A STANDARD AND INTEROPERABLE TECHNOLOGY-ENHANCED ASSESSMENT SYSTEM FOR SKILL AND KNOWLEDGE ACQUIREMENT

Enosha Hettiarachchi[1], Maria Antonia Huertas[2], Enric Mor Pera[2] and Ana Elena Guerrero Roldan[2]
[1]*Internet Interdisplinary Institute (IN3), Universitat Oberta de Catalunya (UOC), Barcelona, Spain*
[2]*Department of Computer Science, Multimedia and Telecommunication, Universitat Oberta de Catalunya (UOC), Barcelona, Spain*

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Abstract: There are some subjects that require a high level of skill practice and knowledge acquisition. Many of these are related with mathematical content. In particular, logic for computer science is a good example. There are some interesting tools and systems available for e-assessments of this kind of subjects in higher education, but none of them is providing rich feedback in a qualitative manner. In this paper, we describe a technology-enhanced assessment system for assessing both skill and knowledge acquisition in online higher education while adhering to e-learning and e-assessment standards and specifications. This technological requirement is achieved through designing a system which allows the integration of existing partially effective tools with common Learning Management Systems (LMSs) according to standard conformance. The system is designed and developed in a way that it can be used as modules to existing systems or LMSs. The reason for doing this is that institutes who are interested in the system can use the tool as a module integrated to their existing system which maintains interoperability.

1 INTRODUCTION

Technology-Enhanced Assessment (TEA) can be noted as the end-to-end electronic assessment process where Information and Communication Technology (ICT) is used for the presentation of assessment activity, and the recording of responses. This includes the end-to-end assessment process from the perspective of learners, tutors, educational institutions; awarding bodies as regulators, and the general public (JISC, 2007). Technology-enhanced assessments, which is most commonly known as e-Assessment or online assessments has become an integral part of e-learning based study programmes, ordered by educational institutes. The main reason is that teachers are seeking to expand assessment tasks, while at the same time broaden the range of skills assessed and provide students with more timely and informative feedback on their progress.

There are a wide range of tools which can be used for both learning and assessment. But most of the tools are focused towards learning and only few can be used for assessment. Technology-enhanced assessment can have questions and activities that have a predetermined correct answer or questions and tasks that have more than one way of giving the solution. Currently, most of the tools support only predetermined questions such as Multiple Choice Questions (MCQ) and True/False questions.

However these types of questions are good for assessing knowledge levels of students but when it comes to assessing skill levels, it is needed to go beyond these types of questions to provide rich feedback.

Both in learning and assessment, sharing of learning resources as well as communicating with similar systems has become a major challenge. Therefore different standards and specifications have been defined to represent the e-learning systems and components. In order to have a high quality technology-enhanced assessment system, a set of features and requirements have been identified. One of these requirements is e-learning standard and specification conformation while designing and implementing the systems. Standards help to ensure five abilities to the e-learning and e-assessment system such as Interoperability, Reusability, Manageability, Accessibility and Durability (Al-

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Smadi et al., 2009).

e-Assessment systems which can be used for both skill and knowledge assessment while adhering to most common standards and specifications are an interesting research and development goal.

The rest of the paper is organized into five sections where section 2 gives a general introduction about the standards and specifications used. In section 3, goals for developing a TEA system will be explained with more emphasis on logic course while also considering about e-assessments in general. Last two sections will explain about the design and architecture of the system and discussions consecutively.

2 STANDARDS AND SPECIFICATIONS FOR E-ASSESSMENTS

Most used standards and specifications associated with learning and assessment objects are; IMS Basic LTI (Learning Tools Interoperability), IMS QTI (Question and Test Interoperability), IMS LIP (Learner Information Package) (IMS GLC, 2011), IEEE PAPI (Public and Private Information) (CEN WS-LT LTSO, 2011), LOM (EduTech Wiki, 2011), and SCORM (Sharable Content Object Reference Model) (ADL, 2011). Additionally there are some assessment formats whose main objective is the authoring and sharing of assessment resources. This is an important factor which has to be considered when communicating and exchanging information between different systems, especially to maintain the interoperability among systems. These assessment formats should include the features such as response and outcomes processing (Proc), metadata capabilities (Meta), hybrid question management (Hybrid), correct response indication (C.R.) and multiple responses (M.R.) related to one question (Gutiérrez et al., 2010). Based on the above features, a comparison of some of the assessment formats are illustrated in Table 1.

From the above table, mostly considering about interoperability; IMS QTI, Hot Potatoes, MoodleXML, OpenMark and Blackboard can be taken into account. However, Blackboard is a commercial software and both Hot Potatoes and OpenMark are application specific (Gutiérrez, Kloos, and Crespo, 2010). Some systems are commercial/specific and they are not built according to standards as with open source systems, which can be easily integrated with other tools. As a result we can take MoodleXML, a common format of the popular and most used open source LMS, Moodle (Moodle, 2011) and IMS QTI, a defector standard.

Table 1: Key features in assessment formats.

Formats	Meta	Proc	M.R.	C.R.	Hybrid
IMS QTI	x	x	x	x	x
Hot Potatoes	x	x	x	x	x
MoodleXML	x	x	x	x	x
OpenMark	x	x	x	x	x
Blackboard	x	x	x	x	x
DocBook	x		x		
FML	x				
QAML	x		x		
SuML	x				

To communicate between LMSs and other tools while maintaining the interoperability, IMS has introduced some standards such as IMS Basic LTI and IMS-LIP. IMS Basic LTI, allow remote tools and content to be integrated into a LMS in a secure and interoperable manner. IMS-LIP specification addresses the interoperability of internet-based Learner Information systems with other systems that support the Internet learning environment. Also for tracking and transferring data between systems SimpleOutcome (IMS GLC, 2011) service can be used with OAuth (OAuth, 2011), an open protocol which allows secure API authorization in a simple and standard method for web applications.

3 KNOWLEDGE AND SKILL ASSESSMENT

There are subjects in which the skill levels of students are needed to be evaluated in order to qualify students of that particular subject. When considering mathematics as an example, the more general e-assessment systems offer a range of question types but they are not designed to offer a specific assessment experience. Therefore, systems and tools for e-assessment of mathematics have to add to more general characteristics of e-assessment systems, the possibility to represent mathematical notation first, to recognize symbolic representations, secondly and to asses complex processes and not only knowledge

These raised the need to go beyond ‘usual’ type of questions and incorporate a dynamic and an interactive user-friendly dimension into e-assessments. In particular, it is needed to develop a system for e-assessments of skill acquirement, which can communicate with currently available LMSs,

and which adheres to most commonly used standards allowing interoperability among systems.

As the case study, Mathematical Logic courses at the Universitat Oberta de Catalunya (UOC), a fully online university) will be considered. Logic is a subject which requires a high level of skill and knowledge. At the moment, UOC use a particular tool developed especially for mathematical logic called Logic E-Learning Assistant (LELA), which is an intelligent tutoring system for assisting the learning of Logic (Huertas et al., 2011). The current LELA system will be used as a module in the new e-assessment system along with other tools. At the same time, the data gathered from the new system can be used to measure the impact of e-assessments which in turn can be used to improve the assessment process. It will also help to gather knowledge on which methods/strategies are suitable for conducting formative and summative assessment as well as which indicators/variables should be gathered to draw conclusions in e-assessment. General requirements are being considered when designing and developing the system for both formative and summative assessments and it will be proved by using mathematical logic subject of the UOC.

4 SYSTEM DESIGN AND ARCHITECTURE

Following User Centred Design (UCD) approach, firstly we identified the problems related to skill and knowledge acquisition in online higher education. Existing tools and research projects used for evaluating both skills and knowledge acquisition in formative and summative assessments were analyzed. Then we identified the features and pitfalls in those systems and decided to develop a new technology enhanced e-assessment system. As our main case, we use Mathematical logic subject of the UOC. We designed scenarios for the system, which was evaluated and revised based on the feedback of the teachers and students. Since the system is being developed as a series of modules, it was needed to identify open source tools compatible with assessment formats such as IMS QTI and Moodle XML. It is highly important that these tools adhere to standards and specifications. LELA, will also be enhanced into an e-assessment tool. Then the architecture of the system was designed. Here we decided on few tools (eg: Moodle Quiz module, IMS QTI compatible tools) and how they can be integrated with the most common LMSs as shown in Figure 1.

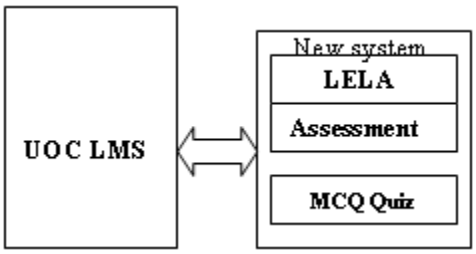

Figure 1: Architecture of the system – Level I.

We also decided on e-assessment standards (eg : IMS Basic LTI, IMS LIP, IEEE PAPI) needed to communicate with the LMS while maintaining security and interoperability. Also web services and security protocols (eg: SimpleOutcome and OAuth protocol) needed for tracking data from several databases and passing them to a common database are begin studied. Here both MCQ Quiz module and LELA will be used for formative assessments modules. Knowledge will be assessed by using MCQ and skills will be assessed by using LELA. The processed results are displayed in a common interface, which is accessible by students, teachers and administrators. The most cost effective way of displaying information to the users are studied, either by passing information from the common interface to the gradebook of the LMS or giving access to the interface through single sign-on facility. The ways to notify students and teachers after processing the information such as final grade or statistics of the system are also studied.

How to provide information rich feedback within each module and also how often feedback should be provided to improve the student learning process are being studied. The final system will be implemented with appropriate standards, web services and security protocols. The architecture of the final system is illustrated in Figure 2.

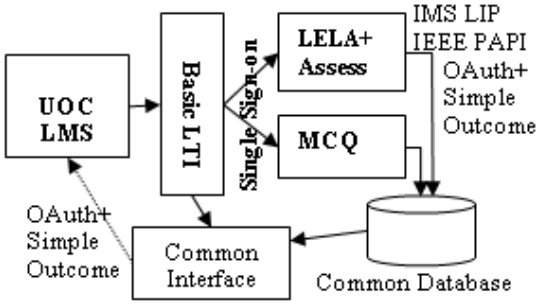

Figure 2: Architecture of the system – Level II.

After implementation, the system will be validated in a real online learning environment in the mathematical logic course. Through the

information/data obtained study whether it is possible to track student learning over the duration of the course. It is important to find out, which type of e-assessment and what kind of feedback should be provided to both teachers and students. It is also important to analyze whether the information obtained can be used to improve the system and the assessment process.

5 DISCUSSION

Through the User Centred Design process, we will be able to find out the most appropriate standards that should be used for the communication between systems while maintaining interoperability and also the suitable web services and security protocols that can be used to track, process, transfer and store data between systems. The system validation is carried-out with pilot studies in a real online classroom of mathematical logic. With the results obtained, we will be able to find an appropriate method for conducting e-assessments, the importance of feedback for e-assessment process, when to give quantitative feedback with guidance for students and also when to offer e-assessments in the learning process. In turn check the impact of e-assessments in the learning process.

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