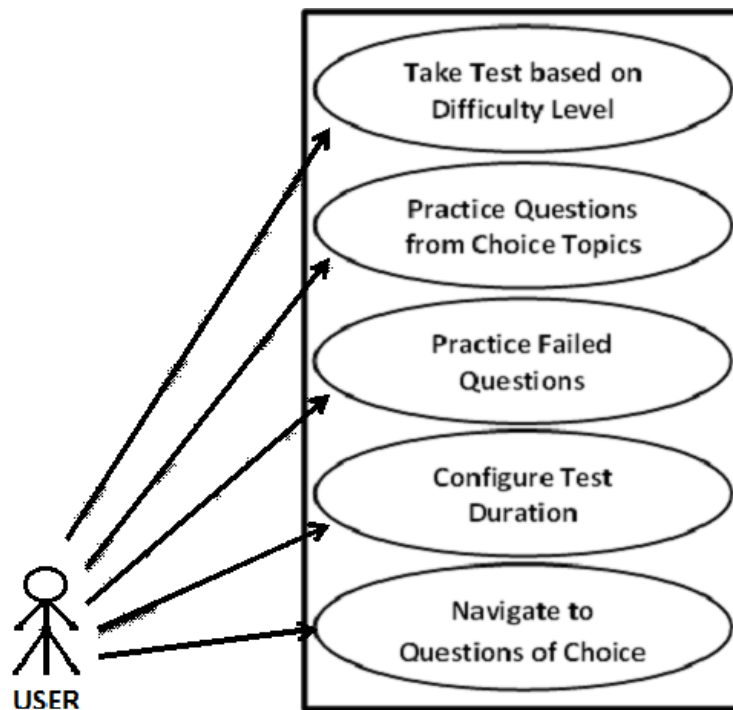


Figure 1. System Architecture

- a. As depicted in Figure 1, the system is a web-based application with four practice modes: Standard Randomized Examination Mode, Difficulty level-configured Mode, UTME Year-based Practice Mode and Topic-Centric Practice Mode, accessed via a web browser. The tutorial system developed in this work familiarizes users with CBT as it provides the exact model and nature of UTME questions. There is a large pool of non-repetitive questions to eliminate random guessing by user. The system also features configurable test duration, options of adapting practice sessions according to choice topics and difficulty levels, with well explained solutions to failed questions. In the display of practice results, topic-based breakdown is available together with user's performance history.

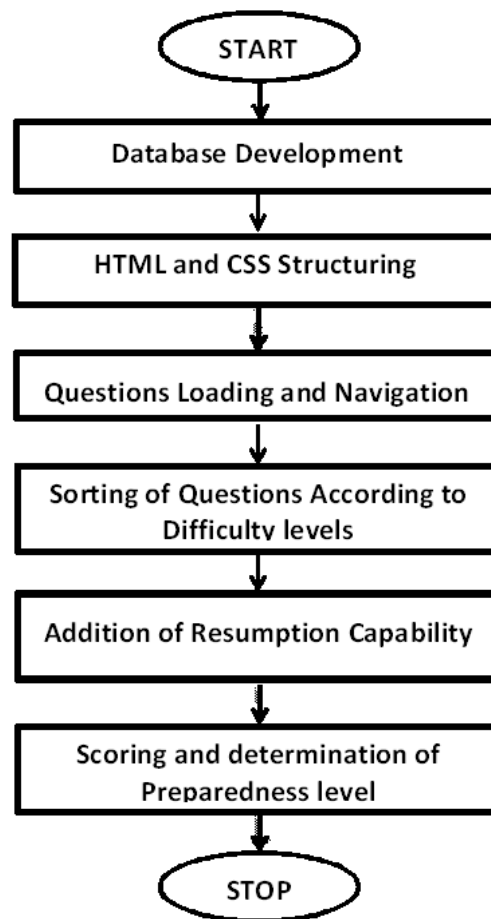


**Figure 2. Usecase Diagram showing system functionalities**

The system is adaptive in that student's performance can be tracked and subsequent tests selected to help the user/examinee gain strength in previous areas of weaknesses (this is obtainable in the Standard Randomization Examination Mode). There is inclusion of standard time. Students can navigate as they want. A link is provided for each question on the interface. Scores, solutions to questions and calculations are provided after each test. The CBT Application automatically resumes from the last question if a user logs-out or closes the application before submitting. Ratings, depicting estimated level of preparedness, are also offered to encourage student practice more and perform better. User can also choose between difficulty levels – Easy, Medium, and Hard. There is also the functionality of practicing more questions on topics previously failed-questions belong. Good speed was also ensured by using pure JavaScript, HyperText Markup Language (HTML), Cascaded Style Sheets (CSS) and Hypertext Preprocessor (PHP) languages for software development in order to reduce loads that may have come from external Libraries. Also, the Database is well structured and organized to ensure speedy retrieval of data during queries. The tutorial system is limited to Use of English and three Science subjects (Mathematics, Physics, and Chemistry), four subjects in all. The use case diagram in Figure 2 helps explain the features of the system.

### **3.2 System Development**

The system was developed using incremental software development model, done in seven (7) stages as depicted in Figure 2.



**Figure 3. Flowchart showing System Development Stages**

As shown in Figure 3, first the database was developed using My Structured Query Language (MySQL). Next was HTML and CSS Structuring. Done in the third increment was the loading of questions and their navigation, using JavaScript, Asynchronous JavaScript and XML (AJAX) and PHP. Sorting of questions according to topics in the UTME Syllabus using JavaScript and PHP was done in the fourth increment/stage. Next was the sorting of questions according to difficulty levels (Easy, Medium, and Difficult). Built into the system in the sixth stage was software's ability to resume from where a user was last active, if a user logs out or closes the application without submitting for grading. In the final stage was rating and scoring of students and determination of an estimated level of preparedness.

## **4. RESULTS AND DISCUSSION**

### **4.1 Increment One: Database Development**

A Database was developed to store information like the questions and answers. The particular Database used for storing the information of this work was MySQL Database on a phpMyAdmin interface as shown in Figure 4.

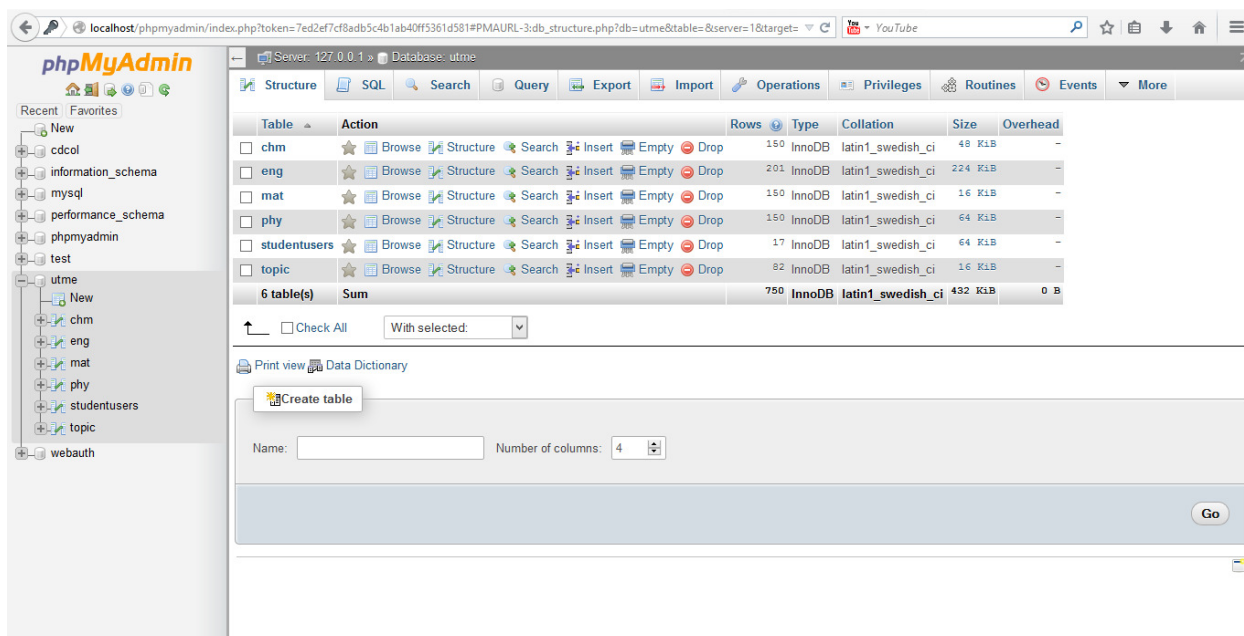


Figure 4. A phpMyAdmin User Interface showing Database and Tables

As in Figure 4, the database was named "utme". The Database comprises of six (6) tables as follows:

- ❖ **chm:** For storing all the information related to Chemistry.
- ❖ **eng:** For storing all the information related to English.
- ❖ **mat:** For storing all the information related to Mathematics.
- ❖ **phy:** For storing all the information related to Physics.
- ❖ **studentUsers:** For storing Students information after they have registered. This helps to keep track of their performances and makes it possible for the test to be adaptive.
- ❖ **topic:** This table is used for storing the various topics contained in the UTME syllabus in all four subjects.

localhost/phpmyadmin/index.php?token=2c1d66383be1a29be92c155333756a90#PMAURL-&tbl\_structure.php?db=utme&table=chm8

Server: 127.0.0.1 » Database: utme » Table: chm

#	Name	Type	Collation	Attributes	Null	Default	Extra	Action
1	<u>examsYear</u>	year(4)			No	None		Change Drop Primary Unique Index Spatial Fulltext More
2	<u>examsSerial</u>	tinyint(4)			No	None		Change Drop Primary Unique Index Spatial Fulltext More
3	a	varchar(200)	latin1_swedish_ci		No	None		Change Drop Primary Unique Index Spatial Fulltext More
4	b	varchar(200)	latin1_swedish_ci		No	None		Change Drop Primary Unique Index Spatial Fulltext More
5	c	varchar(200)	latin1_swedish_ci		No	None		Change Drop Primary Unique Index Spatial Fulltext More
6	d	varchar(200)	latin1_swedish_ci		No	None		Change Drop Primary Unique Index Spatial Fulltext More
7	question	varchar(600)	latin1_swedish_ci		No	None		Change Drop Primary Unique Index Spatial Fulltext More
8	examOption	enum('A', 'B', 'C', 'D')	latin1_swedish_ci		No	None		Change Drop Primary Unique Index Spatial Fulltext More
9	solution	varchar(1500)	latin1_swedish_ci		No	None		Change Drop Primary Unique Index Spatial Fulltext More
10	difficulty	enum('E', 'M', 'H')	latin1_swedish_ci		No	None		Change Drop Primary Unique Index Spatial Fulltext More
11	topicSerial	smallint(6)			No	None		Change Drop Primary Unique Index Spatial Fulltext More

Check All With selected: Browse Change Drop Primary Unique Index

Print view Relation view Propose table structure Track table Move columns

Add 1 column(s) At End of Table At Beginning of Table After examsYear Go

+ Indexes

Information

Space usage		Row statistics	
Data	16 KiB	Format	Compact

**Figure 5. Columns on the chm table**

Each of the Tables is made of various Columns or Fields. Figure 5 describes the columns in the chm table. It can be noticed that in Figure 5, the "examsYear" and "examsSerial" fields are both underlined. This is because a combination of these two fields were used for the Composite Primary key. The choice of these two fields was because no two questions can have same serial number and examination year.

#### 4.2 Increment Two: HTML and CSS Structuring.

HTML was used for the basic structuring of the web pages by arranging and defining the positions of the different layouts, while CSS was used for styling and adding aesthetics to the Graphics User Interface (GUI) of all the web pages. Figure 6 shows a HTML page, Figure 7 shows a CSS page, Figure 8 shows the Home page, while Figure 9 shows Examination page.



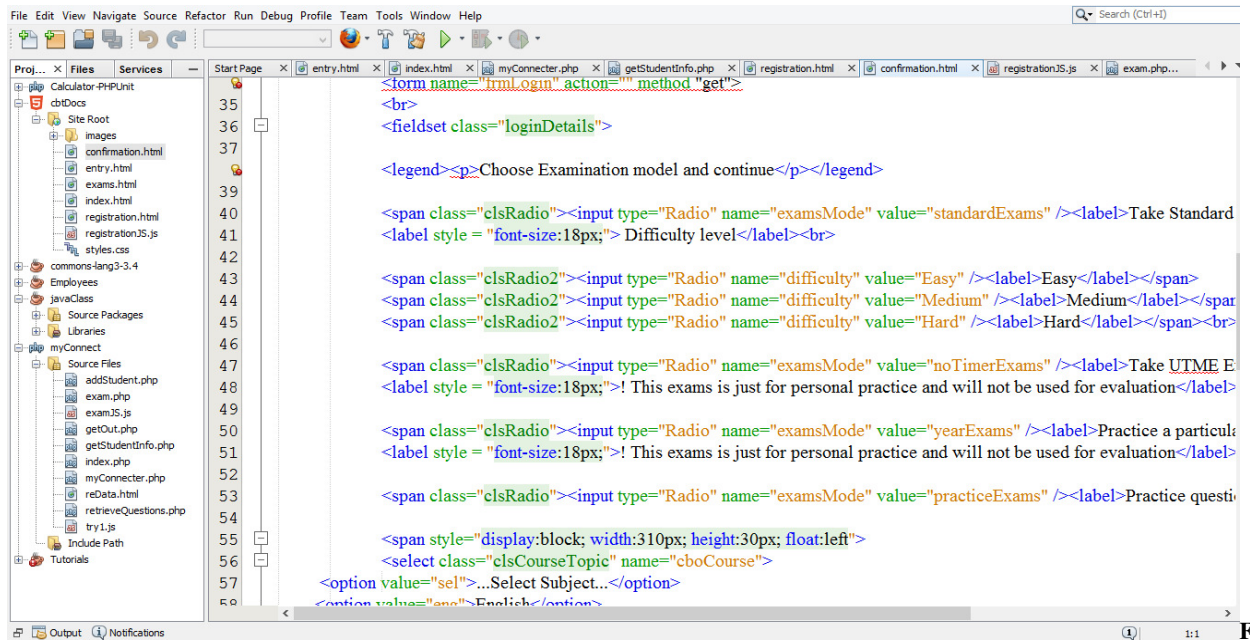


Figure 6: A page showing HTML GUI screenshot

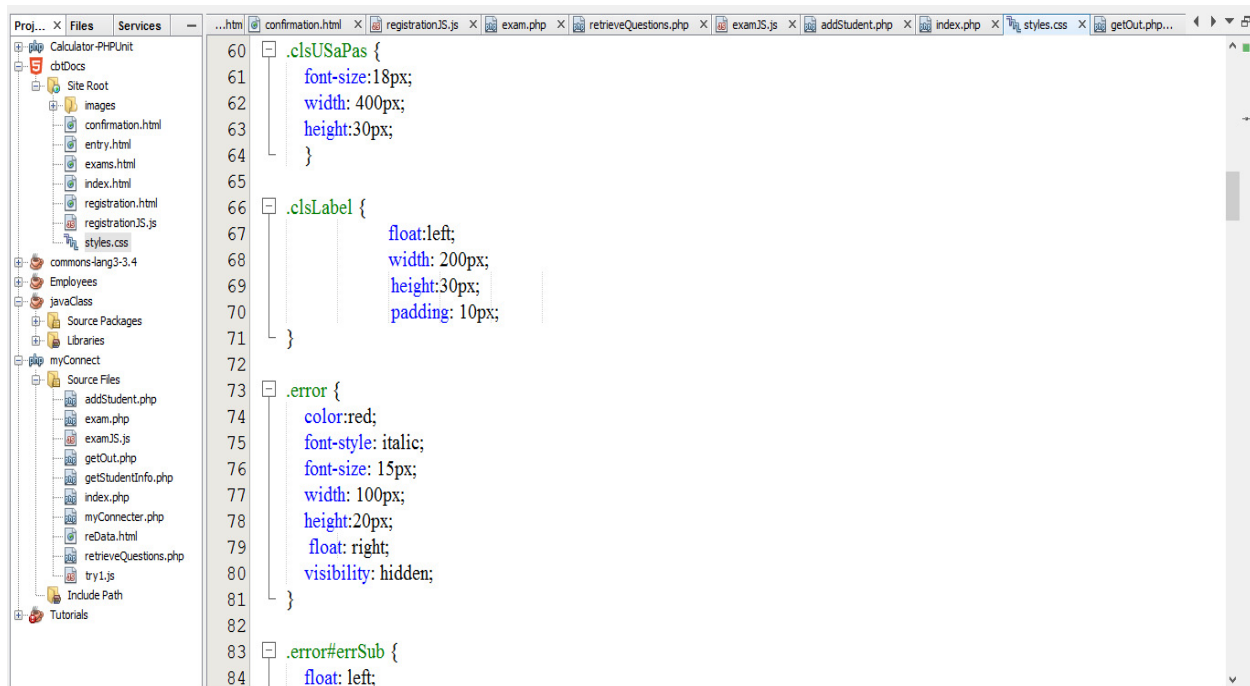


Figure 7: A page showing CSS GUI snapshot

Figure 8: Home Page

3 : 41 : 42

### Chemistry

35.) When plastic and packaging materials made from chloromethane are burnt in the open, the mixture of gases released into the atmosphere is most likely to contain

- A.) ☐ ethane
- B.) ☐ chlorine
- C.) ☐ hydrogen chlorine
- D.) ☐ ethane

Previous

Next

Finish

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50				

Figure 9: An Examination Page

#### 4.3 Increment Three: Loading of questions and their navigation without refreshing of Page - using JavaScript, AJAX and PHP:

As shown in Figure 9, when the navigation button of any of the questions is clicked, the question loads and the button representing the active question is colored amber. Buttons colored green represent answered questions while those colored red are the unanswered questions. Clicking on Previous button displays previous question while clicking the Next button navigates to the next question. Finish button exits question pane and displays result. The questions were stored in the Database, and PHP, which is a server side Language would have been used to fetch the required questions, but doing this would however cause the page to refresh and open another page which is not appropriate for user's experience. AJAX, a tool comprising of a combination of JavaScript and XML (eXtensible Markup Language) was used to communicate with the PHP Server without refreshing the page.



The code snippet for JAX post function is shown in Figure 10 while Figure 11 shows a simple flow chart explaining the question loading and display procedure.

```

240 function ajax_Post() {
241     var hr = new XMLHttpRequest();
242     var url = "retrieveQuestions.php";
243     var cQues = "6tg" + document.getElementById("btnKp").value + "6tgques" + document.getElementById("urName").value + "6tg";
244
245     var vars = "curentQues="+cQues;
246     hr.open("POST", url, true);
247
248     hr.setRequestHeader("Content-type", "application/x-www-form-urlencoded");
249     hr.onreadystatechange = function() {
250         if (hr.readyState === 4 && hr.status === 200) {
251
252             var return_data = hr.responseText;
253             var examsVal = return_data.split("m7Sep");
254
255             if (document.getElementById("subKeeper").value === 'eng') {
256                 document.getElementById("engQues").innerHTML = examsVal[0];
257                 document.getElementById("engOp1").innerHTML = examsVal[1];
258                 document.getElementById("engOp2").innerHTML = examsVal[2];
259                 document.getElementById("engOp3").innerHTML = examsVal[3];
260                 document.getElementById("engOp4").innerHTML = examsVal[4];
261             } else if (document.getElementById("subKeeper").value === 'sub1') {
262                 document.getElementById("sub1Ques").innerHTML = examsVal[0];
263                 document.getElementById("sub1Op1").innerHTML = examsVal[1];

```

Figure 10: Code snippet for an AJAX post function

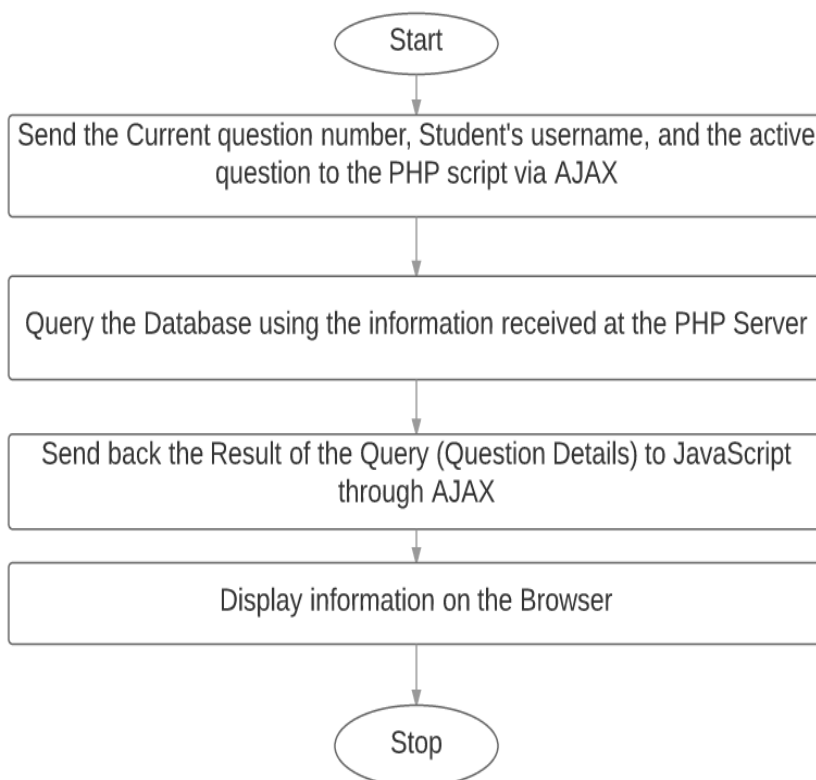


Figure 11: Flow chart detailing the loading and display of questions

#### 4.4 Increment Four: Sorting of questions according to topics in the UTME Syllabus using JavaScript and PHP:

During the communication and requirements gathering stage of this increment, UTME past questions and Syllabus were given to professional teachers to help in sorting of the questions.

The screenshot displays a list of physics questions. Each question is preceded by a difficulty level (E for Easy, M for Medium, H for Hard) and followed by a topic number. The questions cover topics such as velocity-time graphs, tension in a cord, kinetic energy, potential energy, and pressure.

**Questions shown:**

- Question 8 (H):** The diagram below shows a uniform wood of weight 200 N and length 50m. It is pivoted at one end and suspended by a cord at the other end at an angle of  $30^\circ$  to the wood. Calculate the tension in the cord if the wood is horizontal.
  - A. 10 N
  - B. 20 N
  - C. 100 N
  - D. 200 N
- Question 9 (M):** An object of mass 50 kg is released from a height of 2 m. Find the kinetic energy just before it strikes the ground.
  - A. 250 J
  - B. 1000 J
  - C. 10 000 J
  - D. 100 000 J
- Question 10 (E):** A cone in an unstable equilibrium has its potential energy
  - A. decreased
  - B. increased
  - C. unchanged
  - D. oscillating
- Question 11:** Calculate the magnitude of the force required to ...
- Question 18:** The mass of a specific gravity bottle is 15.2 g when it is empty. It is 24.8 g when filled with kerosene and 27.2 g when filled with distilled water. Calculate the relative density of kerosene.
  - A. 1.25
  - B. 1.10
  - C. 0.90
  - D. 0.80
- Question 19 (M):** If a solid X floats in liquid P of relative density 2.0 and in liquid Q of relative density 1.5, it can be inferred that the
  - A. weight of P displaced is greater than that of Q
  - B. weight of P displaced is less than that of Q
  - C. volume of P displaced is greater than that of Q
  - D. volume of P displaced is less than that of Q
- Question 20 (E):** The melting point of Naphthalene is  $78^\circ\text{C}$ . What is this temperature in Kelvin?
  - A. 100 k
  - B. 351 k
  - C. 378 k
  - D. 444 k
- Question 21 (M):** A motor tyre is inflated to pressure of  $2.0 \times 10^5 \text{ Nm}^{-2}$  when the temperature of air is  $27^\circ\text{C}$ . What will be the pressure in it at  $87^\circ\text{C}$  assuming that the volume of the tyre does not change?
  - A.  $2.6 \times 10^5 \text{ Nm}^{-2}$
  - B.  $2.4 \times 10^5 \text{ Nm}^{-2}$
  - C.  $2.2 \times 10^5 \text{ Nm}^{-2}$
  - D.  $1.3 \times 10^5 \text{ Nm}^{-2}$
- Question 22:** When 100 g of liquid L at  $70^\circ\text{C}$  ...

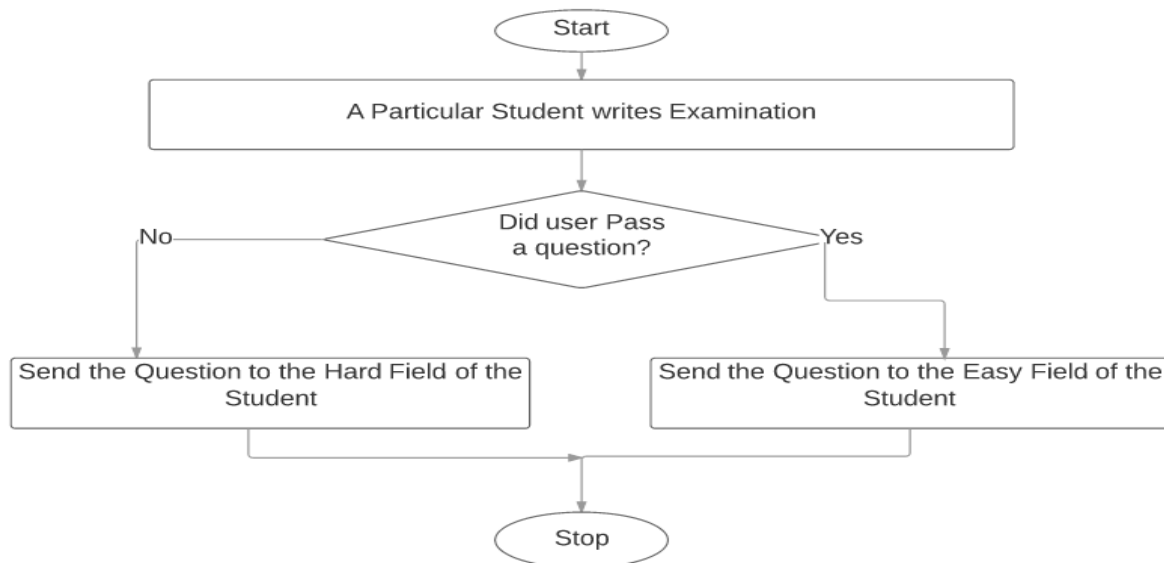
Figure 12: Screenshot of question with difficulty levels and topics indicated

Questions were sorted based on the difficulty level and based on the topics they belong. In Figure 12, difficulty levels as classified by the teachers were represented on the left of each question (E - Easy, M - Medium and H - Hard) while the numbers written on the right of each question corresponded to the topic number on UTME syllabus. The Table named "topic" carried information of all the topics in the Database. Hence, if a user chooses to practice questions based on topics, an appropriate query is used to select and collate questions from the chosen topic of interest using a combination of PHP and JavaScript. Also, after every examination, the topics table is used to determine which of the topics the user performed poorly or well, as the case may be.

#### 4.5 Increment Five: Sorting of questions according to difficulty levels (Easy, Medium, and Hard) using JavaScript and PHP:

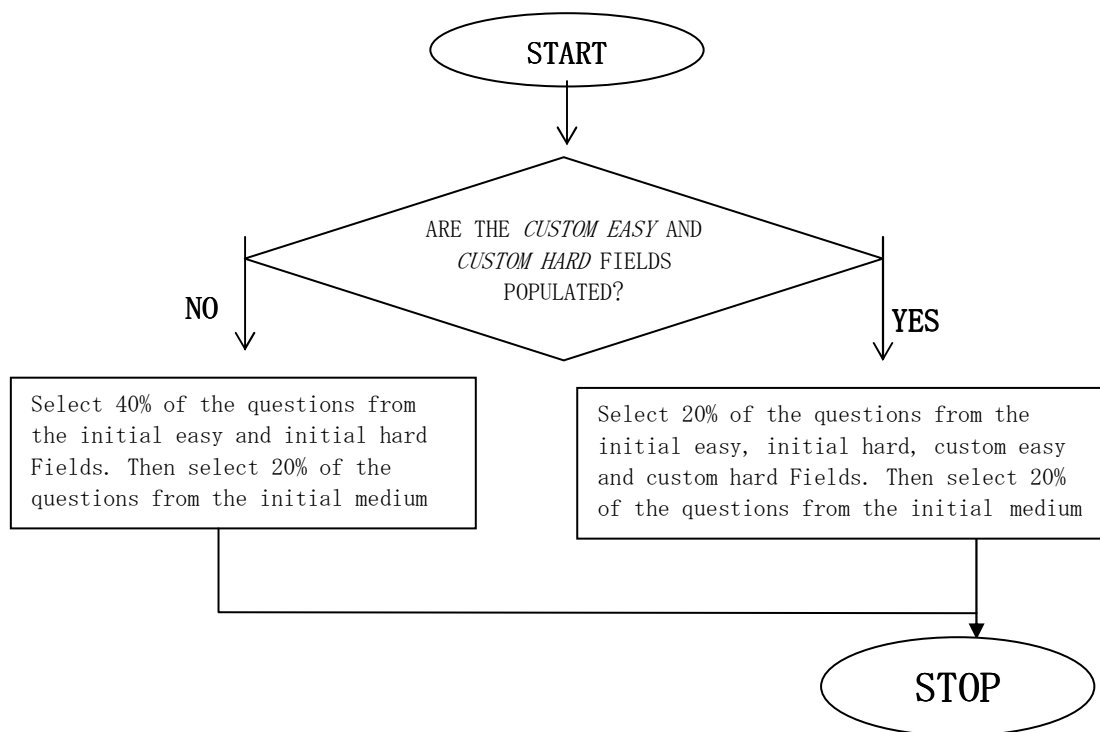
The sorting is explained as follows:

- Initial Difficulty Levels:** These are the difficulty levels which were provided by the Teachers using their discretion: (E- Easy, M-Medium, H-Hard). All the questions were sorted accordingly using their classification and stored in the Database.
- Custom Difficulty Levels:** Although almost all questions can be generally classified as being easy or hard, the difficulty level of a question can also depend on the user. A particular question which is easy for one user might be hard to another. Hence, as shown in Figure 13, for the Custom difficulty levels, questions that are answered correctly are classified under Custom Easy while the incorrect ones are classified as Custom Hard and sent to the particular user's profile in the database.



**Figure 13: Flow Chart for Custom Difficulty level classification**

The Difficulty Level-based Mode offers questions corresponding to the difficulty levels which were sorted by the teachers. If a user chooses Standard Randomized Examination, the application selects questions based on the algorithm shown in the flow chart in Figure 14:



**Figure 14: Flow chart for Randomized question classification**

From Figure 14, if any students just registered and has not yet had their custom easy, custom hard and custom medium Fields populated in the MySQL database, the application makes use of data in the initial easy, initial medium and initial hard Fields alone (see increment 4 in section 4.4). Also, if a Student chooses to practice questions based on difficulty level, the following will be implemented for each difficulty level chosen:

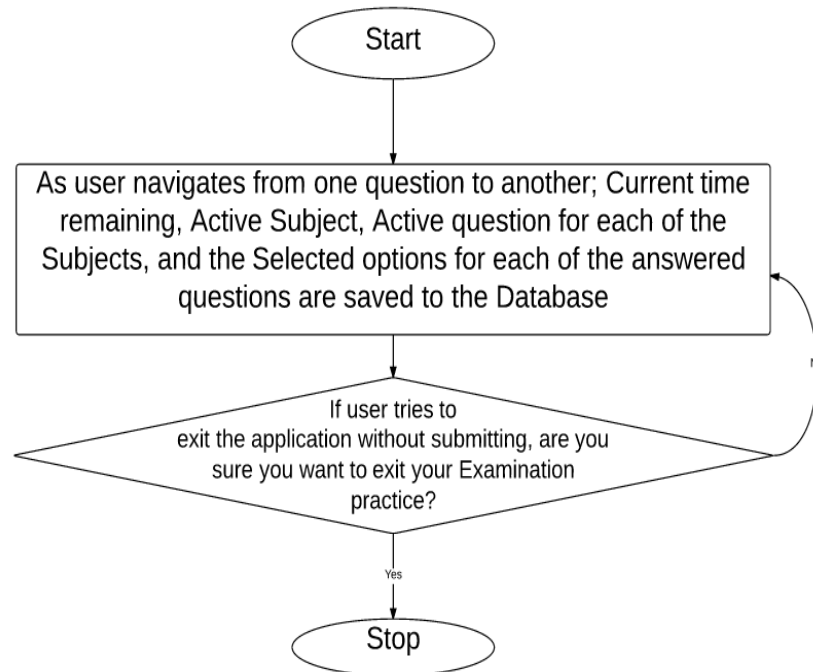
**Easy:** 50% from initial Easy and 50% from custom Easy if Initial Easy is populated, else, 100% from initial Easy.

**Medium:** 50% from initial Medium and 50% from custom Medium if Initial Hard is populated, else, 100% from initial Medium.

**Hard:** 50% from initial Hard and 50% from custom Hard if Initial Hard is populated, else, 100% from initial Hard.

**4.6 Increment Six: Capability of the software to resume from where a user was last active if a user logs out or closes the Software Application without submission for grading - using JavaScript and PHP:**

There might be times when a user will have to pause on his or her Test practice. At such times, the program has to save the test up to the point where the user had stopped for easy continuation. Information that has to be saved include: Current time remaining, Active Subject, Active question for each of the Subjects, and the Selected options for each of the answered questions. A flow chart illustrating this is shown in Figure 15:



**Figure 15: Flow Chart illustrating how questions are saved for resumption**

#### 4.7 Increment Seven: Rating/scoring of students and determination of his level of Preparedness - using JavaScript and PHP:

Students are rated based on their overall average performance. As shown in equation 1, this rating average of previous rating and current score.

$$\text{Rating} = \frac{\text{Previous Rating} + \text{Current Score}}{2} \quad (1)$$

The rating gives a rough estimation of user's UTME preparedness. Table 1 gives a break-down of the ratings. The rating of Students outlined in Table 1 is only active when a user practices with the Standard UTME examination module.

**Table 1: Classification of User Ratings**

Rating (over 400)	Star	Degree of Preparedness
Below 180	Unprepared - 1 Star	10 %
180 – 199	Learner - 2 Stars	40%
200 – 219	Beginner - 3 Stars	50%
220 – 239	Prospective - 4 Stars	55%
240 – 259	Impressive - 5 Stars	65%
260 – 279	Brilliant - 6 Stars	70%
280 – 310	Sparkling - 7 Stars	80%
310 – 350	Superb - 8 Stars	90%
350 – 390	Extra Superb - 9 Stars	95%
390 – 400	Prepared -10 Stars	99%

## 5. CONCLUSION AND RECOMMENDATIONS

In order to increase the chances of Students passing their Examination, the CBT Software in this Project is implemented with the same structure as that of the UTME CBT in order to make Students familiarize with how to use the CBT Application before the Examination date, this increases the success rate and reduces chances of mistakes. Answers and solutions to each questions are also provided at the end of every examinations which makes the Students learn at a much faster pace. The availability of additional features like various practice modules, Difficulty levels, subjects classified into their different topics, confidence level, large pool of questions and ratings made based on Students performances also make the Software suitable tool in driving users' success in UTME/Post-UTME.

In extending this system, level of preparedness rating can be tied to cut-off score for successful admission into examinee's choice course of study and institution.

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