Abstract
Technology as we know today has come a long way in changing different aspect of lives and helping in human efficiency and accuracy. There is a growing need for educators and stakeholders to explore other means of assessment of students using different medium to help students. Examination is the major and widely accepted use of measuring student ability and understanding of a subject initially taught to him/her. The use of Information and Communication Technology registering and administering examinations helps in attaining efficiency and error-free results and computation. Flexible timing functionality, stand-alone subject module, robustness and scalability are some of the major advantages of the Computer based Test software. The CBT was developed using both the widely accepted Waterfall Model and Reuse-oriented software process models. The whole implementation of the software was achieved using Source Based technologies such as XAMP server, PHP, MySQL, JavaScript, Hypertext Markup Language and Cascading Style Sheet as template design. It provides immediate notification of the student’s final score based on what was provided as well as report. It also provides diagrammatic questions as well as mathematical symbols in all subjects. The paper focuses on using Component-Based software model in development of a Computer based Test software, that is, reuse of single core component of the software over and over to develop multiple components of the software. No two component areas (subject) are the same but all (sub-component) follow the template-component.

Keywords
Computer Based Testing Software, Examination, Component Based Software Engineering

I. Introduction
Examination as we know is one of the best methods of evaluating knowledge and grade student’s ability understanding of what he/she was taught in the classroom. There have been various methods used for assessing students such as projects, pencil-written examination, presentations, assignments and oral examinations. Traditional Examination refers to a formal examination administered through question papers to which students respond. After the exams, the teachers are given some period of time to individually mark the OMR sheet based on what was there assumed answers. The OMR sheet consist of questions mostly 50 questions having 5 options A, B, C, D and E. The student uses a pencil to tick the correct option corresponding to the questions to be answered. The result of taking pencil based examination or Computer based testing is seen as a catalyst for changes in pedagogical methods (OECD, 2010). It is seen as a catalyst for change, bringing about a transformation in learning, pedagogy and curricula in educational institutions (Scheuermann & Pereira, 2008). In order to establish valid Computer based testing (CBT) the international Guidelines for Computer-based and Internet-Delivered Testing (International Test Commission, 2004) state that equivalent test scores should be established for tests using the conventional paper-based mode and the new computer-based mode. This set of testing standards is supported by classical True-Score Test Theory (Allen & Yen, 1979), which is the basis of both computer-based and paper-based testing. According to this theory, someone who takes the same test in the two modes can be expected to obtain nearly identical test scores. The result of taking pencil based examination or Computer based testing has little or no difference between them.

Most secondary schools in Nigeria basically use paper-based test in assessing student’s performance from the junior school to Secondary school. Teacher’s supplies question for typist to type the questions and all students assemble in an examination hall to write and answer questions using OMR sheet. The OMR sheet prevent communication between students and prohibit the use of notes or other revision aids. There has been a growing interest in recent years in developing and using Computer based tests in educational assessment especially in Nigeria. The Joint Admission Matriculation Board (JAMB), the body responsible for admission into Nigerian University went a step higher in 2013 with the use of Computer based tests (CBT) software in conducting her examination. It became a necessary and timely innovation to keep with technological trend. In the 90’s, when students sat for JAMB, it was kept on a pedestal of fear for most students but today it has become a norm in our educational sector. The advantages of computers are well-known and apparent. They offer student the opportunity to improve their productivity and time management when answering questions. The standardization of test administration conditions is one of the benefits offered by computer-based testing (CBT). No matter what the tests’ population size is, CBT helps students to set the same test conditions for all participants. It also improves all aspects of test security by storing questions and responses in encrypted databases and enables testers to create randomized questions and answers from vast question pools. Moreover, offering different exam formats and the immediate presentation of different types of feedback, either to students or testers, are also some of the great advantages of CBT.

Computer based testing (CBT) or computer based assessment is seen as a catalyst for changes in pedagogical methods (OECD, 2010), It is seen as a catalyst for change, bringing about a transformation in learning, pedagogy and curricula in educational institutions (Scheuermann & Pereira, 2008). In order to establish valid Computer based testing (CBT) the international Guidelines for Computer-based and Internet-Delivered Testing (International Test Commission, 2004) state that equivalent test scores should be established for tests using the conventional paper-based mode and the new computer-based mode. This set of testing standards is supported by classical True-Score Test Theory (Allen & Yen, 1979), which is the basis of both computer-based and paper-based testing. According to this theory, someone who takes the same test in the two modes can be expected to obtain nearly identical test scores. The result of taking pencil based examination or Computer based testing has little or no difference between them. The exams, the teachers are given some period of time to individually mark the OMR sheet based on what was there assumed answers.

II. Literature Review
• Features of a Computer Based Testing System
• Overview of Computer Based Testing System (CBTS)
• Overview of CBT using Component-Based software Engineering (CBSE)
• Applications of CBT in Nigeria

A CBTS as earlier mentioned is a form of assessment and evaluation in which questions are delivered to students on a computer screen based on the subject picked by the students. The
computer is an integral part of question papers’ delivery, response storage, marking of response or reporting of results from a test or exercise. The questions are usually delivered in multiple choice formats consisting of 4 options in which only one serves as the answer to the displayed question which provides an easy to use environment for both Test Conductors and Students appearing for Examination. The main objective of a CBTS is to provide the same features that a traditional Examination System must have coupled with an interface that is easy to use by the user (student). According to Taylor as cited in Newhouse, a Computer-Based Testing could be delivered on a stand-alone personal computer, within an isolated Local Area Network (LAN) or through the use of online technologies such as web-pages over the Internet.

There are two types of CBT which include:

- **Linear Test** - This involves a full-length examination in which the computer selects different questions for individuals without considering their performance level.
- **Adaptive Test** - Here the computer selects the range of questions based on individuals’ performance level. These questions are taken from a very large pool of possible questions categorized by content and difficulty.

In this paper presentation, both type of CBT are used in delivering questions to register students on the software. According to S. O. Kuyoro in his articles published February 2016, the effectiveness of a computer based testing system depends largely on factors such as standardization, security, examination conditions, mode of administering the examination, cost and so on. Some of these factors are as follow:

- A CBTS is cost effective especially when deployed in the conduct of a mass-driven examination as there will be no need to print questions or answer booklets.
- Osang in his study of electronic examination in Nigeria suggested that course coordinators prefer electronic examination to pen and paper examinations as it requires lesser administrative tasks for the coordinators and enhances a timely release of examination result.
- Adewale, Ajadi, and Inegbedion in Perception of learners on Electronic Examination in Open and Distance Learning Institutions stated in 2010 that human errors can be eliminated and examination malpractice eradicated when a CBTS is adopted in the process of examination. Akunyili, D. (2010) in a paper (ICT and e-government in Nigeria: Opportunities and Challenges, 2011) stated that manually marked scripts were more prone to errors than computer marked ones.
- S. Al-Amri in Computer-based vs. Paper-based Testing paper stated that the standardization of test administration conditions is one of the benefits offered by CBTS. No matter the size of the test-takers, CBTS helps test developers to set the same test conditions for all participants.
- In Journal of Educational Computing Research, Bodmann and Robinson (Speed and Performance Differences among Computer-Based and Paper-Pencil Tests) researched the effect of several different modes of test administration on scores and completion times. They observed that undergraduate students completed the computer-based assessment test faster than the paper-based assessment test.
- Adebayo in E-Exams System for Nigerian Universities with Emphasis on Security and Result Integrity article stated that security will be more effective since the system includes biometric fingerprint authentication, picture capture and data encryption and decryption.
- Jamila in Computer-based vs. Paper based examinations: Perceptions of university teachers (Turkish Online Journal of Educational Technology) presented that technology based assessment provide opportunities to measure complex form of knowledge and reasoning that is not possible to engage and assess through traditional methods.

### A. Overview of Computer Based Testing System

The CBT software developed using CBSE has a central computer which serves as the server (supplier and storing of questions). Teachers upload student information and questions with corresponding answers into the system. The student walks into the Computer hall, picks a computer, enters the required his/her login information and begins his/her examinations. The time starts counting down immediately after logging in and logs off immediately at 0.00s. A supervisor is in position to prevent students from beating the system. Skilled Computer students can/ will always beat any system no matter the security put in place. The solution to this problem is to regularly update the software as flaws or errors are detected. The questions appear randomly for each student and no two questions are alike. Immediately after ending the examination, the result is displayed showing the number of wrong and right results.

### B. Overview of CBT using Component-Based software Engineering (CBSE)

Component-based software engineering (CBSE) emerged in the late 1990s as an approach to software systems development based on reusing software components. Its creation was motivated by designers’ frustration that object-oriented development had not led to extensive reuse, as had been originally suggested. Single object classes were too detailed and specific, and often had to be bound with an application at compile time. One had to have detailed knowledge of the classes to use them, and this usually meant that you had to have the component source code. This meant that selling or distributing objects as individual reusable components was practically impossible. Components are higher-level abstractions than objects and are defined by their interfaces. They are usually larger than individual objects and all implementation details are hidden from other components. CBSE is the process of defining, implementing, and integrating or composing loosely coupled independent components into systems. It has become as an important software development approach because software systems are becoming larger and more complex. Many IT dependent companies are demanding more dependable software that is delivered and deployed more quickly. The only way that industry can cope with complexity and deliver better software more quickly is to reuse rather than re-implement software components.

The paper focuses on developing CBT system having several file representing each subjects for the examination. A single file (Core Component) contains a subject and all images, results, questions and answers relating to the subjects. Each file is reused for creating different subjects. For example, a firm wanting to conduct 7 examinations will have 7 separate files to allow for each file developed and designed according to administration specifications.
C. Applications of CBTS in Nigeria

Computer Based software has come a long way in Nigeria and is more adopted in mass-driven examination. This is to curb time wasting during marking, assessment and provide error free computations and result. A CBT is aimed at providing good execution of examination and evaluation. Recently the Joint Admission Matriculation Board (JAMB), the body responsible for admission into University employed the use of electronic examination in conducting her examinations. Universities, Polytechnic and Secondary schools have adopted this means in assessing and evaluating student’s performance. Some Universities fully or partially implementing the CBTS for assessing their students include the following:

• University of Ibadan in conducting Post Graduate Use of English Test Examination
• Obafemi Awolowo University, Ile Ife
• National Open University of Nigeria (NOUN)
• University of Ilorin, Ilorin
• Federal University of Technology, Minna
• Covenant University, Ota (Private)
• University of Nigeria, Nsukka
• University of Lagos, Lagos

Some secondary schools fully or partially implementing the CBTs for assessing their students include the following:

• Hallmark College Ibadan (for Senior School only)
• Sunshine Secondary (both Junior and Senior Secondary school)

Furthermore, the Joint Admissions and Matriculation Board (JAMB) which is the national matriculation examination body for admissions into Nigerian higher institutions of learning has adopted the use of a CBTS for the conduct of its examination. The revolutionary dimensions of this ICT-enhanced service has revolutionized the body in attaining almost 100% result computation, minimizing cheats and early delivering of results to students.

III. Related Works

There have been numerous researches focusing on the development of Computer based test and Electronic learning information system. Zhenning et al (2003) developed a novel online examination system based on a Browser/Server framework which carries out automatic grading of objective questions for basic computer operating skills. The courses included Visual Basic programming, Microsoft Windows operating system, Word, Excel and PowerPoint editing, Internet and Email skills. It was successfully applied to the distance evaluation of basic operating skills of students offering computer science in some Universities. The system was a distributed collaborative system which was based on Distributed Component Object Model (DCOM) technology. Internet Information Server 4.0 (IIS) was used as the Web Server, Microsoft SQL Server 7.0 as Database Server and a user friendly browser as the client’s interface. Cryptography, real-time monitoring system and data transmission encryption were used to guarantee security of the system. The system can be improved on through a random administration of questions to reduce the level of examination malpractice.

The CBT system developed by Fagbola et al (2013) was an online examination system that assesses students using multiple choice questions set by the lecturers and is capable of grading students accordingly. The system provides an effective solution for mass student evaluation and provides numerous functionalities such as auto-submission of examination on expiration of set time, auto-grading of students and examination result report generation. The Waterfall Model of software development Life cycle was adopted and the conceptual design (activity diagram, the use cases, the data flow diagram and the entity-relationship diagram) were presented. Macromedia Dreamweaver 8.0, Microsoft Visual Studio 2012 and Microsoft SQL Server 2008 were the tools used for the development of the CBTS. The system was implemented using C# (C Sharp) and SQL server. The CBTS system was composed of six different functional pages which are the student login page, the admin login page, the result summary page, the question page, question upload and configuration page and the student result page. It was expected that the system would proffer solutions to challenges such as examination malpractices, low capacity examination venues, inadequate invigilators and inadequate examination materials. Performance assessment of the CBTS system was carried out using 250 students and the statistics proved the system as highly flexible. This CBTS system can be improved on through the implementation of essay-based questions. Integration of students’ continuous assessment should also be included for it to be effective in a tertiary institution. Taşci et al (2014) proposed an online examination system architecture which provides for integrated management of an examination main functionalities. These include question pool creation and update, examination authoring, execution and evaluation, management of the feedbacks from students, along with ensuring use of analysis reports related to the questions and examination created by an intelligent agent in the decision-making processes. The system architecture includes Administration, Implementation, Finalization and Support layer. A Monitoring Agent was designed to help students through creating reports. Analyses on this system at Sakarya University Turkey showed that the proposed intelligent agent supports online examination system, detects problems that may arise and enables the instructors to make decisions more easily on such problems in a shorter time. The expert system which uses the IF THEN construct is expected to expand to include additional intelligent features with the aim of resolving different problems.

IV. System Design and Analysis

The Computer Based Test Software developed in this work is based on the existing implementation infrastructures and also modeled to along the traditional mode of examination. The systems adaptability has been improved to meet the demands of the Nigerian structure of higher institutional examination systems. The Software Development Life Cycle (SDLC) for this system is the Waterfall Model and Reuse-oriented software Model. The CBTS design was presented using; use case diagrams, architectural diagram, entity-relationship diagram and data flow diagram. The design was based on the users and system requirements of the CBTS.

A. CBTS Development Life Cycle

The Waterfall model was used in the development of the software. It is an example of a plan-driven process—in principle, one must plan and schedule all of the process activities before starting work on them. All the process activities of the software from the admin login page to the user login page were carefully planned before commencement of the project. The principal stages of the waterfall model directly reflect the fundamental development activities:

• Requirements analysis and definition: The CBTS system’s services, constraints, and goals are established by consultation with system users (students in this case). They are then defined
in detail and serve as a system specification.

- **System and software design**: The CBT systems design process allocates the requirements to either hardware or software systems by establishing an overall system architecture.

- **Implementation and unit testing during this stage**: The CBT software design is implemented and each unit tested before overall testing is done on actual students. All takes are duly corrected and improvement made.

- **Integration and system testing**: The individual program units or programs are integrated and tested as a complete system to ensure that the CBT software requirements have been met. After testing, the CBT software system is delivered to the institution.

- **Operation and maintenance**: This is the longest life cycle phase. The CBT system is installed and put into practical use. It is regularly maintained by correcting errors which were not discovered in earlier stages of the life cycle, improving the implementation of system units and enhancing the CBT system’s services as new requirements are discovered.

Using the waterfall model, the CBTS SDLC was split up into a number of independent steps as shown in Figure 1 below. Each step was carried out in sequence and accordance to one after the other. The previous stage is always completed before moving to the next stage of the life cycle. The phases involved in the CBTS SDLC are:

- Requirements Analysis and Definition
- System and Software Design
- Implementation and Unit testing
- Integration and System testing
- Operation and Maintenance

**User and System requirements** - This describes the end-users requirements for the system. The users of this system are the students, the teachers and an administrator who is familiar with the system. The Use Case Diagrams (informal graphical representation of requirements) show the user requirements and a more detailed system requirements (specific functions to be carried out by the system) for the CBTS system are also presented. The two main actors for the CBT software are:

- The Student
- The Teacher

The homepage displayed after entering the CBT URL on the address bar gives brief description of the software and the name of the institution/school. For this paper, the software was developed for Hallmark College, Ibadan a secondary school in Oyo State Nigeria.

**The Student**

The Fig. 2 below shows the Student’s Use case diagram indicating what student will be able to do on the system before and after successful login:

- Log in to the system using specified registration number
- Full name is displayed immediately the correct registration number is entered
- The system displays a message when the students registration number is not registered on the subject database
- Login button to start exam

**The Teacher**

The Fig. 3 below shows the use case diagram for the teacher indicating that he/she will be able to perform the following functionalities:

- Log on to the system using their username and password
- Register new student information in the system
- View and modify examination questions and corresponding answers
- Upload bulk questions at a time
- Search, register and update student existing information
- View the scores of his or her own students

**1. Requirement Analysis and Definition**

Requirements analysis and definition involves the writing of a clear statement, often in natural language, of what the system is expected to provide for its users. This information is called the requirements specification. Requirements elicitation also called requirements recovery is the process of gathering information about the required system and existing systems, and distilling the user and system requirements from this information. Sources of information during the requirements discovery phase include documentation, system stakeholders, and specifications of similar systems. Requirements elicitation were derived from the interaction with students and teachers of different secondary schools and Institutions and also from literature review of other related works.
(iii). The Administrator

This paper focuses on using Component Based Software model to develop Computer based software. The core file representing the major component which runs the software. The file is copied and pasted in the “htdocs” folder of the local server and represented as a subject. This can then be used to further create more subjects depending on the number required.

Fig. 4 shows the Administrator’s Use case diagram indicating that administrator shall be able to:

- Register teachers in the system
- Create default password for all teachers
- Create student classes and subjects
- Set timer for each subject

![Fig. 4: Use Case Diagram for Admin](image)

2. Data Flow Diagram (DFD) for the CBT System

A data flow diagram (DFD) uses a very limited number of primitive symbols to represent the functions performed by a system and the data flow among the functions. Starting with a set of high-level functions that a system performs, a DFD model hierarchy represents various sub-functions. The data flow diagram depicted in figure 5 below shows the relationship among the entities in the CBT system. The entity “STUDENT” can take an examination after he or she gains access to the system. The entity “TEACHER” can upload bulk questions and corresponding answers to be answered by student into the CBT database using any preferred question format, set the examination instructions and configure the correct options or set of options for the questions. The entity “ADMINISTRATOR” is saddled with the responsibility of inserting students, teacher and setting the default password for the users of the system. The entity “SERVER” is responsible for authenticating the users of the system and also provides the timing functionality for the examination. The system logs off a student upon expiration of duration for the examination.

![Fig. 5: Data Flow Diagram for the CBT Software](image)

3. Entity relationship diagram (ERD) for the CBT Software

ERD is a data-modeling tool and can be drawn using a variety of notations. They are normally represented in an Entity Relationship Diagram (ERD), which uses graphical representations to model database components. Fig. 6 shows the ERD for the CBT software:

![Fig. 6: Entity Relationship Diagram for the CBT Software](image)

4. Programming Tools for the Developed CBT System

- XAMP local server
- Macromedia Dreamweaver 8.0
- Macromedia Fireworks

V. Result and Discussion

The CBT system is composed of two (2) core pages which are the admin page and student page. The admin contains a dashboard which include add new student/registration page, check and edit question page, search panel page, view and edit existing student page and the upload page using CSV format.

A. Student Login Page

The figure 7 depicts the Student Login Page. This is the page displayed after picking class of the user. It contains the login section for the student to provide his or her details which is used to authenticate the student to gain access to the system. The Full name is automatically generated when the required ID is provided. The student logs-in with the ID number and his/her is generated. The school in focus Hallmark College, Ibadan requested that they wanted a simple login system that requires the student only knowing the registration number. This was because of the frequent case of misplaced password or forgetfulness on the part of the student. The page also contains a link to the teachers section.

![Fig. 7: Student Login Page](image)
1. Question Page

After successfully logging in, the system displays a simple and short summary of the candidate information: registration number, Candidate name and his/her picture. Student can view Previous and next question in random order from the database, that is, no two questions are alike. On clicking on the submit button, a summary of the result is displayed. Each question is picked randomly from the database and no two students can have the same question. The summary result displays the order in which the question was picked randomly and shows the answer, what he/she picked and Status (FAIL or PASS). Figure 8 depicts the question page and figure 9 depicts the result summary page.

B. Admin Login Page

As shown in Fig. 10, this page is used by the teacher to login into the system in order to carry out operations like uploading questions and corresponding answers, viewing the result summary report to generate a complete list of student’s grade after their examinations, registering new students among other things. The teacher always logs in with a pre-assigned and re-modified username and password.

1. Dash Board

The dash board provides all functionality of the system using simple icons to depict functions. The table below shows all icons used, functionality and description of each icon.

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Logo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registration Page</td>
<td>Quick registration of student into the database. Student ID, name and picture are the only information required</td>
<td>![Register a New Student]</td>
</tr>
<tr>
<td>Check Question/Editing</td>
<td>Teacher can view questions and make correction immediately using the Inline grid function</td>
<td>![Check Questions]</td>
</tr>
<tr>
<td>Check result</td>
<td>Check and print result for that subject. This function has been existing</td>
<td>![Check Result]</td>
</tr>
<tr>
<td>Add bulk Question</td>
<td>There are 2 ways of adding questions. Teacher can type in Excel and Upload it directly in CSV format or type question directly on the EDIT questions DASH Board</td>
<td>![Add Bulk Question]</td>
</tr>
<tr>
<td>Search Page</td>
<td>Search student record, filter, sort in arranging or descending order</td>
<td>![Search]</td>
</tr>
<tr>
<td>View/Edit Registered student</td>
<td>View all students registered for the subject, make inline editing, sorting and filtering, quick add of a new student</td>
<td>![View &amp; Registered Student]</td>
</tr>
<tr>
<td>Update Existing Student Info</td>
<td>View all students registered for the subject, make inline editing, sorting and filtering, quick add of a new student</td>
<td>![Update Existing Student Info]</td>
</tr>
<tr>
<td>LOGOUT</td>
<td>Logout of the page</td>
<td>![Logout]</td>
</tr>
</tbody>
</table>
VI. Conclusion

In an evolving and technologically-driven world, the need for a computerized examination system in our secondary school cannot be overemphasized. The information system is an online examination system that delivers questions randomly set by the teachers to the student and generates the report of the results of students who take the examination as well as overall examination result summary. In this paper, a CBT system is developed and deployed in a secondary school (Hallmark College, Ibadan) using Component Based Software model. Using this model provided the CBT software with independent extensions, component market, interactions between components and reduced cost in deployment of the software. There are challenges involved in using CBSE as maintenance cost and timing to develop software components takes a big effort. Challenges encountered in traditional examinational mode which includes examination malpractices, low capacity examination venues, inadequate invigilators, inadequate examination materials, omission of student’s results and human error(s) during the marking / grading process will be automatically eliminated following the adoption of this system. The cost implication of conducting a mass-driven examination will become drastically and significantly reduced as there will be no need to print questions or answer booklets anymore. However, future research work should accommodate theory-based questions as opposed to only the multiple-choice and structured question formats that the CBT system currently accommodates. Also, provision for video-based e-assessment can be investigated.

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Ajinaja Michael received his B. Sc degree in Computer Science and Engineering from Obafemi Awolowo University, Ile – Ife, Osun State, Nigeria in 2012. He is currently a student of University of Ibadan running his Masters Degree. He fully developed the first Computer Based test software for secondary schools used in different schools in Nigeria at present. He has written books on tourism (World of tourism) as part of his love for adding knowledge in other areas of knowledge apart from computing. His research interests include Data mining and Machine learning.