# eAssessment: Trends in Content Reuse and Standardization

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*Abstract* - **eAssessment saves human work by automating presentation and marking, but also enables new forms of testing of interest for engineering education. Authoring reliable, high quality assessment content is a difficult and costly task. Public content repositories populated with stand-alone items of assessment content enable authors and teachers to set up an exam by selection and ordering, with little additional effort. Reusable, shareable assessment objects require conformance to standards of packaging and transportability. After revising eAssessment tools and content creation standards, this article identifies some popular learning platforms, authoring tools and public repositories, and verifies their standards compliance. Most popular learning platforms support packaging standards, but not assessment content transportability. Though some outstanding examples exist, there is a need for more public objects repositories and a deeper engagement in standards compliance. Government agencies and educational organizations have a role to play as the most powerful driving forces towards standards adoption for reusable content creation and sharing. Research in tools to aid education practitioners will be always valued, and can be carried on with rough consensus and small funding.**

*Index Terms* - eAssessment, eLearning, IMS QTI, SCORM.

## INTRODUCTION

The importance of eAssessment is increasing, not only for its greater spread but also for its being used in critical tasks such as job promotion or professional ability certification. After a brief review of eAssessment capabilities, this article addresses issues such as reusability, interoperability and standardization of assessment content, in an attempt to determine present trends in eAssessment evolution.

Two key standards are SCORM (Shareable Content Object Reference Model) and IMS QTI (Question and Test Interoperability specification). SCORM allows for sequencing, packaging and sharing of content; IMS QTI allows for transportability of assessment content. Generation and delivery of assessment content can be done within a learning platform or through specific tools. Content repositories provide teachers and authors with ready made material which they can improve, adapt or take as is.

Assessment content creation, conformance to standards and development of content repositories are issues of concern. Consensus on the value of reuse, interoperability and standardization does not ensure adoption. Practical considerations, authors' needs and will, institutional interests, economics and several other factors may act as driving forces or impediments. This article evaluates the current state of standards adoption and attempts to discover the driving forces behind. Only free software implementations are considered, and among them a selection of those more widely deployed.

This article is structured as follows:

- an overview of the assessment capabilities offered by learning platforms, authoring tools and object repositories help to focus on the subject.
- some examples show the potential impact of eAssessment on engineering education.
- the two key standards, SCORM and IMS QTI, are briefly revised.
- four most popular learning platforms are selected, and their support for SCORM and IMS QTI is verified.
- some content repositories are explored as to public access, completeness and standards compliance.
- standards conformance of eAssessment authoring in learning platforms and specific applications is evaluated.
- a summary of results leads to identify present trends and needs in eAssessment development.

## EASSESSMENT

eAssessment comprises all assessment processes where ICT (Information and Communications Technology) is used for the presentation of assessment material and the recording of responses [1]. eAssessment is commonly offered in learning platform or LCMSs (Learning Content Management Systems), web or computer based applications designed to manage educational and assessment content [1]. Most LCMSs provide several types of question [2]:

- Multiple Choice, with one or more correct answers.
- True or False.
- Short Answer, a word or simple phrase from a list.
- Numerical, an exact number or a number within a range.
- Matching, a two-column concept matching question.
- Calculated questions: random values are placed into an equation, result differs each time the question is seen.

Questions can be presented each time in a different random

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order, time limits can be set, number of attempts and final results can be recorded. Other assessment facilities include:

- workshops where students evaluate example assignments and submit their own work for instructor and peer review.
- assignments allow students to upload any digital content.

Innovative engineering education tests are made possible:

- mastering of a computer language or testing knowledge by writing a program can be marked just by running a suite of unit tests on submitted code.
- simulators allow for design, testing and research in several areas of engineering, far beyond the limits of available or highly expensive physical resources.
- executable code can be included in an assessment object, allowing for the generation of new kinds of tests.

As a concrete example, a learning object for the TCP network protocol includes a graphical network simulator. Students are asked to build a network of hosts, routers and links, estimate their behavior by calculation and then run a simulation to "see" packet traffic, verify results and draw conclusions on congestion control, delay, jitter, packet loss, and other parameters of interest [3].

Authoring of such innovative content has its own costs. Much can be gained if self-standing, specific assessment units are created as shareable objects reusable in different contexts. Moreover, such testing units can be made accessible to authors and teachers in objects repositories as "off the shelf" assessment "parts". In this way, an exam or other assessment instance can be set up by selection and ordering, with little additional work, or modified to taste.

### SCORM

SCORM (Shareable Content Object Reference Model) is a collection of standards and specifications for the packaging and sequencing of learning and assessment material in the form of shareable, reusable content objects.

SCORM aims at four basic qualities to be effective [4]-[5]:

- Reusability. Content must be independent of the learning context, apt for use in different situations, for different audiences, on different delivery platforms with different applications or tools.
- Interoperability. Content must be exchangeable and executable among different application programs or platforms whatever the tools employed for its creation.
- Durability. The content must go on running without any modification upon any change or update in systems hardware or software.
- Accessibility. The content must be identifiable and locatable when needed. Adequacy for the objectives in hand must be apparent without requiring access to the content itself or paying royalties for it, through the provision of sufficient information about each learning object (metadata).

SCORM intends to reach these qualities through the use of Sharable Content Objects (SCOs) containing instructional, educational or assessment material, named assets in SCORM terminology, able to be delivered in a runtime SCORM environment, eventually provided by an LCMS or accessible from a learning object repository. The use of metadata, a set of structured information about the learning object, allows to identify and locate instructional material, for example in learning content repositories online, before actually examining its content, which may require payment [4]. The set of metadata for a learning object is called LOM (Learning Object Metadata). The most ample metadata standard is IEEE LOM v1.0 [6].

### IMS QTI

The IMS Global Consortium, an industry and academic consortium, produced the IMS QTI (IMS Question & Test Interoperability Specification) to enable the exchange of question and test data, as well as their corresponding results reports [7]. It was designed both for interoperability and innovation, by the provision of extension points where specialized or proprietary data can be wrapped consistently. Present version is QTI 2.0; a draft QTI 2.1 v2 release completes update from 1.x to 2.x, and addresses issues raised with the QTI 2.0 specification; resolution of remaining issues is expected to be included in the final release.

QTI specific goals are to provide a well documented content format for storing items independent of the authoring tool used to create them, support their deployment in different types of item banks and delivery systems, support deployment of items and item banks from diverse sources into a single system, and enable systems to report test results consistently. The specification comprises several documents:

- an Implementation Guide goes through the data model by example, treating subjects such as simple and composite items, response processing, feedback, adaptive items and other techniques.
- an Information Model, the reference guide to the main data model for assessment items. Variables, classes and interactions are described in UML (Unified Modeling Language), and states the requirements of delivery and authoring systems.
- Metadata and Usage Data, a profile of the IEEE LOM data model suitable for assessment items and a different data model for usage data (statistics), of interest for item bank development and use.
- XML binding, a way to represent the abstract data model in XML format.
- a Conformance Guide, which provides two profiles for a rigorous approach as to the extent to which the item information and packaging models are supported. QTI-Lite Version 2 (only for content) and QTI-All Version 2 (comprehensive) can be used to interpret statements such as "conforms to all of QTI Version 2".
- an Integration Guide comprising a set of methods for using QTI items in combination with other technical specifications.

- a description of Meta Data and Usage Data, in line with the IEEE LOM since QTI version 2.0.
- a Migration Guide to help transition from QTI version 1 data model to QTI version 2.

This collection of guides are up to the promise of providing a "well documented" content format, as stated in the specification objectives. The data model in UML allows for the use of a variety of data modeling tools and programming languages. For data interchange among systems use of the XML binding is strongly recommended. Use Cases and definitions of components and actors are precise and avert ambiguity.

Interoperability in question design tries to avoid or lighten the effort it takes to transfer questions or evaluation tasks from one system to another, or from one technology to a newer one. Notwithstanding the value of the project and its maturity, adoption has not been as enthusiastic as deserved.

### SELECTION OF LEARNING PLATFORMS

Few of the available learning platforms comparisons are up to date and deal with aspects relevant to this article [8]. Some witness platforms were selected according to popularity. Google [9] was sought for two numbers: the quantity of references to several LCMSs and a count of the links to the home pages of those same LCMSs, limiting the search to the last year. Since a single site may serve many students, names may refer to something different than the LCMS , LCMSs be referred by slightly different spellings, or an LCMS have several different sites (in different languages for instance), these numbers may be misleading. However, some platforms emerge as more "popular". The platforms were selected from those mentioned in Wikipedia articles "Virtual Learning Environment", "Learning Management Systems" [10], and Eric Wolfram's Directory [11]. Results are shown in Table I.

As expected, Moodle emerged in the first place, with Claroline and Dokeos as second and ATutor as third. Ilias shows a great number of references but few pages link to it. Bodington was classified as "not available" in references, since it is also the name of a place. Consequently, Moodle, Dokeos, Claroline and ATutor were hereafter considered.

Registered sites in their homesites: Moodle 19014, Dokeos

TABLE I
POPULARITY OF LCMSS

| LCMS | Refs | Homesite | Links | Select |
|------|------|----------|-------|--------|
| Atutor | 598000 | www.atutor.ca | 1950 | 3 |
| Bodington | n/a | bodingtong.org | 35 | |
| Claroline | 902000 | www.claroline.net | 3060 | 2 |
| Docebo | 136000 | www.docebo.org | 603 | |
| Dokeos | 759000 | www.dokeos.com | 3650 | 2 |
| DotLRN | 689000 | dotlrn.org | 653 | |
| Fle3 | 157000 | fle3.uiah..fi | 185 | |
| Ilias | 2250000 | www.ilias.de | 195 | |
| LON-CAPA | 177000 | www.loncapa.org | 76 | |
| Moodle | 11200000 | moodle.org | 20400 | 1 |
| OLAT | 224000 | www.olat.org | 69 | |
| Sekai Project | 91400 | www.sakaiproject.org | 952 | |
| Site@School | 359000 | siteatschool.sourceforge.net | 274 | |

1277, Claroline 718, ATutor does not declare registered sites. Again Moodle emerges far ahead of the others (14 to 1).

Standards support is not always clearly stated; README files in installation packages and wikis were often used as sources. A definitive answer as to features and support requires installation and thorough testing of the product. Table II summarizes support for Moodle [12]-[13], Dokeos [14]-[16], Claroline [17] and ATutor [18]-[22].

TABLE II
SCORM AND IMS QTI SUPPORT

| LCMS | SCORM | IMS QTI | Hot Potatoes |
|------|-------|---------|--------------|
| Moodle | 1.3 | exports 2.0 | Imports |
| Dokeos | 1.3 | exports 2.0 (?) | Imports |
| Clarolinee | 1.3 basic | no | No |
| Atutor | 1.2 | no | no |

### IMPORT / EXPORT IN MOODLE 1.6

Owing to its outstanding popularity, a revision of Moodle 1.6 capabilities was carried out at a Moodle production installation (http://iie.fing.edu.uy/cursos). Moodle 1.6 offers four formats to export questions:
- GIFT format (Moodle's own format).
- IMS QTI 2.0 format.
- Moodle XML format.
- XHTML format.

Moodle 1.6 offers 13 formats to import questions, including several proprietary formats and Hot Potatoes format. This is a general tendency: efforts are concentrated primarily in importing from foreign formats rather than exporting, even to standard formats. Moodle 1.6 does not offer IMS QTI import.

### ON-LINE ASSESSMENT SOFTWARE

Ferl Becta [23]-[24] lists 21 software tools for eAssessment: CASTLE Toolkit, CQuest, E-assessor, Exam Manager, Exam View, Fast Test Pro, Hot Potatoes, i-assess, InterQuiz, NewSlate, Question Mark, Question Tools, Quia, Quiz Factory, Quiz Rocket, Respondus, RIVA e.test, Test Nation, Test Pilot, TestWise, xDLS.

Support of SCORM and/or IMS QTI is mentioned by:
- RIVA e-test 3.0: SCORM and QTI, no versions indicated.
- Respondus StudyMate: IMS QTI 1.x (imports), SCORM 1.2 (exports).
- xDLS QTI-Ready: IMS QTI 2.0, uses HTTPS and runs on server, does not provide AICC nor SCORM support for "insecure".
- Questionmark Perception: SCORM 1.2, IMS QTI, no version given.

To date, only 4 products in 21 provide IMS QTI and SCORM support to some extent.

### HOT POTATOES

An eAssessment authoring tool which seems to have gained popularity is Hot Potatoes [25]. The suite includes six

applications. Several types of questions can be created: multiple-choice, short-answer, jumbled-sentence, crossword, matching/ordering and gap-fill. Hot Potatoes is not freeware: it is free for publicly-funded non-profit-making educational institutions that make their pages available on the web. Any other user must pay for a license.

Hot Potatoes runs under MS Windows and Linux via Wine. A Java version runs on Mac OS, MS Windows, Linux or any computer running a Java Virtual Machine.

Hot Potatoes states to be "thinking about" including "export to XML formats compliant with IMS e-learning specifications (if and when these become stable and practical)".

Moodle provides import from Hot Potatoes, but to date Hot Potatoes does not provide IMS QTI support.

### LEARNING AND ASSESSMENT OBJECTS PUBLIC REPOSITORIES

A learning and/or assessment object repository is a central place where these kind of objects are stored and maintained to the purpose of use as learning or assessment material or reuse as part of a course or exam. Public learning object repositories and assessment item banks turn up as a sort of efficiency ideal: ready made learning or assessment material could be easily pinpointed for the purpose in question, a course or an exam could be put up really fast, or more realistically serve as a sound basis on which to improve or adapt.

It is not easy to locate objects' repositories without any previous knowledge or hint; some kind of index or central information site is needed. Few repositories claim to comply with standards, were they SCORM or other known packaging format. However, most of them can be used with just a navigator and plug-ins. Reuse, though, is not as frequent and easy as desirable. Many repositories are for the benefit of students enrolled in the institutions that create and maintain them.

Though not strictly an object repository, an outstanding example of knowledge sharing is MIT's OCW initative (Massachussets Institute of Technology Open CourseWare), which has made public a considerable amount of learning and assessment material: 1550 courses as of November 1, 2006. Courses provide reading material, lecture notes, assignments and guidance to learners. MIT's aim to "provide free, searchable access to MIT's course materials for educators, students, and self-learners around the world" is certainly an example to follow [26].

Some comments on content repositories examined follow:

- MERLOT is an excellent public repository, showing outstanding activity, a lot of objects and high quality. Science and Technology exhibits 5667 results, 1970 in engineering, computer science, nanotechnology and information technology [27].
- JORUM is a "free online repository service for teaching and support staff in UK Further and Higher Education Institutions". Access is limited to people belonging to institutions affiliated to the service [28].

- CETL (Centre for Excellence in Teaching and Learning) in Reusable Learning Objects started in April 2005 and has built to date some 61 completed learning objects and about the same quantity are in development, on 15 subjects as different as Sports Science, Maths for Medics and Vets, Music, Statistics and Study Skills, but not for any area of Engineering, Computer Science or Information Technology. Most objects require Adobe Flash Player 8, and are designed to be delivered via web. It is an ambitious project with a 5 year schedule of development and dissemination [29].
- COL (Commonwealth Of Learning) provides several services to developing Commonwealth countries that strive to provide affordable education to their citizens. Online learning content is provided to Commonwealth countries free of charge. Search of words "Math", "Statistics", "Engineering", "Computer Science" and "Information Technology" in any of title, description and keywords produced 0 results. A search with no word produced 18 results. Some assets examined were MS Word documents. COL also offers a Knowledge Finder for open and distance learning information repositories available through the Internet [30].
- APROA (APRendiendo con Objetos de Aprendizaje, learning through learning objects) is an educational initiative to promote adoption of learning object technologies in a community of developers and users aiming at the collaborative creation of a continuous education program. Objects of three universities are found in its object repository. Most of them are "on show" (title, author and description), accessible only to registered users, who must be teachers or students. University of Chile comprises 14 colleges and exhibits 568 objects in Agronomical Sciences and 3 in Veterinarian Sciences. University of Tarapaca offers 46 objects in Agronomical Sciences, 2 of them are accessible, and consist of PowerPoint presentations both for development and evaluation. Arturo Prat University offers 20 objects in Agronomical Sciences, all of them on show [31].
- Connexions is an active place designed to view and share educational material. Connexions require authors to organize material in small knowledge chunks called modules to favor reuse. Modules can be organized as courses, books or reports. Guidelines are provided to authors, instructors and learners. Format is specially taken care of to ensure stand alone usability of each module. Modules are written in a markup language called CNXML, the Connexions version of the XML language, to enable easy access from different computer platforms, as well as to be printed or read online with no formatting work. Several editing ways and tools are provided for authors. As of May 7, 2007, 3969 reusable modules are available, woven into 217 collections [32]. Connexions seems to be very active in its spread. Recently Connexions representatives have contacted several South American universities to replicate their content and foster translation to and content creation in Spanish.

For Engineering Education, only MIT's OCW, MERLOT and Connexions were found of interest.

SUMMING UP

This section sums up some points which arise from former work in this article, and observations made during the search for information. Some of these points may be argued against, and more sound proof be required, but the difficulties of obtaining enough evidence are almost insurmountable on a world wide perspective. Even so, the importance of the trends observed makes it difficult to pass over them as if they were not seen, though no sound proof can presently be provided.

*I. LCMSs*

- LCMSs generally support SCORM, with some delay.
- Interest in reuse of content among LCMSs and other tools does not seem to be general: educational government agencies are usually deeply interested and fund many initiatives, particularly in the UK, Canada and the Commonwealth. Educative associations also favor reuse, but if all members accept the same LCMS interoperability is effortlessly guaranteed. Employee instruction within companies has few reasons to concern about learning object reuse; a uniform system can be easily deployed, either in-house or through contract.
- None of the examined LCMSs provides IMS QTI import/export. Only Moodle offers export.

*II. eAssessment software tools*

- Very few eAssessment software provides support for IMS QTI and SCORM. The degree and extent of support vary, newest versions of the standards tend to lack support, promises of compliance are uncertain.
- Pure eAssessment systems exist, but their intended purpose is certification of ability or qualification for a job, not education. Their customers are companies or organizations who need to select, evaluate, qualify or certificate personnel.
- Authors do not seem to be pressing hard towards interoperability or standard compliance of eAssessment content. Facilities offered by LCMSs or applications like Hot Potatoes are the tools at hand.
- LCMSs take pains to import from other LCMSs or applications formats into their own, rather than exporting into standard formats. Moodle imports from Hot Potatoes, but not from IMS QTI; however, it exports to IMS QTI.
- Generally, present eAssessment software does not favor interoperability or content reuse. This is rarely openly recognized, since it would be very difficult and inconvenient to deny interest in standards which almost everybody think useful, their only serious drawback being that they may be difficult to implement.
- No eAssessment authoring tool supporting SCORM packaging and capable of interaction with the LCMS was detected; standalone eAssessment content (e.g. a set of HTML + Javascript pages) packaged in SCORM format would allow for interoperability among different LCMSs.

*III. Learning and Assessment Repositories*

- There are few public learning and assessment object repositories, and they are not easy to locate.
- Repositories rarely provide reusable objects or follow a standard.
- Many public repositories are funded and made available by government educational agencies or educational foundations.
- Presently, very few public repositories allow for a complete course set up or even a basis of essential subjects to start with; assessment material is even more scarce. Growing of repositories seems slow, not a surprise considering the great efforts high quality authoring demands.
- Learning and assessment contents live a short life if not regularly updated; a continuous effort is required. It is easier to fund creation, a one time expense, than maintenance, a continuous expense. Schools can manage repositories profitably once initial costs have been paid for; skillful usage makes maintenance affordable.

CONCLUSIONS

Support for learning and assessment content reuse seems to have extended at a much slower pace than originally thought. Though the most popular LCMSs support SCORM, not much use is made of it. Public repositories are scarce, difficult to find and rarely designed for reuse. In eAssessment, the IMS QTI standard is poorly supported, both in LCMSs and authoring tools. Private content repositories exist, for the benefit of students enrolled in the institutions which create and maintain them. Present day copyright offensive does not favor content creation for the public benefit or even knowledge sharing.

Public education agencies and governments are the driving forces in eLearning and eAssessment, promoting reuse, standards adoption and the widespread use of e-portfolios, the lifelong history of a person's educational achievements [33]. Institutions associations may not be easy to organize and manage, and may not be compelled to standards adoption if a common LCMS is accepted. No other actors of significant power can be identified as deeply interested in content reuse and interoperability.

Definitely more effort is needed in content creation, standards compliance, public repositories availability and population. More widespread information on the benefits of sharing education content and sticking to standards could greatly help towards availability of educational and assessment material, saving hours of hard work to teachers, course managers and institutions. MIT's OCW initiative brings hope to educators and learners all over the world.

Education practitioners, all those content authors, teachers and course managers trying to deliver curricula content in time and best form, more and more overwhelmed by an increasing

mass of students [34], will certainly make use of whatever tools are at hand. Learning and assessment content has a short life, and frequent revisions are required. A sound organizational scheme could make wonders with reusable objects, but a strong engagement of authorities and institutions is required. Information campaigns on the benefits of collaborative education and public discussion may provide powerful forces to push education towards a next stage of evolution.. New technical aids to education practitioners will be always welcome, and may provide significant relief to present day limitations. Research in these areas is possible without much coordination, some funds exist and is a way to follow. Helping teachers can do a lot for education, and requires comparatively little, both in funds and coordination.

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