THE DESIGN AND IMPLEMENTATION OF AN E-ASSESSMENT SYSTEM FOR COMPUTER LITERACY SKILLS

Abstract

The increasing demand for computer literacy skills worldwide led into the development of assessment tools and systems. This paper presents the design and implementation of such a system. It explains the system's technical architecture and components, its functionalities and services and discusses the pedagogical and educational aspects embedded in the design.

Introduction and Background

People of all ages, students at all levels of the educational system, employees and managers in all types of organizations, use computers and information communication technologies (ICTs) for activities ranging from completing school assignments, carrying out routine work at the office, making management decisions, socializing on the internet.

Computer Literacy

Early definitions of computer literacy focus on two areas: "whatever a person needs to know and do with computers in order to function competently in our society" and "a measure of competency to exploit computer technology" (Halaris & Sloan, 1985). Although early work for computer literacy has its roots in elementary school (Albee, 2003; Asan, 2003), globalization has definitely affected this field as well and computer literacy has now become a global issue (Asan, 2003; Csapo, 2002).

A similar definition was adapted by the Australian Ministerial Council on Education, Employment, Training and Youth Affairs. (2007) as cited by Ainley et al (2008) according to which ICT literacy is defined as:

> 'the ability of individuals to use ICT appropriately to access, manage, integrate and evaluate information, develop new understandings, and communicate with others in order to participate effectively in society'(p.1).

The notion of computer literacy has been highlighted by governments, organizations and business alliance stakeholders. The European Union Member Countries, in response to the European Union Lisbon Strategy (2000), to initiatives and action plans such as e-Europe (2000), e-Europe 2002 (2001a), e-Europe 2005 (2003) and i-2010 (2005) which identified the lack on ICT skills among European citizens and called for 'digital convergence' (2005:pp 3,5,6,10,11,12) and digital literacy, prepared e-strategies which included specific measures and actions for the up-skilling of their citizens.

Currently, the European Commission under the Flagship Initiative 'A Digital Agenda for Europe' aims to 'promote internet access and take-up by all European citizens, especially through actions in support of digital literacy and accessibility.' (2010:p.12) and urges Member States 'to promote deployment and usage of modern accessible online services (e.g. e-government, online health, smart home, digital skills, security).'. (2010: p.12).

With the vision of 'Fostering 21st century e-skills and digital literacy of Europe's workforce and citizens for a competitive, innovative and inclusive Europe', the e-Skills Industry Leadership Board (2010) brings together leading ICT vendors to contribute to the development and implementation of a long term e-skills and digital literacy agenda in Europe.

Cristobal and Romani (2009) identify a variety and diversity on the approaches related to the term e-Competences and they elaborate on five definitions relating to it; namely 'e-awareness, technological literacy, informational literacy, digital literacy and media literacy' (p.19). Their distinctions of e-competences confirm Hoffman and Blake (2003) that computer literacy has evolved with time as technology improved and society became more dependent on computers. They also elaborate on 'technological literacy' (2009:pp.20, 21) according to which a user is equipped with confidence in operating ICT applications ranging from the standard office applications to popular digital devices. It is important to note that Cristobal and Romani (2009: p.21) identify only the 'ECDL or EPICT' as the 'formal environments' in which this level of literacy can be acquired. A

similar elaboration is presented by Owens (2003) who identifies database concepts, general computer concepts, Internet concepts, presentations, spreadsheets, web authoring, word processing as key areas of computer literacy.

Computer Literacy Assessment Models

Evidence shows that existing computer literacy assessment tools build on these definitions. Typical examples include the introductory awards for computer users, which assess competence in the use of common IT applications; examples include the ITQ (Information Technology Qualification) designed by e-kills UK; OCR's CLaIT (Computer Literacy and Information Technology) certificate, the European Computer Driving Licence (ECDL), City & Guilds Certificate for IT Users, Edexcel Diploma in Digital Applications (DiDA). (Leney & Ponton, 2007).

The Case of ECDL – European Computer Driving Licence

The ECDL is managed internationally by the ECDL Foundation, a not-for-profit organization based in Dublin. To acquire the ECDL qualification a person has to succeed in seven tests, one theoretical and six practical. The practical tests are taken on the computer and relate to the most common office applications used both in the office and at home, by young students, employees and professionals in all areas of the business environment.

The ECDL (2010) is considered today to be the most widely and internationally recognized computer skills certification for end-users. It is considered as the de facto pan-European standard for measuring end-user basic ICT skills. With a structured syllabus translated in over 40 different languages it has become a universally acceptable model for assessing computer skills. Its ever increasing base of ten million holders of the certificate the ECDL constitutes the most massive and active community of computer learners globally.

Numerous European Commission (2001, 2002, 2005) and OECD (2002, 2007) studies make reference to the ECDL recognizing its role as a best practice of computer literacy and its importance in the education systems and the business world. A brief review of related documents reveals two important guidelines of the European Commission (2001b) relating to the ECDL:

> 'Member States, in partnership with private actors, should provide incentives for the unemployed to get a recognised certificate of basic ICT skills, like the European Computer Driving Licence (ECDL).' (p.6)

The High Level Group Employment and Social Dimension of the Information Society (ESDIS)(2001) has also recommended to the Commission:

> 'That the ECDL be accepted as a Europe wide basic IT accreditation scheme, fulfilling the referenced eEurope2002 action line intention, without prejudice to either existing national schemes or the possibility of including other schemes. Moreover, the future direction of a European basic IT skills diploma should be further elaborated under the "eLearning action plan" as envisaged there.' (p.2)

Weiss et al (2005) report for CEDEFOP that

> 'The ECDL Foundation has created a widely respected set of quality guidelines for the creation of syllabi and the conducting of tests.' (p. 100)

and that

> 'the ECDL possesses significant recognition at European and International Level.' (p. 72).

e-Assessment for ECDL

The development of e-assessment systems for ECDL is based on a set of quality guidelines issued by the ECDL Foundation (2010) which also undertakes the evaluation task in order to provide the required approval to the vendors interested to develop such systems. Despite its huge worldwide success the ECDL has not managed, yet, to establish a unique, universal and standard assessment model. This practically means that in some countries ECDL tests are manually assessed by assessors where as in other countries ECDL assessment is computer based. Within the ECDL community, such e-assessment models are referred to as Automated Testing and Evaluation Systems (in brief, ATES).

Bennett (2002) explains that in the same way that technology is important and critical to learning, it will soon become equally vital to assessment. As cited by Sterling (2009), Kim and Huynh (2008) are strongly convinced that computer-based tests are seen as "the future of testing". This is especially true for the case of the ECDL, the large number of ATES available for ECDL prove this fact.

Due to the ECDL content, the software used for testing are primarily the versions of Microsoft Windows and Microsoft Office (2010). ATES implementations follow two basic approaches based on:

a) simulation techniques (called in brief as SIM-ATES). These systems simply simulate the application software's environment and present only limited functionality to the user as required by the particular test questions. Although in many cases these systems appear to be impressive and resemble to a very high degree to the actual application software, a closer look immediately reveals their limitations.

b) the full operation of the actual application software. So, if a candidate will be tested for his word processing skills, then the application software installed on the candidate's personal computer, for example MS Word, will launch and fully operate during the whole testing process and the test candidate will solve the test working within the application. Thus, the term In-Application Automated Testing and Evaluation System (InA-ATES) is proposed.

SYSTEM DESIGN DECISIONS

Integrating Pedagogical Issues in System Design

In practical terms relating to the discussion on formative and summative assessment, we adopt Bull and McKenna (2004, p. 12) that computer assisted assessment offers a bridge between the two approaches, that the line between them is blurred and the timely utilization and exploitation of marking and feedback is vital.

Feedback is a component within the learning process provided either by peers or teachers or the learning environment itself. Black and Wiliam (2009) identify the provision of feedback that moves learners forward as a key and strategic aspect of formative assessment.

InA-ATES can be considered as fundamentally and primarily summative assessment tools. They are offering pure assessment of learning and measure the performance of test candidates on a particular application's test set of questions. A preliminary review of some of the available ECDL InA-ATES (2010) indicates that these systems, although technologically sound and in some areas innovative, do not embed any formative

assessment techniques. An unsuccessful assessment mandates the repetition of the learning and assessment cycles and feedback becomes fundamental for the potential success of the candidate in subsequent test attempts. Adopting a candidate-centric approach to design, the design team considered it as the cornerstone for the design. To this end, the system provides a detailed results feedback report for each candidate indicating the reference items of the ECDL syllabus for each test question, the duration taken by the candidate to resolve the question, the mark (0 or 1) and the question status (answered, not answered or ignored). Analysis of the data provided can serve the post and self-assessment process which each candidate, in cooperation with the trainer, has to perform. The aim of this activity would be to identify gaps of knowledge and weak areas in which the candidate has to pay further attention and plan his further learning upgrade. Furthermore, the information provided can be directly linked and mapped to the ECDL Syllabus and the learning objectives, thus offering unique guideline to trainers to identify the areas in which additional exercises and work must be prepared for those candidates who have failed. This approach is also recommended by Rountree (1987) who argues that "feedback or 'knowledge results', is the life-blood of learning" which enables a learner to identify strengths, weaknesses in knowledge areas and guide him to enhance the former and plan for improvements on the latter.

In today's classroom there is a misalignment between the way people are learning and the way they are assessed. Students are learning a number of topics in parallel, revisiting and reflecting on resources in order to fully comprehend concepts and theories. Black and Wiliam (1998, 2002) demonstrated that well designed formative assessment can lead to major benefits in student attainment on a wide range of conventional measures of attainment and this is independent of the discipline of the learner. The notion of "orderly learning" simply does not fit with the modern learning environments. When it comes to assessment using traditional paper-based methods, students have the flexibility to answer the questions starting from any part or question in the test, spend as much time they feel they require on a question, revisit their work and reflect on theories to confirm the correctness of their action.

Provision of enhanced flexibility to the candidate focused on the order of solving the questions, the number of attempts on a question and the time dedicated on a question. Implementation of these aspects required a detailed review of the test questions of all modules which indicated that questions should be as independent from one another as possible. So, the system allows the selection of questions and their solution in any order. The questions are presented highlighted in different colours according to their current status.

Figure 1. Interface for selecting test questions from a list in any order

These facilities resemble the way candidates actually act in the learning environment bringing an alignment with the tools and methods used during InA-ATES assessment. They also respond positively to Ridgway's and McCusker's (2004) valid concerns on the matter. It can also be claimed that their existence may also lead to better test performance; this is a question which needs to be researched.
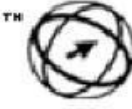
CYPRUS COMPUTER SOCIETY ™ EUROPEAN COMPUTER DRIVING LICENCE

Candidate Results Feedback Report

Test Center: COMPUTER INTERNATIONAL LATSIA	**Session:** 11.05.2010, 18:00 (675804) **Module:** M3 - Word Processing(M3)		
Name: KYPIAKOY MAPIA(29266653)	**Mark:** 81 (Passed)		

Question	Syllabus Knowledge Area	Grade	Duration	Status
1.	3.1.I First Steps with Word Processing	1	109	Answered
2.	3.3.1 Text Formatting	0	91	Answered
3.	3.2.3 Edit Data	1	110	Answered
8.	3.2.5 Search and Replace	1	145	Answered
9.	3.4.1 Tables	1	37	Answered
10.	3.4.1 Tables	1	37	Answered
11.	3.4.1 Tables	1	90	Answered
23.	3.2.3 Edit Data 3.3.1 Text Formatting	0	80	Answered
24.	3.5.1 Concept and Practice	0	125	Answered
30.	3.1.2 Adjust Settings	1	44	Answered
31.	3.3.3 Document Formatting 3.6.2 Printing	1	41	Answered
35.	3.6.1 Preparation	1	19	Answered
36.	3.6.2 Printing	1	26	Answered

Total Questions: 36 [**Correct:** 29 | **Wrong:** 7 | **Ignored:** 0 | **Not Answered:** 0]

Figure 2. Sample Candidate Results Feedback Report

Creating the Test Sets

In a manual testing environment the candidate is utilizing one major work file on which he applies his knowledge and skills to solve the questions presented in the test paper in a series. As the candidate progresses the work file is gradually extended and enhanced reflecting the candidate's work. The candidate can assess, to some degree, his status and progress by looking at the differentiation of his work file from one question to the next.

Skipping a question to solve the next is, of course, allowed but returning to revisit a skipped question is not a trivial action any more. This is because, the content of the work file may have changed to such a degree that the candidate's action to solve this skipped question may not be applied to the correct content of the work file.

To implement the same scenario in an InA-ATES environment would require having one work file to be saved after the candidate solves each question. An attempt to prototype such a solution led into many design complexities and it was abandoned. The solution given was based on the always working rule of "keeping things simple". Each test would consist of thirty six unique questions with no dependency from one to the next. This would allow implementing the evaluation of each question independent from the previous or next work of the candidate. This simple approach and solution also facilitated the flexibility in the navigation process among questions, kept the utilisation of system resources to the minimum and it caused no limitations to the candidates' numerous attempts to solve a question.

The system includes a large number of multi-part questions which are currently evaluated by giving 1 or 0 marks only. However, pedagogically this is considered unfair. To this end, a detailed review of the questions database is in progress in order to develop a "fairness-formula" which will allow the allocation of marks to the distinct parts of the questions.

InA-ATES Test Development Life Cycle

For the effective development of tests a rigorous and interactive process was established which allowed the rapid development, testing and quality assurance of the test questions and their registration in the Questions Test Base, an integral part of the InA-ATES Engine.
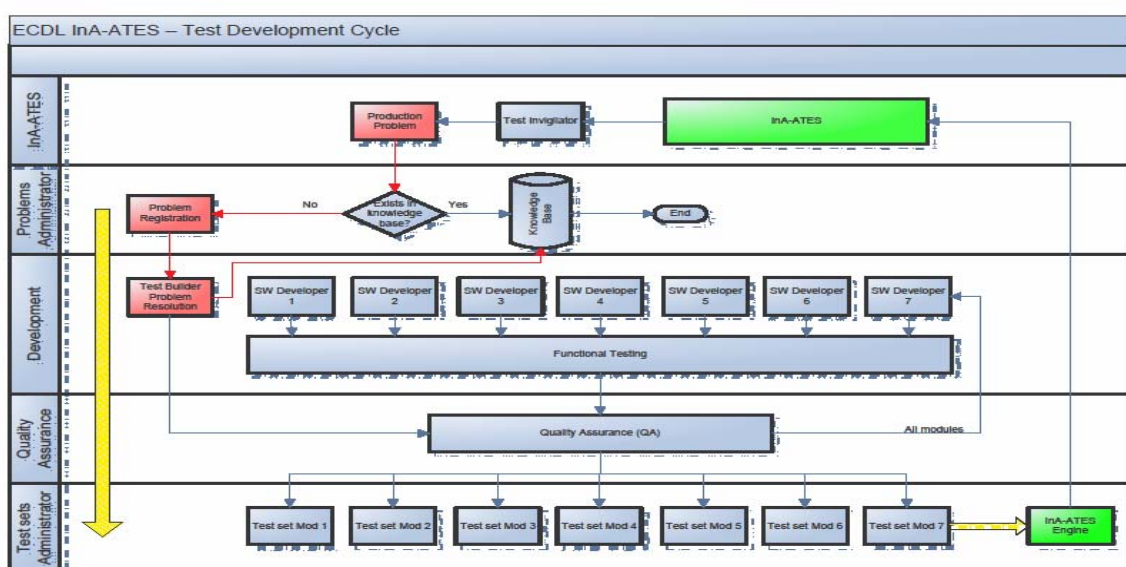

Figure 3. ECDL InA-ATES Test Development Life Cycle

Technical Architecture and System Components

The technical architecture of the system exploits the web based EMS – Exams Management System responsible for the registration and management of exam sessions and candidates. The EMS interfaces with the Exams Manager application which resides locally in each Test Centre (TC) lab to which a number of clients are connected. The test supervisor downloads the exam sessions for the particular lab on its exam manager, distributes the tests to each of the clients where the candidates sit and take their exam. On completion, the test supervisor collects the results from the client onto the Exam Manager and then uploads the results to the EMS for subsequent viewing by the candidates.
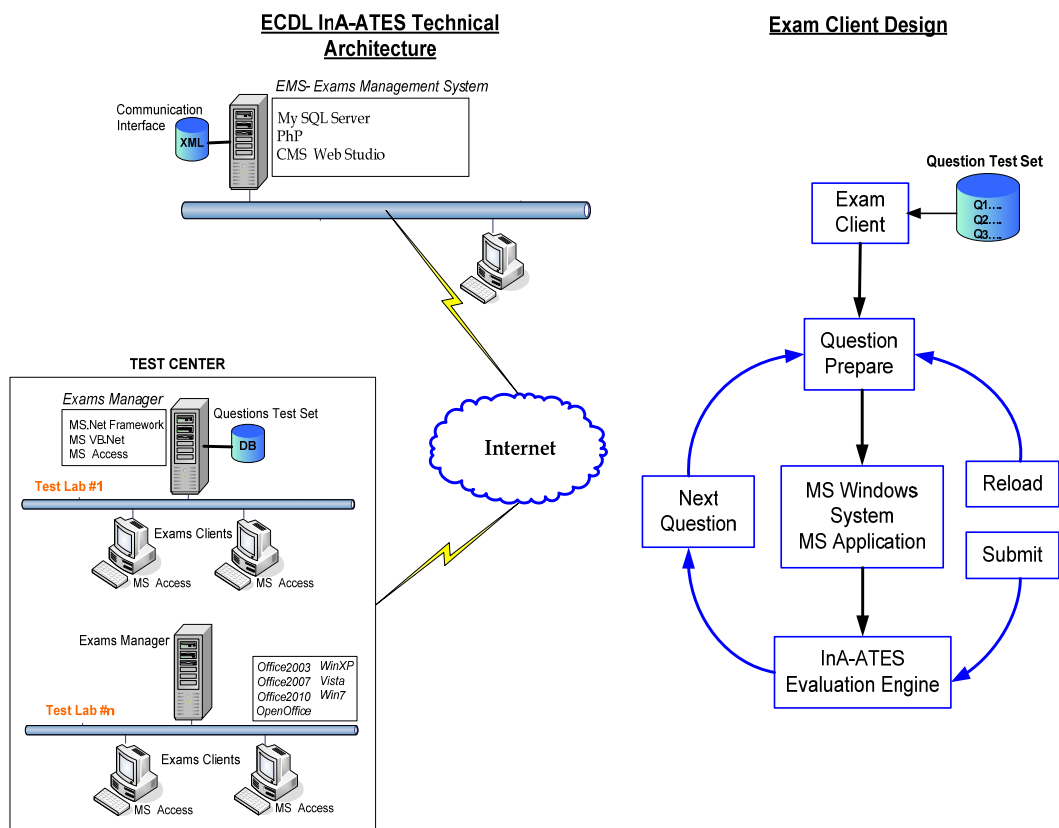

Figure 4. InA-ATES Technical Architecture & Exam Client Design

System Features

The system provides for an extensive set of features which can satisfy the business requirements of any type and size of a TC or even an ECDL national operator. Specifically it supports direct linking to the ECDL Syllabus and the defined learning objectives, multi-location and multi-test laboratory support, transparent use of multiple MS Office and MS Windows platforms within the same test lab, an intuitive and trivial user interface, support for people with special needs, integration with a candidate registration, administration and reporting systems and dual language question support.

User Interface Design

The intuitiveness of the user interface was discussed extensively among the development team members in view of the fact that the system would be utilised by a large number of candidates of all ages, different educational backgrounds and variable computer experiences. Winning the candidate by providing him with a simple user interface with the minimum possible options which would allow him to carry out the test process effectively was an easy decision to reach. For this first release of the system, however, it was decided that no customization of the user interface would be provided. The user interface consists of a number of easily understandable buttons whose functionality is self-explanatory.

Create a form using all the fields from the **Students** table. Accept the default settings. Save the form as **Students Form** and leave it open.

Figure 5. The Intuitive User Interface with a loaded question

Security

Ensuring the integrity and validity of the test process is a fundamental principle for the maintenance of the high quality standard of the ECDL concept worldwide. A number of measures and policies have been implemented which, in combination with the controls performed by the system itself ensures that the testing process is carried out effectively and that no unauthorized candidate can take the test.
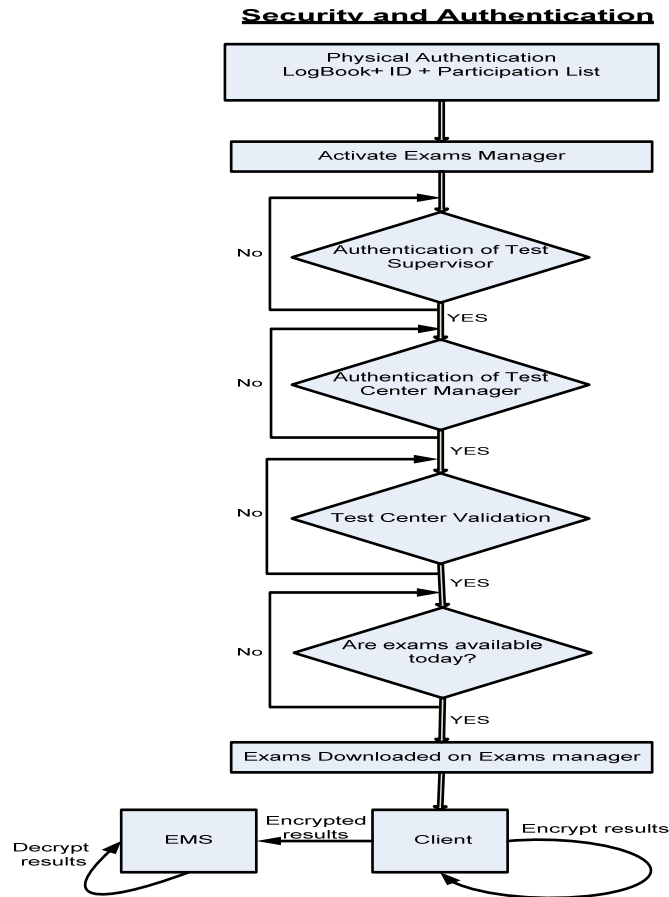
Figure 6. Candidate Authentication & InA-ATES Security Controls

Encoding the results of the candidate and preventing illegal and unauthorized access and subsequent modification is a fundamental functionality of the system. The results file is encoded using the standard Triple DES cryptography algorithm (2010b) at the exam manager level and decrypted at the EMS level before storing the results in the EMS Database.

Security measures are also implemented during the actual test process. Specifically, the copy/paste and Print Screen facility of the operating system are disabled so that the question text can not be copied and saved in a document and no screen captures can be taken and stored for later review. Although every effort is made at the TC to ensure that the network and the exam clients are virus free, there is always a possibility that a virus may exist which may jeopardize the integrity of the candidates' results files. To this end, any attempt to modify the results' file size is monitored and reported and the results are not uploaded in case of such incident.

System Stability and Reliability

One of the most impressive aspects of the system is its ability to recover from any point of failure allowing the candidate to transparently restart the test at the exact question and with the exact time left to completion as it was recorded at the time of failure. Such failures may be attributed to electricity power cuts or disruptions, system hang-up, accidental system power offs or system reboots. This functionality also solved a chronic problem of the manual system where in case of technical failure the candidate simply had

to retake the exam. It also enhanced the candidates' and TC managers' confidence as to the technical superiority of the system.

Conclusions and Future Developments

Although a formal evaluation of the system and a formal user satisfaction survey has not taken place yet, feedback received from TC managers, trainers and candidates on the quality of the system has been very positive. Following their first, mostly expected, reservations and reactions as to the level of candidates results in comparison with the results of the manual system; they soon realized that the tangible benefits offered on the overall organizational and educational aspects surrounding the learning and assessment process system reduced and mostly eliminated concerns. Their satisfaction on the project team's readiness and responsiveness to provide detailed information and the common understanding that new systems need time for refinement and adaptation by all users involved, served in the change management process. The minimum number of technical problems encountered after the national roll-out and the immediate corrective actions taken raised the confidence of all towards the new system.

Enhancements have already been identified and are in the pipeline for review and potential implementation. These include a feature for multi-language support, implementation of an n-computing solution, customization of the user interface, enhanced facilities for people with disabilities and an open systems edition. The process of problem reporting and resolution worked quite successfully due to the dedication of the team members and the detailed reporting they maintained, mainly using an Excel spreadsheet. If is to take this system further then it is expected that a more professional approach to this issue will be followed. The successful implementation of the system opens new horizons for replicating its success in other markets, thus providing an opportunity for global co-operations equivalent to the success of the ECDL.

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