INTEROPERABILITY BETWEEN ELEARNING SYSTEMS

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Abstract

The University of Hertfordshire has delivered many on-line courses over a period of years and uses Question Mark Perception (QMP) for formative and summative assessment in undergraduate and postgraduate courses. We found on-line assessment to be an integral part of our eLearning systems. Over the years lecturers have developed many objective tests using QMP. However, if we would like to transfer these tests to another Learning Management System (LMS) is it possible? Typically, eLearning systems store exam questions using proprietary formats and then make use of standard formats for interoperability purposes. Many products on the market today provide limited interoperability options. At the moment there are two main standards: Question and Testing Interoperability specification (QTI) and Question Markup Language (QML). In the paper we will attempt to demonstrate why interoperability between different systems is not straightforward.

How can we exchange information between these two main contenders for a standard? We can export question banks from present systems and import them into others that support the same format. However, a translator or converter is required if the destination system supports a different format for question banks importation. For example, Moodle uses QTI for export so we could import our Moodle questions into another system that uses QTI, or we could convert the QTI to QML to use in, for example, Question Mark Perception.

In the initial stages of our work (2010) we sent an on-line questionnaire to software manufacturers of eLearning products and asked which question types they supported in their LMSs together with which import/export functions**.** Two hundred and fifty-one were contacted; twenty-eight (11%) replied. The results of the questionnaire overall showed that an import function is more available than an export function and that QTI is most common for both Import and Export. The study was carried out again in 2013 to tack any increases. The full results are outlined in the paper; these results confirm the lack of interoperability options between standards.

In our preliminary work we also carried out research to establish the types of questions available in both standards. We established that QML has 20 different types of questions and QTI also has 20 different types of questions. Some of the question types are common to both. Some question types are the same but have different names. Eleven question types are common to both QTI and QML and these are outlined in the full paper.

As regards to previous work in this area, a JISC funded project at the University of Hertfordshire called MultipleChoiceFiveMethods (MCQFM) was completed in 2008**.** The project provided a web service that can convert five basic question types. In the main paper we also provide a comparison of our work with the MCQFM project.

1 INTRODUCTION

As with the development of any industry standards are necessary. Standards in computing can help with the portability and compatibility of systems and the ease of exchanging information between systems. Several software houses within the eLearning industry have developed their own proprietary format to aid assessments and evaluation through objective test question banks. Certain proprietary formats have emerged and standards have been adopted by several parties. The eContentplus programme funded a study by Agea et al.[2] (2009) that analysed various standards, particularly the IMS QTI specification and proprietary formats used by ICOPER participants, namely: Moodle XML, HotPotatoes, OpenMark, Blackboard, DocBook, FML, QAML, and SuML. The study revealed that the QTI specification was actually the de facto standard and supported most question types even though it was not highly adopted due to lack of interoperability between learning management systems.

Smith [3] (2009) from CAPDM which is a company that specialises in education programs explained that their customers made use of a diversity of applications. Therefore, they created a proprietary

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format based on DocBook called Universal Question Format (UQF) to support the development and marking of questions irrespective of the formats used by their clients. However, they also utilized QTI as an intermediate exchange format whilst keeping their own format to facilitate maintenance on questions due to their independence from other assessment engines. On the other hand, Bennett and Nuthi[4] (2008) proposed that the best way to share questions was to ditch standards such as QTI and QML and implement plain text representations for the five (5) most popular question types. He explains that this would cover 95% of the questions which could be stored in a database with simple metadata and one could then visualise them using creative tools. The MCQFM project was created on this idea.

Deibler[5] (2007) explains that assessments should be structured in groups by learning objective and randomly load a number of test items from a test bank larger than the assessment itself with different types of test items could be used for the same information. Deibler continues by specifying that in order for a SCORM assessment to be effective certain data needs to be collected to evaluate the learning performance and provide reports.

Overall, the situation at the moment is that the eLearning market is making use of gateways or converters to provide compatibility between different products, and, we have two contenders for a possible future standard.

2 ELEARNING SYSTEM STANDARDS

Various *Learning Management Systems* (LMS) exist and a market analysis was carried out in this work to quantify them. Such systems usually include *Objective Test Questions* (OTQ) in the form of exams and quizzes to aid formative and summative assessment in educational courses. For example, the University of Hertfordshire has delivered many on-line courses over a period of years and uses Question Mark Perception (QMP) to assess distance learning students enrolled in undergraduate and postgraduate courses.

At a storage level, these systems typically store such exam questions internally using proprietary formats. However, standard formats such as *Question Markup Language* (QML) or *Question and Testing Interoperability specification* (QTI) are often used for import and export purposes, with only a few that support both. Such interoperable formats allow educational institutions to export their question banks from their present systems and import them into others that support the same formats, however due to the lack of support for standards, this often make such moves impossible.

At a presentation level, these systems typically present assessments using a web-based or app-based interface coded using custom code. However, the *Sharable Content Object Reference Model* (SCORM) can be used to build such interfaces as packages that can be loaded into any SCORM-enabled LMS and communicate assessment results to the LMS using *Application Programming Interfaces* (API).

This paper also defines the QML and QTI formats and lists the types of objective test questions supported whilst highlighting those that are common to both formats. In order to assess the level of import and export formats supported online research was carried out by the authors and this identified a substantial number of LMSs. Furthermore, the manufacturers of the identified systems were then questioned to augment collected information. This study was carried out twice, the first time in 2010 and recently in 2013 to track any increase in available applications and re-assess the adoption of such standards.

Previous work to aid conversion between these two standards was carried out at the University of Hertfordshire through a *Joint Information Systems Committee* (JISC) funded projected called *Multiple Choice Questions Five Method* (MCQFM[1]) which was completed in 2008. This project provided a web service that converted five basic question types. As part of this study, WebCU was developed as a web-based utility to support the conversion of eleven objective test question types that are common to both QML and QTI formats. This software ensures full conformity to standards and enables institutions to migrate their existing test question base to a different LMS without the need to re-input their questions.

2.1 Question Markup Language (QML)

QML was created by Questionmark which was founded in 1988 and specialises in the deployment of computer-based assessments. Kleeman[6] (2009) mentions that their first assessment platform was

windows-based and was converted into a web-based application in the 1990s. Such transition required the migration of questions between platforms at the inconvenience of their customers. To address such embarrassment and to sustain forecasted company growth and planned software improvements, they came up with a proprietary language called QML.

The first version of the QML definition 0.9.5 dates 30th January 1997 and is used to maintain questions and answers for use in tests and assessments. Since then, Questionmark has published QML as an open standard in order to allow industry participants to implement it in their products and increase interoperability with their products, specifically Perception. Another important product for QML is The Authoring Manager that can be used to create all types of QML questions.

2.2 Question and Testing Interoperability specification (QTI)

The IMS Global Learning Consortium provided the QTI specification as a data model used to represent questions, test data, and reporting of results. Such specification facilitates the exchange of assessments between various authoring tools, learning systems, assessment delivery systems and even question banks. This data model is described in *Unified Modeling Language* (UML) and was delivered using the *eXtensible Markup Language* (XML) industry standard to enable interoperability between systems.

The initial version of the QTI specification 0.5 was released in March 1999 for consultation purposes, whose final version 1.0 was released in May 2000. This was based on the QML proprietary language by Questionmark, however it evolved during the years and various versions have surfaced, with the latest version 2.1 released in September 2012 after having been temporarily withdrawn in 2009.

2.3 Shareable Content Object Reference Model (SCORM)

The *Advanced Distributed Learning* (ADL) Initiative came up with the SCORM specification as a collection of standards for web-based eLearning. This defines how content can be packed into a cabinet called *Package Interchange Format* (PIF) and uses XML as its course structure format. Objective test questions can be packaged into *Shareable Content Objects* (SCO) with SCORM 2004 in which the cmi.interactions data model was provided to record performance/score of single questions back to the LMS via API. Without such API integrations, assessments would be disconnected from the LMS hosting the package and therefore assessment results would not be incorporated in the learning program.

The initial version of SCORM specification 1.0 was released in January 2000 and it has evolved throughout the years into 2 major versions: SCORM 2004 in January 2004 and the Tin Can API draft in September 2011 with its latest version 1.0.0 released in April 2013. The Tin Can API[7] carries substantiation improvements over SCOM 2004, can report multiple scores, and provides a vast array of tracking functionality.

2.4 Objective test question types

Cordova[8] (2008) comments that rapid developments in computer technology impacted test delivery positively since test takers are presented with texts and prompts on screen instead of traditional examination booklets and therefore paper work is reduced and illegible handwriting problems eliminated. In practice, computer based testing (CBT) does not necessarily require new test content, but in most cases it only signifies a change in the test method used. In fact, Cordova specifically mentions that objective test questions are ideal for electronic assessments since these provide various advantages, including the possibility to score fixed response items automatically and provide test takers with their test score immediately. However, as a disadvantage Cordova (2008) cites McNamara (2000) who raised concerns on the validity of CBT with particular emphasis on test takers that are unfamiliar with computers who might have a stressful test experience, thus their performance would be impacted negatively.

Irwin [9] (2010) describes that most objective exams are based on recognition learning, which means that the correct answer is supplied, however the test taker is required to identify it. McKenna and Bull [10] (1999) guide test writers to make use of taxonomies, however they also comment that pedagogical issues associated with objective test questions such as the inability to test a student's skills with regards to communication and construction of arguments. On the other hand, an advantage mentioned is that objective test questions are ideal nowadays since the number of students engaging

in studies is increasing. The ways objective tests can be used are also mentioned briefly; however, Buffa et al.[11] (2004) in their document describes the uses of objective tests in more detail:

- Self-tests – these are used by self-paced students or as complimentary assessment methods on a voluntary basis and therefore are not limited by time;
- Formative assessments – these are usually used to guide students during a learning process and therefore are these types of tests are set up by teacher, are related to the topic being studies, and are usually given a submission deadline;
- Summative assessments – these are strict tests used to officially grade student's assessment with regards to the area being studied and therefore are governed by the institutions' examination policy, such as exam location, start time and end time.

All said, the concept of recognition learning has been exploited and a large number of question types have been created to maximise its benefit. QML, QTI, and SCORM are three standards that cater for various types of questions. Seven types are common for all three, and another 4 are common to QML and QTI as follows:

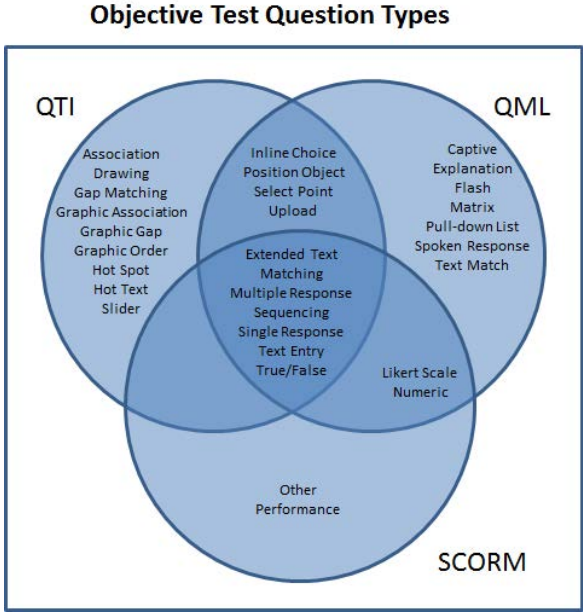


Figure 1: Objective Test Question Types.

- QML, in its manual[12] highlights twenty types of questions: Captivate/Robodemo, Drag-and-drop, Essay, Explanation, Fill-in-the-banks, Flash, Hotspot, Likert Scale, Matching, Matrix, Multiple Choice, Multiple Response, Numeric, Pull-down list, Ranking, Select a Blank, Spoken Response, Text Match, True/False, and Yes/No questions.
- QTI, in its specification[13] highlights twenty types of questions: Associate, Drawing, Extended Text, Gap Match, Graphic Associate, Graphic Gap Match, Graphic Order, Hot Spot, Hot Text, Inline Choice, Match, Multiple Response, Order, Position Object, Select Point, Single Response, Slider, Text Entry, and True/False.
- SCORM, in its specification[14] highlights ten types of questions: Fill-in, Likert, Long-fill-in, Matching, Multiple Choice, Numeric, Other, Performance, Sequencing, and True/False.

For the aim of import and export purposes this study focused on QML and QTI as storage formats. The XML files studies and conversion utility built focused only on the eleven common question types.

3 EXISTING ELEARNING SYSTEMS

In this project online research was conducted to identify the eLearning systems that exist in the market. In 2010, sites such as Capterra[15], MarkosWeb[16], and EduTools[17] helped in compiling a list of 251 applications. In 2013, the same sites were checked again and a list of 264 new applications were compiled, even though the third site was closed in the same year and therefore could not be used. This is an increase in the number of systems known of 104% to a total of 515 eLearning applications. The website of each application identified was visited in an attempt to understand which question types and import/export formats are supported. However, most software houses use their websites purely for marketing purposes and therefore do not provide such information. In this regards, an online questionnaire was sent to these software houses in order to investigate further.

3.1 Existing tools

Amongst the learning management systems identified during the above search, a few were purely authoring and conversion tools. The five most prominent tools are: MCQFM, Perception Authoring Manager, Question Authoring System, Question Writer, and Respondus. In certain cases these tools try to bridge the gap in lack of import and export options by allowing authors to save their question banks in different formats, however, the objective test question types supported are limited to the most

common types and in most cases the formats supported do not fully adhere to official and de facto standards such as QTI and QML.

3.2 Questionnaire results (2010)

Two hundred twenty-six (226) software manufacturers from the identified two hundred fifty-one (251) were contacted either by email or through a contact form on their website to request feedback on the supported objective test question types, formats supported for import and export purposes, and whether further support is planned. Twenty-eight (11%) of the software houses responded.

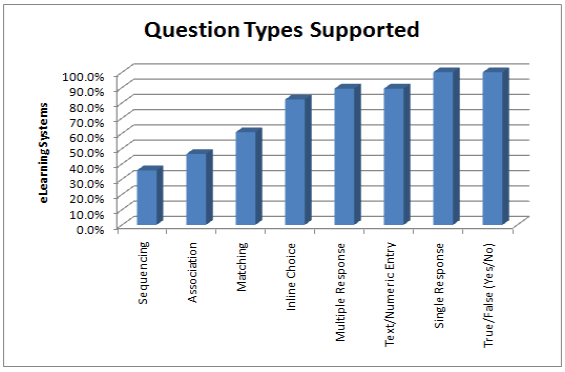


Figure 2: [2010] Question Types Supported.

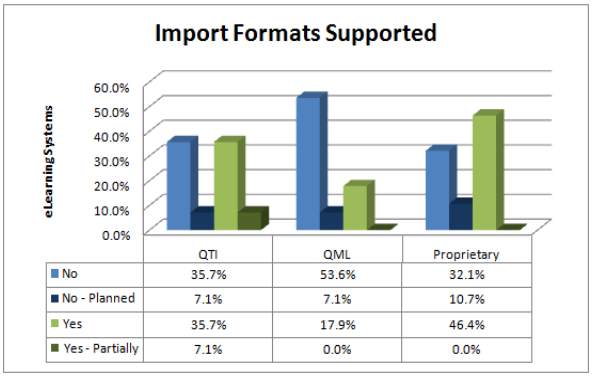


Figure 3: [2010] Import Formats Supported.

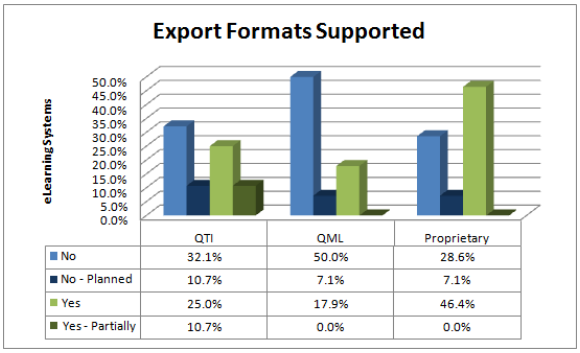


Figure 4: [2010] Export Formats Supported.

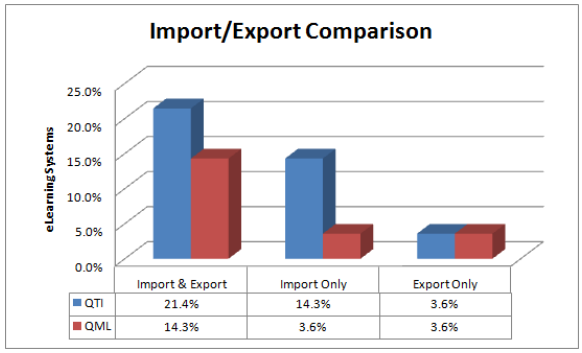


Figure 5: [2010] Import & Export Comparison.

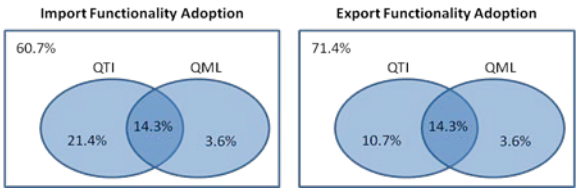


Figure 6: [2010] Functionality Adoption.

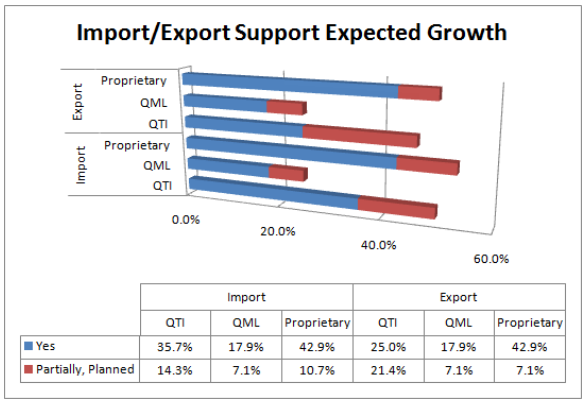


Figure 7: [2010] Support Expected Growth.

The above result analysis show that import and export support by existing eLearning systems vary; the import and export formats supported figures confirms that support of import and export purposes is irregular in both QTI and QML formats. The import and export comparison shows that import functionalities are more available than export functionalities and that QTI is more commonly adopted for both import and export purposes. Moreover, the import and export functionality adoption figures

confirm the lack of interoperability options between standards. On a positive note, the import and export support expected growth prediction shows that software manufacturers intend to increase support in both QTI and QML formats.

3.3 Questionnaire results (2013)

Three hundred fifty nine (359) manufacturers from the identified five hundred sixty nine (515) were contacted by email identifiable from their website to request feedback on the supported objective test question types, formats supported for import and export purposes, and whether further support is planned. Thirty-one (9%) of the software houses responded.

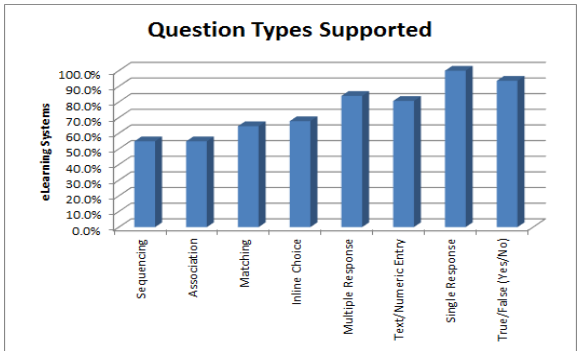
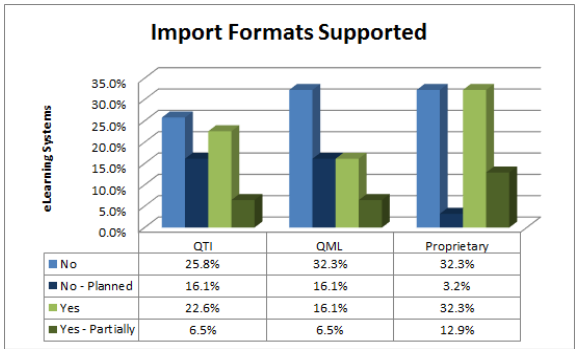
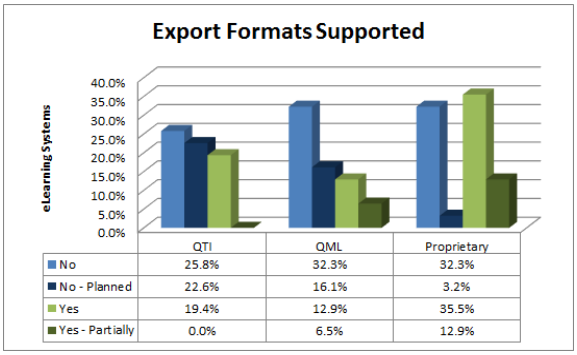


Figure 8: [2013] Question Types Supported.



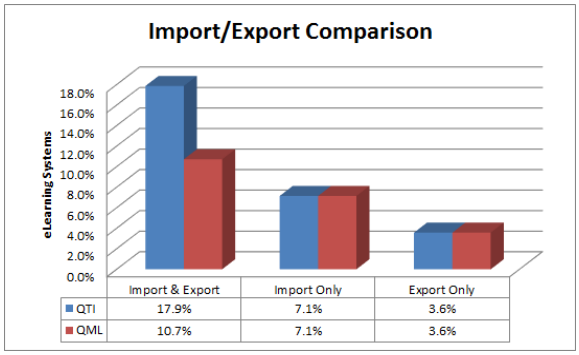
	QTI	QML	Proprietary
No	25.8%	32.3%	32.3%
No - Planned	16.1%	16.1%	3.2%
Yes	22.6%	16.1%	32.3%
Yes - Partially	6.5%	6.5%	12.9%

Figure 9: [2013] Import Formats Supported.



	QTI	QML	Proprietary
No	25.8%	32.3%	32.3%
No - Planned	22.6%	16.1%	3.2%
Yes	19.4%	12.9%	35.5%
Yes - Partially	0.0%	6.5%	12.9%

Figure 10: [2013] Export Formats Supported.



	Import & Export	Import Only	Export Only
QTI	17.9%	7.1%	3.6%
QML	10.7%	7.1%	3.6%

Figure 11: [2013] Import & Export Comparison.

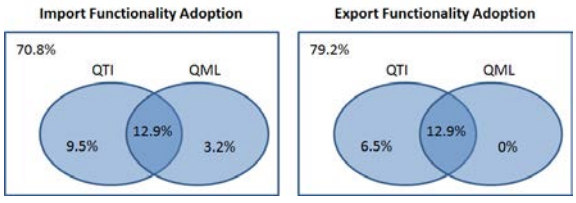
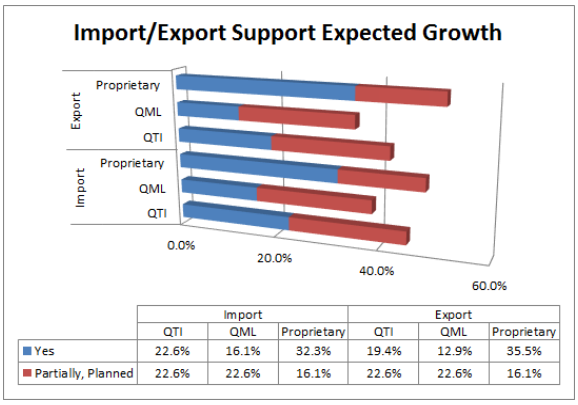


Figure 12: [2013] Functionality Adoption.



	Import			Export		
	QTI	QML	Proprietary	QTI	QML	Proprietary
Yes	22.6%	16.1%	32.3%	19.4%	12.9%	35.5%
Partially, Planned	22.6%	22.6%	16.1%	22.6%	22.6%	16.1%

Figure 13: [2013] Expected Growth.

The number of responses received in the 2nd round of questionnaires is slightly higher than that in 2010, the actual percentage of respondents is lower since a larger number of companies were invited to participate. Nonetheless, the above result analysis confirm that that import and export support by existing eLearning systems vary. The import and export formats supported figures confirms that support of import and export purposes is irregular in both formats. The import and export comparison shows QTI is still used more than QML for both import and export purposes, however the number of

applications supporting import using only one format is now equal. Also reconfirmed is the positive outlook that the import and export support is expected to growth for both formats.

3.4 Finding trends by comparing questionnaire results

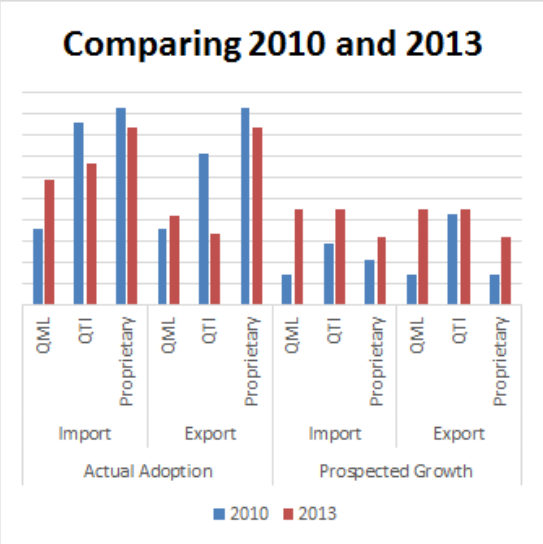


Figure 14: Comparing 2012 and 2013 Results.

Having conducted data collection using the questionnaire technique twice, the first being in 2010 and the second being in 2013, it has given the opportunity to find a trend in the utilization of QML, QTI, and proprietary data formats. Particularly, proprietary formats are still going strong for both import and export purposes, surpassing both QML and QTI, however popularity has decreased slightly.

For import purposes, QML has registered an increase whilst that QTI has registered a decrease, however QTI is still used more than QML. Similarly, for export purposes, QML has registered an increase whilst that QTI has registered a decease, with QML now being used more than QTI.

With regards to prospective growth, there is an increase in both import and export purposes for QML, QTI, and proprietary formats.

4 CONVERSION UTILITIES

Two conversion utilities are featured in this paper to offer alternative approaches to convert test question banks stored in XML files using QML or QTI formats. Both approach seem similar but use different technologies and require different skillsets.

4.1 Multiple Choice Questions Five Methods (MCQFM)

The MCQFM project was commissioned by JISC in 2007 and funded through the e-Learning Frameworks and Tools program to sustain the up-take of the QTI 2.0 specification by providing means of conversion between standard formats. This project was entrusted to Steve Bennett at the University of Hertfordshire and was completed in 2008.

It is provided as a web service that caters for the conversion of multiple choice, multiple response, fill-in-the-blank, sequencing, and matching questions. It uses a textual and simpler intermediary language called QTEXT to perform six (6) types of conversions: QML to HTML/QTEXT/QTI and QTEXT to HTML/QML/QTI. This project also included an interface to create questions using this intermediary language and to present quizzes in HTML.

4.2 Objective Test Questions Web Conversion Utility (WebCU)

The WebCU software artifact was developed as part of the post-graduate study of one of the authors as a web-based conversion utility that supports conversion of question types between QTI and QML. This has been developed as a class library using C#.NET based on Microsoft .NET Framework 3.5 and exposed as an ASP.NET web application.

It parses questions stored in XML documents, identifies their format – QTI or QML – and loads such questions in a high-level object representation of each question type, and then models an XML output in the other format.

An object-oriented (OO) approach was chosen to ease development and provide consistency. A class hierarchy is used to provide generic option and response objects that could be inherited and overridden by question type specific needs. This is described in a high-level class diagram below.

An interface class was used to define required methods and have been applied to an abstract class. The purpose of having a non-implementable abstract class was to define data members and methods

common to all those classes that inherit it, whilst that those methods imposed by the interface and vary per child were not implemented. This abstract class also included two generic objects as data members which were exposed through virtual properties, and therefore allows children to change their exposure by redefining their properties to use custom data contracts. A total of fourteen classes, two of which are an abstract class and an interface, are used to represent the chosen question types. This object oriented approach was chosen to provide a high-level object that is valid for all possible objective test question types. Inheritance is used to customise the structure through method overriding whilst allowing the necessary flexibility by parameter hiding to vary the data type of the option and response data members according to the type of question data.

WebCU is available online at: http://webcu.raland.net

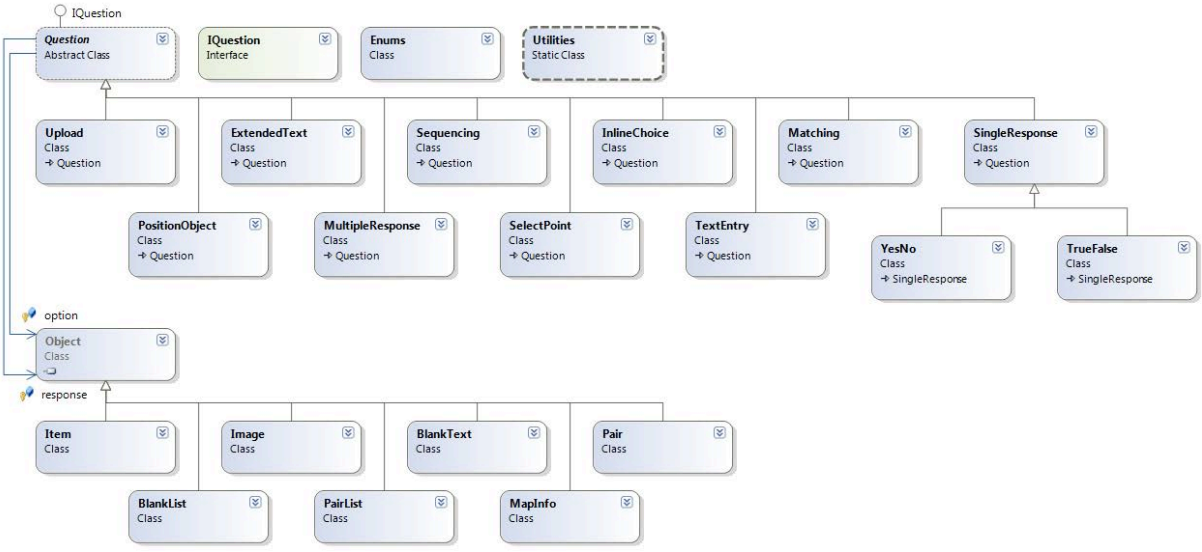


Figure 15: High-Level Class Diagram.

4.3 Comparing MCFQM and WebCU

The MCQFM project utilised *EXtensible Stylesheet Language* (XSLT), a stylesheet language used to transform XML documents into other formats, to perform conversion from QML to QTI. XSLT is very powerful and can make a document unrecognizable, however when two-way transformations are required as in case of conversions between formats, the use of an intermediary language is usually the norm. The introduction of an intermediary format, QTEXT in this case, implies the use of two transformations to achieve the required conversion. The first transformation would generate the intermediary format which would contain information common to both formats by performing the necessary calculations to augment the source format. The second transformation would then use the generated information available in the intermediary language and display it in the destination format. Such style sheets require expert skills.

On the other hand, the approach adopted in our work by WebCU is slightly different. A generic model is defined for each question type and even though this can be seen as identical to QTEXT, it does not require transformations. Information is parsed from QML and QTI documents and stored in the object models. Once the models are filled, their content can be outputted in different formats. The skills required to maintain this type of approach are object-oriented skills to build the models, and XML manipulation to parse and construct documents. Therefore, the approach adopted in this project is a way-forward towards test question banks conversion since it requires fewer skills to develop and enhance when compared to the approach using XSLT.

5 CONCULSION AND FUTURE WORK

Section two of the paper described standards used within eLearning systems in regards to objective test questions, with particular attention given to the origins and evolution of QML and QTI. The types of objective test questions available were also identified per standard format and commonalities from both formats and the questions common to both formats were identified.

Market research in the second part of the paper identified a large number of eLearning systems and their software houses were questioned in regards to the objective test questions supported, both in terms of question types used as well as import/export formats. The study was performed twice, first in 2010 and later in 2013 to draw a trend on the adoption of interoperability options. The results show that proprietary formats are still more adopted than standard formats for both import and export purposes, even though import options are available more than export options, and that growth is forecasted for adoption of QML and QTI for both import and export purposes.

Research and development in the third part of the paper explained two conversion utilities. The first was the MCQFM project built in 2008 and the second was the WebCU built in 2010. Details about the technology used in both was supplied and comparison was carried out. The aim behind WebCU is to promote further question sharing between eLearning systems by demonstrating a simple approach to the conversion of objective test questions. Test question banks are parsed from QML and QTI documents and stored into high-level object models. Once the models are filled, their content can be outputted in different formats.

Future work can be done at both research level as well as at development level. Now that a large number of systems have been identified, further research could question educational institutions in an attempt to define which applications are truly in use today. On a development level, the WebCU software could be extended vertically to cater for the inclusion of scoring elements to enable automatic marking after questions are migrated between eLearning systems, whilst expansion on a horizontal level would introduce conversion support for other proprietary standards to further increase interoperability between eLearning systems. The technical skills required to update WebCU are object-orientation to build the models, and XML manipulation to parse and construct documents.

Computer Science always struggles with interoperability between products. One user's value for a product increases when another user purchases a compatible product. This is referred to as Positive Network Externality in the economics literature. Advantages of compatibility are that if products or product components are compatible then savings are made from not having to produce gateway or converter devices. Gateway and conversion products can overcome some of the efficiency loss caused by incompatibility among products in the short term but in the long term a standard may not emerge. A gateway product may tip the balance in favour of one of the technologies leading to the defacto standardisation of that product (and sometimes this product may not be the best solution), or the gateway may hinder the standardisation completely and again no standard emerges. In our work we have put forward a solution, WebCU, to the problem of incompatibility between eLearning products.

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