

Design and Implementation of an Online Computer-Based Testing System

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ABSTRACT

Computers are now standard and pervasive tools that significantly affect our daily lives and their use in the educational sector provide the needed support for the expected challenges of this century and beyond. In testing and assessment applications, computers have changed the ways in which tests and assessments are developed and administered. One of the most important characteristics of an advanced learning environment is its ability to evaluate the knowledge acquisition and retention rate of students, and to adapt to student needs. Therefore, it is not surprising that an increasing number of technology-based student knowledge testing and evaluation systems are becoming available. Advances in technology have significantly increased the acceptance of computer-based testing (CBT) as an effective method for administering tests and assessments. The cost of purchasing and maintaining a proprietary testing system is however prohibitive hence the challenge to develop a cost effective and maintainable system. This paper presents the design and implementation of a computer-based testing system called Online Tester, developed at the Department of Computer Science, University of Ibadan. The implementation results showed a functional testing system that is easily maintained.

Keywords: *Online system, Assessment, Student, Computer-based Test*

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I. INTRODUCTION

Institutions such as Universities use tests and assessments to evaluate the learning activity of students. Assessments provide feedback to educators about learner's ability and competence on a topic of interest or course. Assessments come in various formats such as paper-based, roleplay-based, and mobile-based.

Traditionally, assessment used to be paper-based tests (PBT) for most science and humanities courses but the increase in number of students admitted into various course of study have made the management of assessment difficult. Difficulties being faced in PBT include delay in result generation, subjective scoring, and manipulation of results. RolePlay tests (RPT) are used in demonstration-based course of studies such as Theatre arts and music where the physical activity is evaluated. Computer-based tests (CBT) are defined as tests or assessments that are administered by computers in either stand-alone or networked configuration or by other technology devices linked to the Internet or the World Wide Web [14]. A wide variety of computer-based tests have been designed and developed to meet different testing purposes. The test specification for a computer-based tests should include: the test purpose, the content domain definitions, the content structure for the test items, required response formats for the test items, sample test items illustrating the response formats, the number of items to be developed and administered, scoring and reporting formats and procedures, and test administration procedures.

Computer-based testing systems that are available for implementation are proprietary systems and cost a lot of money to purchase and maintain. The cost of purchase has hindered some institutions from adopting computer based testing even though there is evidence that using computer-based testing is better [4, 16]. In this work, a computer-based testing system is developed that is low cost, allows multiple users and addresses the inefficiencies of the paper-based assessment method.

II. RELATED WORKS

Education Testing Services, an organization that conducts computer-based tests including but not limited to Test of English as a Foreign Language (TOEFL), Graduate Record Examination (GRE), has conducted research studies indicating that computer-based General Test Scores are comparable to scores earned on the paper-based General Test. Field-tests have shown that it is possible to develop a computer-based test where someone

who has never touched a computer before can do just as well as a computer-literate person. The tests might provide an introductory tutorial, which may be repeatedly practised to teach people all they need to know.

Field studies by [10] and [7] have shown that there is no significant difference between how men and women of similar ability perform on computer-based tests. Persons with disabilities have also expressed concern that these tests might require motor skills or sensory input they do not have. However, since computer-based tests can be more flexible, it is possible to create alternative versions. So instead of computer-based tests providing new obstacles, they could help to equalize the testing situation. Studies done by [9]; [7] and [10] have been carried out to determine how students perceive the use of computer-based tests. According to [10] the acceptance rate in Landmark University for the use of computer based tests is high i.e. above 80% for students in general studies, library and ICY, Entrepreneurial Studies and Total Man concept. They however noticed that Physics and Chemistry had low acceptance rate. [7] discovered that the low acceptance of CBT for Chemistry courses was due to the impaired validity of the test items such as erroneous chemical formulas, equations and structures.

[13] developed a biometric authentication system for a computer-based testing system. The performance tests carried out indicate that the overhead added to the time of the user is minimal while the benefits of additional security are enormous.

Computer-based tests (CBT) are being used for university examinations in Nigeria [3]. Institutions such as Obafemi Awolowo University, Ile-Ife; National Open University of Nigeria (NOUN); Covenant University, Ota and University of Ilorin use CBT for their entrance examinations. [2] described the developments that led to the adoption of CBT at University of Ilorin and identified ways the current CBT implementation could be improved. [12] gave the design for an online examination system for Covenant University, Ota.

Several computer based testing systems have been developed in Nigeria and elsewhere to address the cost of proprietary systems. Table 1 gives more details about each system.

[15] developed a secured computer based examination system using HTML, Javascript, JQuery, Ajax, JSP and

MySQL. The system was tested in a real environment at the School of Management Sciences, Lucknow, India.

III. METHODOLOGY

The experimental approach was used to develop a low cost testing system for an institution. The Software Development Life Cycle (SDLC) was the chosen method for implementation.

The system was designed using the following requirements:

1. adaptive testing environment and fast score reporting
2. accommodate several test-takers taking the same examination concurrently without being aware of each other's presence
3. reliable validation of test-takers' identity, and
4. easy to use graphical user interface.

The system designed decomposed the computer-based testing system into the following modules:

- 4.1 Student Registration Module
- 4.2 Question Presentation Module
- 4.3 Question Selection Module
- 4.4 Assessment Engine
- 4.5 Result Presentation Module

Figure 1 gives an overview of the relationship between the modules.

The computer-based testing system was designed to function on X86-based computer systems running a Win32 operating system with the Java Virtual Machine and Oracle 8i RDBMS version 8.1.7 installed.

The basic inputs into the system are: student record, centre record, and questions and answers. Sample input for the centre record and questions are contained in the SQL code that was used for the creation of the database. The questions were taken from Teach Yourself C++ in 21 days [8]. Each test taker is expected to answer thirty questions in sixty minutes.

The database design is shown in Figure 2.

A demonstration of Online Tester was done using twenty computer systems in the departmental laboratory. A

system was designated as the server and the appropriate server codes loaded, while the others had the client Java classes loaded. The different modules of Online Tester were implemented as java classes. Java classes used to implement this system are contained in SplashScreen.java, MainMenu.java, NewStudent.java, LogForm.java, TestClient.java for the client side; while ServerScreen.java, ServerLog.java, Testee.java and TestServer.java were used on the server side.

SplashScreen: This initialises the system and sets up the main menu. Its major feature is the two-dimensional animation effects supported by Java. This class extends the javax.swing.JPanel class, implements java.awt.event.ActionListener interface and imports packages such as java.awt.*, java.awt.event.*, javax.swing.* and a self defined class MainMenu.

MainMenu: The MainMenu class consists of JRadiobutton driven menus that leads to other parts of the online tester. The menu items are Register as New Student, Log in as Registered Student and Exit. The first option sets up the NewStudent class while it hides the MainMenu, the second option leads to the log on frame displayed by the LogForm class after hiding the MainMenu frame. The last option is the menu that exits the system. This class extends the javax.swing.JFrame class while it imports java.awt.*, java..awt.events, javax.swing.*, NewStudent, and LogForm.

NewStudent: The class module provides the interface for online registration of students and displays the student id dynamically assigned by the server. The class returns to the MainMenu class after registration of the student. This class, extends javax.swing.JFrame, imports java.awt.*, java.awt.event.*, javax.swing.JoptionPane, java.net.*, java.util.*, java.io.* and MainMenu.

LogForm: This class provides the authentication of registered students profile and that of the examination centre. On successful authentication the class sets the student for the test. LogForm is a derived class from javax.swing.JFrame and uses methods from imported packages such as java.awt.*, java.awt.event.*, javax.swing.*, java.net.*, java.util.*, java.io.* and self defined TestClient.

TestClient: This class contains functionalities for the question selection, question presentation module and assessment module. Assessment is done in collaboration

with the TestServer on the server side which supplies the basis of assessment. The presentation of the questions is time driven and if student does not supply a response after two minutes, it moves on to the next question. Presentation of the result to test taker is done within this module on completion of the test and necessary documentation passed on to the server. Apart from importing all of the standard packages that were also imported by the LogForm class, it also imports the MainMenu class as it takes the user back to the MainMenu menu to properly exit the system after display of the result.

ServerScreen: This class is the two-dimensional animated introduction frame for the server side and it has similar features to the client side introduction screen except in the self defined classes it imports. It imports ServerLog in addition to the standard packages

ServerLog: This class authenticates a registered student's profile at the server end before launching the TestServer.

Testee: This class extends the thread and gives the functionality that allows for multithreading in this application. Each instance of the Testee class is a thread that can be executed concurrently with other threads within the system. This allows multitasking and multiple users to access the system concurrently. Each individual instance of this class has a socket connection to the client side and a database connection to the oracle database

TestServer: This is the major class on the server side of this system; it does all of the co-ordination of the classes on the server end. It starts up the ServerScreen, which in turn sets up the ServerLog. The TestServer continues execution only if authentication is successful.

IV. EXPERIMENTAL RESULTS

Online Tester was designed as a three-tier distributed system consisting of the client side, server side and the database system. Implementation of the system was done using Java Software Development Kit version 1.3.02 and Oracle 8.1.7 Relational Database Management System. Socket connection was used for the client-server connection while java database connectivity (JDBC) was used to link up with the database system.

The results of the implementation are shown in Figure 3.

The main menu that is displayed in Figure 3 comes up after the animated splash screen that introduces Online Tester and initializes appropriate java classes. The student has the option of accessing the testing system as a new student or registered student and to exit.

The screenshot in Figure 4 shows a completed registration process for a new student using Online Tester. The student is given a registration identification number that is automatically generated by the server.

Figure 5 is the login/authentication screen for Online Tester. The system requests for specific details before students are allowed access to the test. New students are shown this form after completing registration, while registered users are transferred here directly from the main menu. The information supplied is authenticated at the server before the user is allowed to take the test.

The questions and choices (possible answers) are presented to the test taker as shown in Figure 6. Radio buttons are used to accept input from the test taker. The *next* button moves test takers to the next question. Questions are clearly differentiated from answers using different font size and colour.

At the end of a particular test the results are calculated immediately and displayed as shown in Figure 7. This provides prompt and effective feedback to the test taker. An offline method can be used to verify the marking of the test questions for accuracy.

In this work, a testing system for students in a higher institution was developed and implemented. The users of the systems were also identified as follows:

Test-Takers: These are the candidates to be tested. They should have access to, after their identifications have been authenticated by the system, only the interface that displays questions and accepts their responses. Additionally, they can view their result on completion of the test. **Exam Supervisors:** These users are synonymous to invigilators in a paper-based system. They set up the test-takers for the examination by authenticating their identification as supervisors at the first level and combining their identification with that of the test-takers for a second level authentication. **Examiners:** These refer to the institutions, persons or group of persons that are

responsible for testing the test-takers. They have the utmost privilege on validation of their identification. They set up the questions, grading standards, validation of test-taker's registration and distribution of results.

Java was used as the programming language because it is freely available and supported by all operating systems. The user interfaces was also produced using Java classes thus making interaction between the codes fast and without needing conversion. The database management system used was Oracle 8.1 which was available for free during the implementation. Alternative database management systems can be used for the database if required. The existing local area network (LAN) on which the system was installed and tested had the star topology thus all systems had equal access and speed to the testing system. The users who tested the computer based testing system where computer science students in the 300level. Although a usability test was not carried out the general response of the tests was that they believed in the operations of the software. There was no dispute from any student on the results returned by system after the testing exercise.

V. CONCLUSION

A simple and easy to use computer-based testing system has been developed using Java programming language. The testing system is suitable for implementation in schools for courses with large population such as general courses e.g. use of English and foundation courses e.g. chemistry and mathematics. The system is easily maintained and can be used for multiple subjects/courses without the need for reprogramming. Online Tester can also be used for selection of candidates in recruitment and competitions. It is also suitable for use in distance learning programs where the students are off campus but have access to the Internet. Developing new user interfaces and allowing the integration of graphics in the question format can improve the Online Tester.

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Table 1: Computer-based testing systems developed in Nigeria

S/N	Author(s)	Development Tools	Remarks
1.	[12]	ASP.net, HTML, C#, Microsoft SQL server, Internet Information Services (IIS)	The security is dependent on the Microsoft platform used.
2.	[11]	Java and MySQL	Used Similar tools to our work but different design.
3.	[1]	Java Servlet pages (JSP), Netbeans IDE7.2 and MySQL	No security and authentication of user
4.	[6]	MySQL, PHP, Javascript, HTML	Limited question type available
5.	[5]	HTML, Microsoft Visual Studio 2012, Microsoft SQL Server 2008	Limited question type available

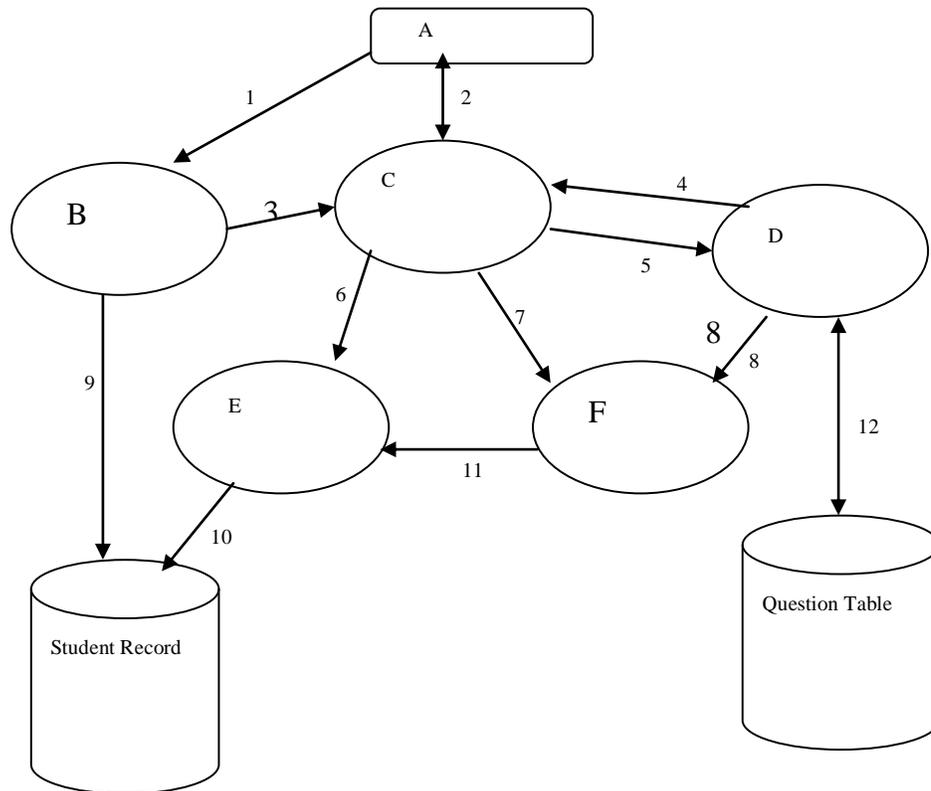


Figure 1: Data flow diagram for system design

Legend

Codes	Description	4	Selected question
A	Test Taker	5	Test-taker identification information (to facilitate question selection)
B	Student Registration	6	Test-taker identification information (to produce result)
C	Question Presentation	7	Test-taker’s response to question for grading
D	Question Selection	8	Standard for assessment of response
E	Result Presentation/Display	9	Fetch test-taker’s information from database to authenticate user profile
F	Assessment Engine	10	Report on student’s assessment
1	User authentication profile (user-id & password)	11	Test-taker’ grade of question
2	Presentation of questions/Acceptance of response	12	Selected questions from database
3	Identification of authenticated user (pass for taking exam)		

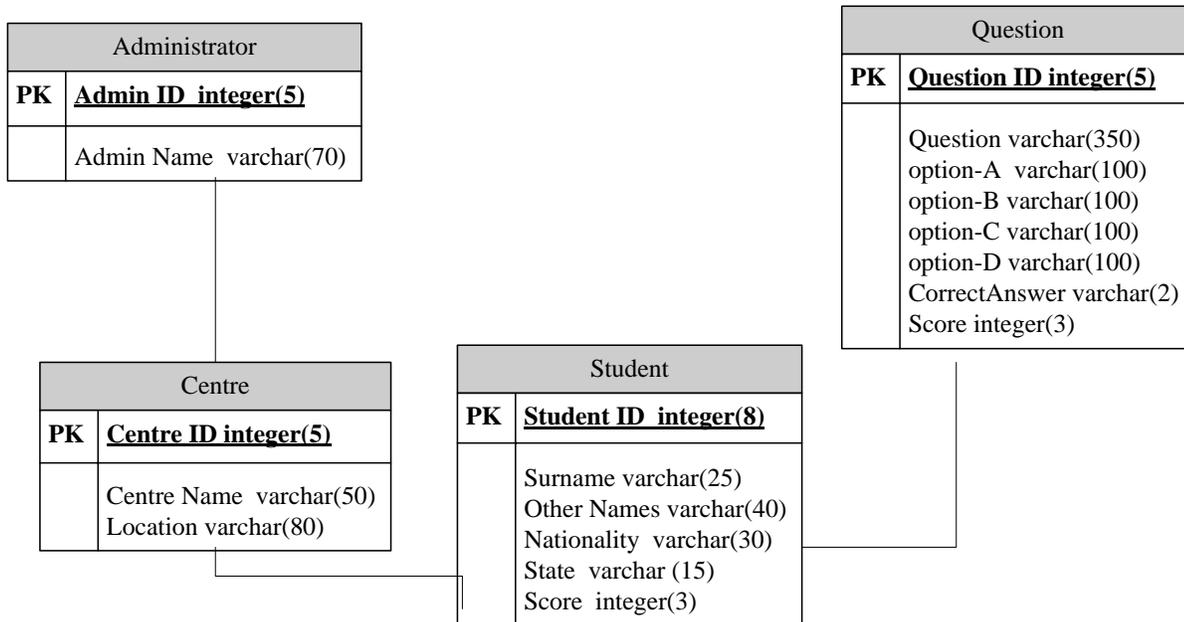


Figure 2: Database design for the testing system

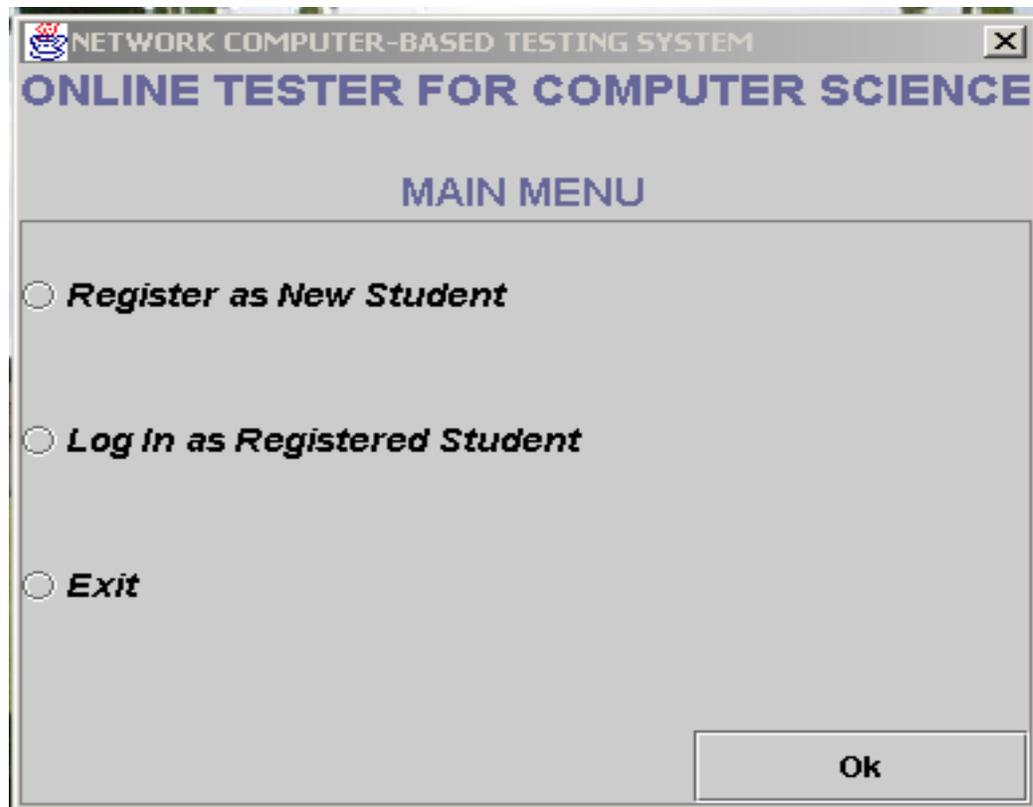


Figure 3: Main menu on client side

NETWORK COMPUTER-BASED TESTING SYSTEM - [NEW STUDENT REGISTRATION]

ONLINE TESTER FOR COMPUTER SCIENCE - STUDENT REGISTRATION FORM

STUDENT RECORD

Surname: Nationality:

Other Name: State:

EXAMINATION CENTRE RECORD

Centre Name: Centre ID: Centre Location:

Administrator: Administrator ID:

Message

Congratulations!!!

You've been registered with id 10006

Figure 4: A successful online registration

NETWORK COMPUTER-BASED TESTING SYSTEM - [STUDENT LOGIN FORM]

ONLINE TESTER FOR COMPUTER SCIENCE - LOGIN FORM

STUDENT LOGIN INFORMATION

Surname: Other Name:

PIN:

EXAMINATION CENTRE AUTHENTICATION

Centre ID: Centre Name:

Administrato ID: Administrator Name:

Figure 5: Registered student log on form

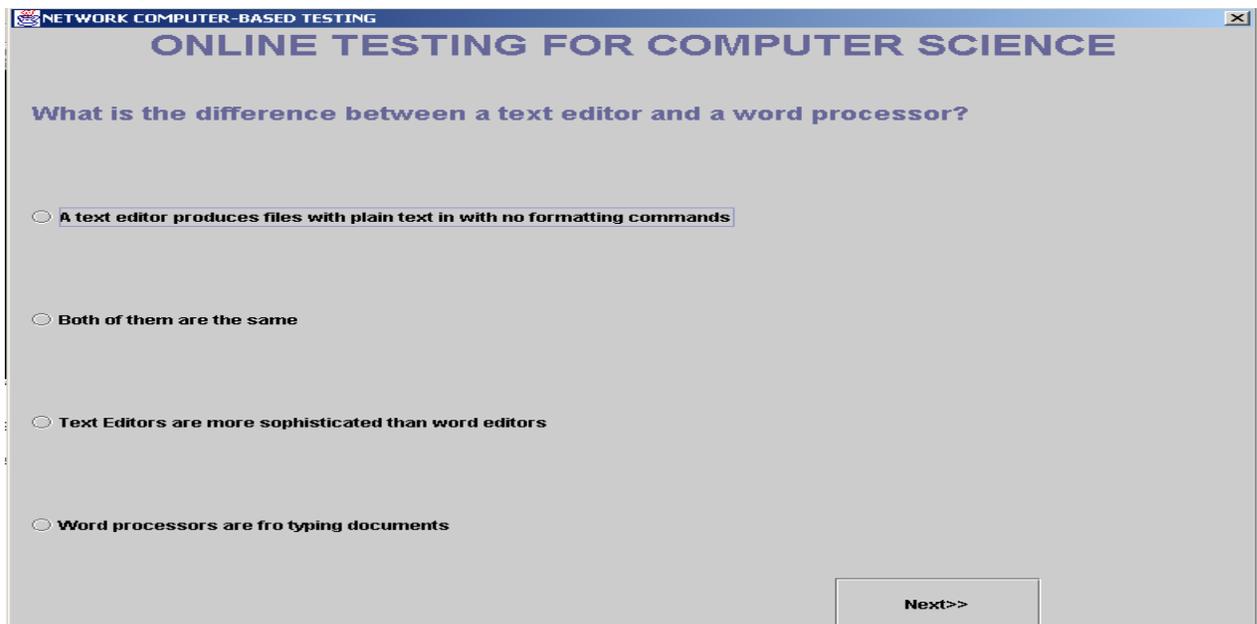


Figure 6: Question Presentation to Test Taker

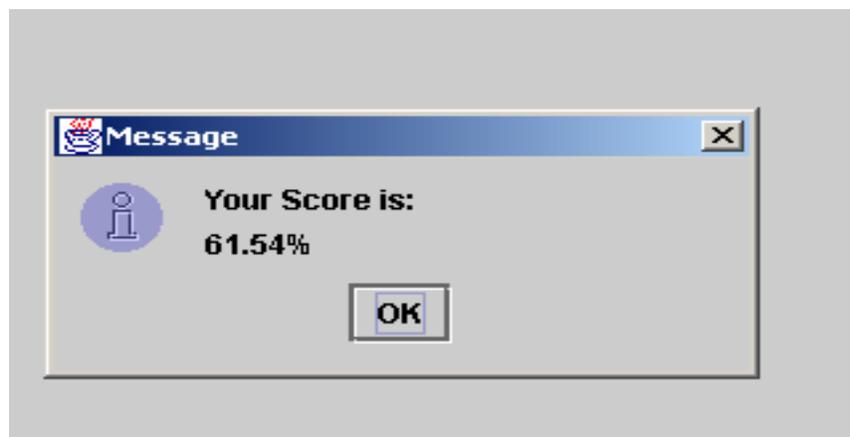


Figure 7: Result display