Developing a Mobile Adaptive Test (MAT) in an M-Learning Environment for Android Based 3G Mobile Devices

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Abstract – **M-Learning (e-Learning through mobile device) is gaining its importance worldwide among the Learning Community owing to the ubiquitous and powerful computing nature of the Mobile Devices. In an M-Learning environment, Student Assessment and Evaluation of their knowledge acquisition is a vital factor. Adaptive Testing helps the instructor to obtain an accurate estimation of the student's level of knowledge and learning ability. The significant advantage of Adaptive Tests is that each student receives different questions and the number of questions also varies depending on their performance level. The tests are designed according to the instructor's specification for the selection of question, the marks awarded for each question and the evaluation technique. The Adaptive Tests have to include various question and answer formats like drop down list, fill-in the blanks, Yes/No and multiple choice question etc. and the test content should support multimedia objects. The Android Platform for 3rd Generation Mobile Devices provides a rich set of User Interfaces (UI), gestures and 2-D and 3-D graphic capabilities. The goal of this paper is to design and evaluate the Mobile Adaptive Test (MAT) in an M-Learning environment for Android Based Mobile Devices**.

Keywords: Android, Adaptive Tests, Mobile Devices, 3-G, M-Learning

I. INTRODUCTION

Educational institutions and common testing services which conduct tests like GRE, TOEFL, CAT and GMAT are trying to reduce the cost of the exams, the workload and delay of scoring, and the human errors. Apart from this the testing agencies try to increase the accuracy and efficiency of the testing. Recently, most examination organizations use Computer Adaptive Testing (CAT) as the method for large scale testing. With the advancement of Mobile Phone and Tablet which is ubiquitous and becoming smart devices the Computer Adaptive Tests now target the Mobile devices and the term coined as Mobile Adaptive Tests (MAT) in present day learning environment. Mobile adaptive tests (MATs) are becoming increasingly popular in a variety of domains. Because of mobile devices availability and advances in item response theory, adaptive testing is now used in a myriad of settings. MATs tailor the test to each individual examinee in order to obtain accurate measurement across the examinees with varied educational background and performance levels. MAT is a good way to measure accuracy of the test performance besides increasing the test efficiency.

The increasing number of students, the need for effective and fast student testing, multimedia-based testing, self-paced testing, immediate feedback, and accurate, objective and fast scoring push many organizations to use Computer-Based Testing (CBT) or Computer Assisted Assessment (CAA) tools (Brown, 1997). But this is not

enough. Current learning theories lead towards student-centered and personalized learning. There is also increased interest for reducing the cheating, reducing the examinee's anxiety, challenging but not frustrating the examinees, as well as for immediate and continuous examinee's guidance based on his knowledge, proficiency, ability and performance. Thus, many organizations are further driving towards computer adaptive testing (CAT) tools (e.g. GMAT, GRE, MCSE, TOEFL). CAT is a special case of CBT. It is a computer-based interactive method for assessing the level of a student's knowledge, proficiency, ability or performance using questions tailored to the specific student. The CAT system selects questions from a pool of pre-calibrated items appropriate for the level of the specific student. Wainer (1990) indicates that two of the benefits of CATs over CBTs are higher efficiency and increased student motivation due to higher levels of interaction provided.

Mobile application or shortly called as Mobile apps is a term used to describe the applications that have been developed for small low-powered handheld devices such as mobile phones and tablets etc. These applications are either pre-installed on phones during manufacture or downloaded from the mobile app store or through other mobile software distribution platform.

Mobile Adaptive Test (MAT) augments the Computer Adaptive Testing (CAT) with more flexibility in terms of users mobility and test anytime anywhere scenario. Mobile Adaptive Tests enables the learner's performance assessment of the learning content provided to the user in the M-Learning Environment by the trainer. It also helps to modify the content presentation in subsequent training sessions by the trainer.

With the advancement in cellular technology on transmission and multimedia content, education has not only migrated to mobile space, but has also become semantically richer. Mobile Multimedia content, associated with human perception, including acoustic and visual effects, such as animation and graphics, as well as feedback forces, have become very attractive to learners because of the engaging human computer interactions. In recent years, mobile multimedia research has contributed valuable ideas and techniques to improve learning, teaching and testing. State-of-the-art mobile multimedia systems, available online or standalone, were designed to help students explore abstract concepts, keep them engaged in problem solving and improve their long term performance. The goal of multimedia education is to provide equal educational opportunities to everyone, who can access learning and testing support anywhere and at any time.
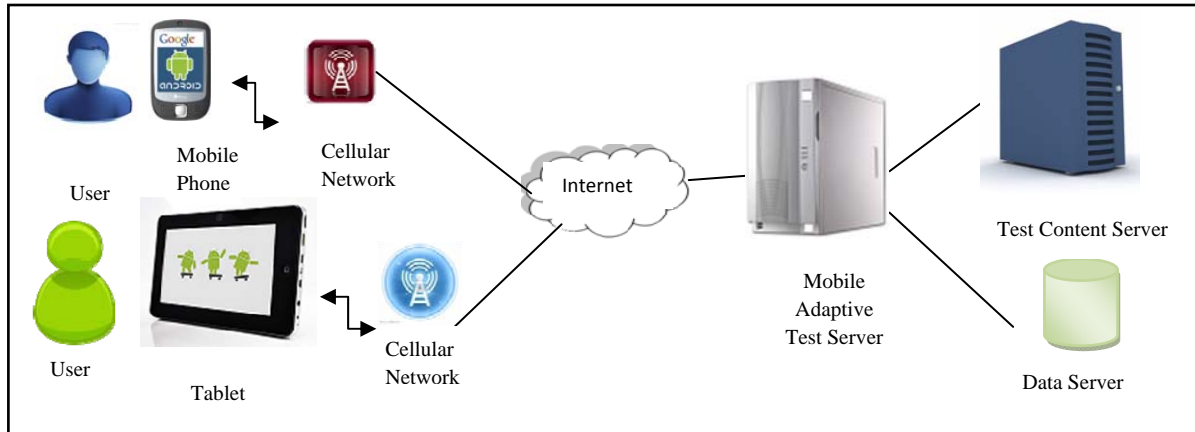

Fig 1. Mobile Adaptive Test Environment Scenario

Fig 1. depicts the Mobile Adaptive Test Interaction with various mobile devices through the wireless cellular network. A typical mobile system varies in terms of devices, user functionalities and the accessibility and operability in various locations and the way it can connect with servers by various methods. The mobile system typically includes mobile devices, wired and wireless connectivity, backend server and underlying Network Infrastructure.

The user presented with the Mobile Adaptive Test after validation by the Mobile Adaptive Server through data server. The Test Questions and other multimedia content relevant to the test data are available on the Test Content server. The Data server holds the data relevance between the test question and answer and other scoring related data. The Mobile Adaptive Server provided with suitable algorithm for presenting the question in random manner with appropriate feedback system based on the learners answering ability and also holds the temporary data provided by the user (Learner). The End user (Learner) access the Mobile Adaptive Test in his\her android based mobile phone or Tablet and other mobile devices.

II. ANDROID PLATFORM

Android is reshaping the way people communicate. It's in our phone or tablet, on our wrist, in our car, on our TV, in our camera, at our home, and at the store. It's a new and almost unlimited landscape for mobile application developers. Android gives the application developer an open platform for developing any application the developer can imagine, and an open marketplace for distributing the products to a large and growing user base. Android is an open platform that drives innovation in mobile communications and beyond. Building on the contributions of the open-source Linux community and more than 300 hardware, software, and carrier partners, Android has rapidly become the fastest-growing mobile OS. There are more than 200 million activated Android devices, and every day more than 550,000 new devices are activated in more than 137 countries and regions. Android's openness has made it a favorite for consumers and developers alike, driving strong growth in application consumption. In the recent times people downloaded more than 2.4 billion apps to their Android devices.

Android is continuously pushing the boundaries of hardware and software forward, to bring new capabilities to users and developers. For developers, the rapid evolution of Android technology lets the user stay in front with powerful, differentiated applications. Android gives the developer access to the latest technologies and innovations across a multitude of device form-factors, chipset architectures, and price points. From multi-core processing and high-performance graphics to state-of-the-art sensors, vibrant touch screens, and emerging mobile technologies such as Near Field Communication (NFC), Wi-Fi Direct, and face tracking — Android gives the developer an open platform for creating any kind of mobile application.

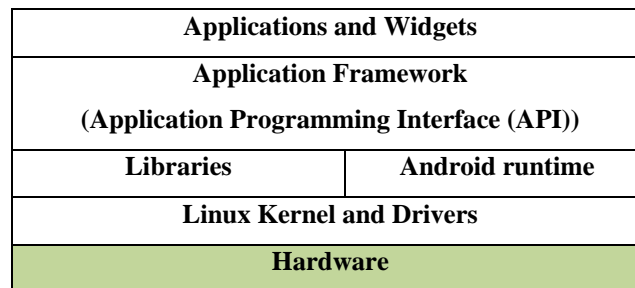| Applications and Widgets	
Application Framework	
(Application Programming Interface (API))	
Libraries	Android runtime
Linux Kernel and Drivers	
Hardware	

Fig 2. Android Architecture

Figure 2 depicts the architecture of Android operating system.

The operating system is based on *Linux kernel* version 2.6.x, that is a monolithic kernel. The kernel includes *drivers* for the mobile device hardware: screen, keyboard, camera, USB, Bluetooth etc. Kernel provides interface hardware and memory management, processes and other resources.

Native *libraries* on the next level are dependent on hardware architecture of the mobile device. These libraries include support for 2D and 3D graphics (Single, OpenGL ES), multimedia, security, storage, browsing (WebKit) and standard C library.

Android applications are developed using Java programming language. Applications require an *environment* to manage their life-cycle. This includes a Java virtual machine (called Dalvik virtual machine) and Java class libraries that provide basic support for applications (collections, input/output operations management etc.). Android applications are not compatible with Java ME or Java SE. The applications are optimized for mobile devices constraints.

The *application programming interface* allows accessing a framework that includes components used by all Android applications. The application framework includes components for Android application management (installation, execution), windows management and user interface graphical, event handling etc.

Application level includes pre-installed applications (contact management, phone, calendar, Internet browser) and user applications. Applications are based on Java technologies and use classes provided through application programming interface. In addition, there is the possibility to use native functions in programs written in C/C++ programming language through NDK (Native Development Kit).

Widgets unlike applications, occupies only part of the main display screen and associated (Home). Android operating system is multitasking, each application running in a separate thread.

III.   MOBILE ADAPTIVE TEST – ASSESSMENT ENIVROMENT FACTORS

The significant advantages of Mobile Adaptive Test platforms are

- Automatic difficulty level estimation for selected subjects / content (Economides, 2007)
- Adaptive testing using innovative multimedia based content rather than traditional multiple choice items
- System-assisted automatic question item authoring, rather than manually creating different questions
- Custom-designed modules for tracking precise concepts that are lacking in recommendation systems
- Accurate Assessment of Mobile Learner's performance level and.
- Ability for testing beyond only subject knowledge, unlike other e-learning systems

The Mobile Adaptive Tests designed for Android based mobile devices have been formulated under following Pedagogical and Technical environment:

The learning environment based on pedagogical principles and test formats consists of the following factors: 1) Multimedia Test Content 2) Test format and presentation for various mobile devices, 3) Adaptive Test Question Sequencing based on the performance level, and 4) Test Performance Feedback.

Multimedia Test Content

The Content refers to the quantity and quality of the Test items in the Test Content Server. It is very important since the test is based on these contents. The contents should be designed based on the Multimedia concepts with suitable graphics, pictures and videos along with Text. It determines not only the test topic but also the test with varying difficulty levels. The content of MAT should be based and supported by present day scenario acceptable didactic and pedagogical theories, such as: creative, explorative, active, constructive, problem solving, critical thinking learning. It should be personalized. They should be relevant, suitable and appropriate for the indented tests, ages and educational level of the examinees. They should adjust and support the values of the examinees and the value of learning.

Test Format and Presentation for various Mobile Devices

The Mobile Devices like Mobile Phone and Tablets comes with different form factor hence the test format and presentation assumes prime importance apart from the content. Presentation refers to the presentation, media and format of the items in the MAT. The presentation, media and format of the items should be personalized. It should be clear, simple, and of low overhead. It should be rich, be based on a variety of media (e.g. text, picture, image, graphs, diagrams, audio, video, immersion) of high quality (e.g. resolution, number of colors, sound fidelity). There should be the right mix of media objects at the appropriate positions with low distraction. The result should be enjoyable.

Adaptive Test Question Sequencing

Adaptive Test is based on the learner's performance levels marked with each question and the test questions are to be sequenced accordingly. Sequencing refers to the sequencing of the items presented to the examinee. In MAT, the Sequencing of the items depends on the examinee's answers. An adaptive algorithm is employed to select the next item to be presented to the examinee. This algorithm should be based on a valid and accredited pedagogical and psychometric theory. The duration and the number of items in the MAT should be enough to produce valid results. It should enhance student's motivation and enjoyment. It should support a variety of item types, sequencing methods and scoring methods. It should support a large number of concurrent tests and examinees. The scores should be stable, reproducibility, and consistent.

Test Performance Feedback

Feedback refers to the response of the MAT system to the examinee's actions. It may aim to control, guide and regulate the examinee, or instruct and teach him, or help and support him. It may inform him about his progress, his strengths and weaknesses. It may also try to develop, enhance and improve his strengths as well as reduce and correct his weaknesses. The feedback to the items should be personalized. It should be timely, accurate, relevant, clear and easy to understand. It should be of proper quantity, media and format.

The technical environment for Mobile Adaptive consists of the following factors: 1) Rich User Interface, 2) Reliability and Maintainability, 3) Functionality, 4) Connectivity, 5) Security, and 6) Adaptation.

Rich User Interface

The User Interface is the aggregate of input and output means by which the examinees interact with the MAT system. It includes the graphical, textual and auditory information the MAT system presents to the examinee, and the control sequences (e.g. keystrokes with the Mobile Devices Keyboard, and selections with the touch screen) the examinee employs to interact with the MAT system. The design of a User Interface affects the amount of effort the examinee must expend to provide input for the system and to interpret the output of the system, and how much effort it takes to learn how to do this. Usability is the degree to which the design of a particular User Interface takes into account the human psychology and physiology of the examinees, and makes the process of using the system effective, efficient and satisfying. Android Based Mobile Devices have Rich User Interface to support wide variety of input methods

Reliability and Maintainability

Reliability refers to the capability of the MAT system to maintain a specified level of operation during the assessment. The MAT system should achieve the following capabilities with minimum effort at minimum time: i) avoid failures and faults, ii) maintain consistent operation even in case of failures, iii) recover from failures re-establishing its previous state of operation, and iv) be available to the examinee at any moment during the assessment. A simple way around this problem is to have "mirror sites" on alternate servers. Additionally, keeping on alternative communication paths between the examinee and the MAT system increases the reliability.

Maintainability refers to the effort and time needed for installation, fault removal, update, upgrade, expansion and other modifications of the CAT system. Also, it is related to the risk taken from unexpected effects of modifications.

Functionality

Functionality refers to available functions, features (e.g. alerting and reminding), tools (e.g. calculator, editor, scratch-work space, drawing, audio and video recorder, camera, etc.), and applications in the MAT systems. It examines the quantity, quality, appropriateness and the properties of these functions to support the examinee during the assessment. Android OS based devices are pre-built in with the above functional requirement tools.

Connectivity

Connectivity refers to the ability of the MAT system to interact and communicate with server through wireless infrastructure. The Android based mobile devices have the capability of Wi-fi to interact with the server in intranet based environment and 3G facility for external factors.

Security

Security refers to the protection of the MAT system against unauthorized access to or modification of information, whether in storage, processing or transit, and against the denial of service to authorized users or the provision of service to unauthorized users, including those measures necessary to detect, document, and counter such threats. It ensures a state of inviolability from hostile acts or influences. It prevents unauthorized persons from having access to restricted information. It also ensures confidentiality so that information is accessible only to those authorized to have access.

Adaptation

The MAT systems select the next item according to the last answer of the examinee. If the examinee answers an item correctly then the next item is more difficult than the current item. On the contrary, if the examinee answers incorrectly then the next item is an easier one. The possibility of two examinees to view exactly the same questions is very small. So, the MAT systems adapt the Content to the level of knowledge of the examinee. However, the systems do not adapt the Presentation to the personal taste of the user and the Sequencing algorithm is hidden. The examinee sees only the questions and the possible answers. Usually, the examinee does not know that the next item is presented according to his last answer. The Feedback is adapted in some tests but most of the tests provide standard information.

IV.   SYSTEM IMPLEMENTATION

The MAT application has been developed with Android Emulator with Version 4.0 Ice-cream sandwich and the prototype has been tested with the Android Based Tablet. The Server Modules have been developed with PHP and MySQL. The prototype Mobile Adaptive Test application developed consists of five activities:

- Authentication
- Test Selection
- Adaptive Question Sequencing
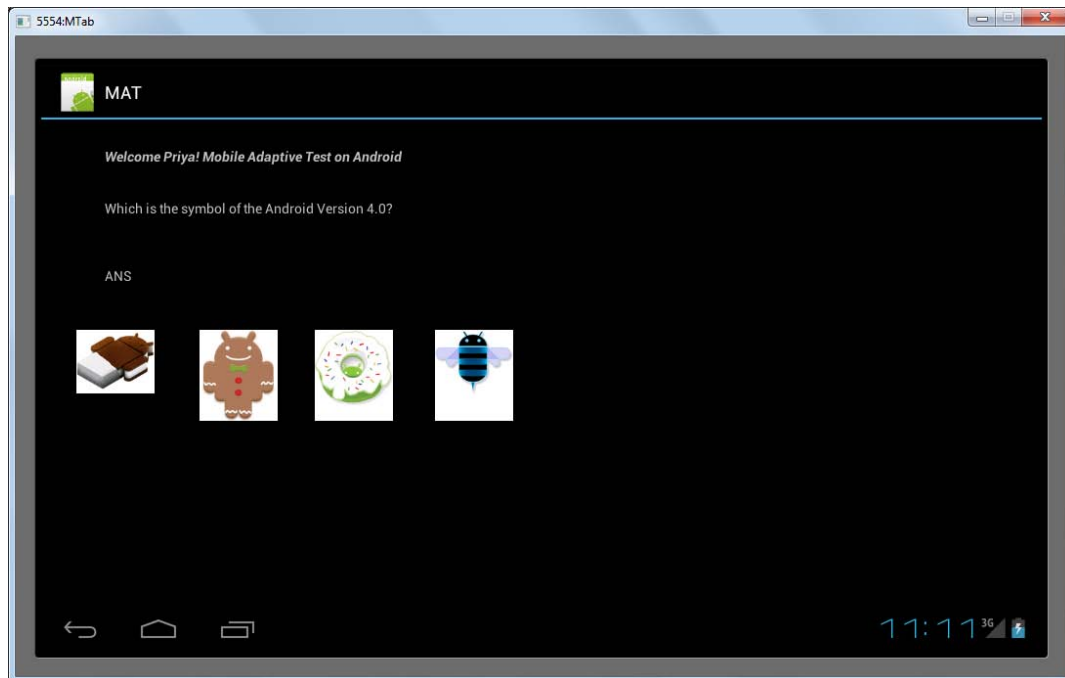- Performance Assessment
- Feed Back

Fig 3. Mobile Adaptive Test User View

Fig 3.depicts the user view of the Mobile Adaptive Test with images to click on it to submit as answer for the test question.

```
<?xml version="1.0" encoding="utf-8"?>
<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
   android:layout_width="match_parent"
   android:layout_height="match_parent"
   android:orientation="vertical" >

  <TextView
    android:id="@+id/textView2"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_alignLeft="@+id/textView1"
    android:layout_below="@+id/textView1"
    android:layout_marginTop="54dp"
    android:text="Which is the symbol of the android version 4.0?" />

    …………….

  <ImageView
    android:id="@+id/imageView4"
    android:layout_width="wrap_content"
```

```
                android:layout_height="wrap_content"
                android:layout_alignTop="@+id/imageView3"
                android:layout_centerHorizontal="true"
                android:src="@drawable/ver1" />
```

```
</RelativeLayout>
```

The following code is an example of a method used in this MAT:

```
package com.android.mat;

import android.app.Activity;

import android.os.Bundle;

public class MATActivity extends Activity {

    /** Called when the activity is first created. */

    @Override

    public void onCreate(Bundle savedInstanceState) {

        super.onCreate(savedInstanceState);

        setContentView(R.layout.image);

    }

}

package com.android.mat;

public final class R {
    public static final class attr {
    }
    public static final class drawable {
        public static final int ver1=0x7f020001;
        public static final int ver2=0x7f020002;
        public static final int ver3=0x7f020003;
        public static final int ver4=0x7f020004;
    }
    public static final class id {
        public static final int button1=0x7f050007;
        public static final int button2=0x7f050008;
        public static final int button3=0x7f050009;
        public static final int button4=0x7f05000a;
.
..
...
    }
    public static final class string {
        public static final int app_name=0x7f040001;
        public static final int hello=0x7f040000;
    }
}
```

The user interface is designed with multimedia content for tester-friendliness. The original version has been designed with interactive and user-friendly icons and menus. The application targets the mobile devices like phones and tablets with touch screen, but can be accessible by any kind of device running Android platform.

A user (Tester) logs in to the application environment and has not been shown in fig. The user is authenticated by the user credentials stored on the database server which stores the unique profile for each learner. Upon logging to the application the user profile is synced with the type of device that he/she uses. After successful login the main screen for Test module selection is presented in Fig 3. The associated activity is MAT and is declared in Androidmanifest.xml configuration file. The next question posted to the user is based on the performance level and is appraised by the Mobile Adaptive Test server which has pre-built configuration and assessment algorithm stored in it.
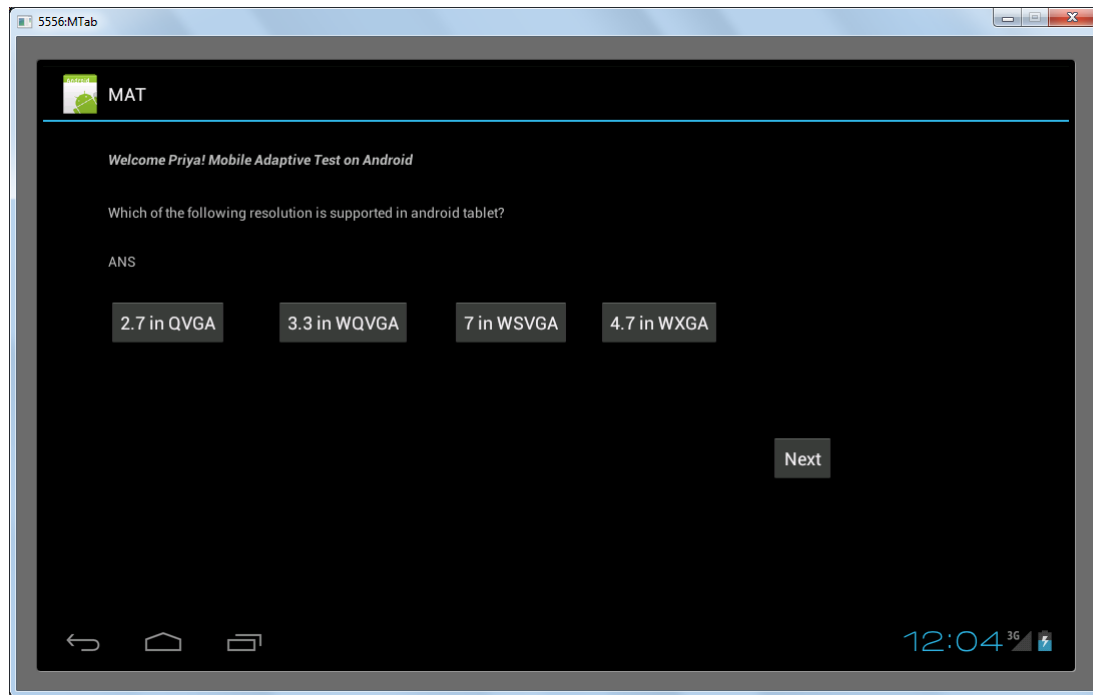

Fig 4. Mobile Adaptive Test User View of the Next Question

Fig.4 depicts the user (Tester) has been posted with next question based on the answer he submitted for the previous question and this is randomly assigned to different users based on his\her performance level.

V. RESULTS AND DISCUSSION

This paper has been dealt with the development of Mobile Adaptive Test (MAT) for the Android based 3rd Generation Mobile Devices. The prototype developed for assessing the English Language Learning among the learners on their academic achievement has been tested with three different groups of learners belonging to Computer Applications specialization. The Mobile Adaptive Tests have yielded positive and better results from the learner when compared to the traditional form of testing methodology in the class-room settings and linear classic testing where each student has been presented with a same set of questions. The multimedia content inclusion in the question formats have enhanced the learners answering ability to a new higher level showing the improvisation in the knowledge acquisition and deeper understanding of the subject content. The Mobile Adaptive testing methodology helps the instructor to re-design the test and lesson content in a quicker way and focus his attention on individual student's performance level. The Mobile Adaptive Test based on multimedia question formats and rich set of User Interfaces provided by the Android platform offers the learner a high interactive test environment.

CONCLUSION

Mobile Adaptive Tests (MAT) can enhance the teaching-learning process in a great way in the M-Learning environment with greater emphasis on learner's knowledge acquirement through various assessment methods. Anytime, Anywhere and Just-in-time testing strategy helps the learner to augment his learning process with

repeated test model which improvises his learning phase by answering different level of questions like beginner, intermediate and advanced level with questions of varying degree of difficulty presented to him every time the learner takes the new test. The instructor can design the lessons with focused attention on learners learning pace, ability and the level of understanding the subject content. The 3G Networks and 3G Mobile Device helps presenting the Multimedia enabled Adaptive Testing for learners due to the high bandwidth it provides for wireless internet connectivity. The open-architecture, multimedia and graphics rendering capability and rich set of User Interfaces, gesture and sensor based controls make the Android a much preferred platform for Mobile Devices and highly suitable for developing and implementing M-Learning applications.

REFERENCES

[1] Android Developer Site - http:/developer.android.com
[2] Angel Syang and Nell B. Dale. Computerized adaptive testing in computer science: assessing student programming abilities. In SIGCSE '93: Proceedings of the twenty-fourth SIGCSE technical symposium on Computer science education, pages 53–56, 1993.
[3] Brown, J. D. (1997). Computers in language testing: present research and some future directions. *Language Learning & Technology*, 1(1), 44-59.
[4] Economides, A.A. & Roupas, C. : Evaluation of computer adaptive testing systems - International Journal of Web-Based Learning and Teaching Technologies, Vol. 2, Issue 1, pp. 70-87, 2007.
[5] ETS, Pearson and College Board - Some Considerations Related to the Use of Adaptive Testing for the Common Core Assessments - http://www.pearsonassessments.com/ - February 2010
[6] Morales, J., Santos, O.C., Boticario, J.G. - An Approach to Standard-Based Computer Adaptive Testing - Ninth IEEE International Conference on Advanced Learning Technologies, 2009.
[7] Patricia A. Dunkel, Georgia State University - Considerations in Developing and Using Computer-Adaptive Tests to Assess Second Language Proficiency – ERIC DIGEST EDO-FL-99-07 October 1999
[8] Phankokkruad M, Woraratpany K - Web Service Architecture for Computer-Adaptive Testing on e-Learning International Journal of Human and Social Sciences 4:9 2009
[9] Tao, Y.-H., Wu, Y.-L., & Chang, H.-Y. - A Practical Computer Adaptive Testing Model for Small-Scale Scenarios. *Educational Technology & Society*, *11*(3), 259–274. 2008
[10] Wainer,H. (1990). *Computerized Adaptive Testing: A Prime*r. Lawrence Erlbaum Associates, Publishers, New Jersey.
[11] Wikipedia -Computer Adaptive Testing - http://en.wikipedia.org/wiki/Computerized_adaptive_testing
[12] Yueh-Min Huang, Yen-Ting Lin and Shu-Chen Cheng - An adaptive testing system for supporting versatile educational assessment – http://www.sciencedirect.com – Computers & Education Volume 52, Issue 1, pp 53-67, January 2009.

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