User-Oriented QTI Authoring

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Abstract

A number of JISC and HEAfunded research projects have produced open source software for authoring electronic assessment resources conforming to the IMS Question and Test Interoperability specification (QTI). However, these have tended to address the needs of users who are already familiar with QTI terminology. In order to engage colleagues who are new to QTI, we are designing an authoring tool starting from the novice user's perspective.

JISC and HEA have funded several projects which have produced open source software for authoring and editing QTI electronic assessment resources. These have included

- Aqurate, which developed the Aqurate editor;
- QTITools, under which development of Aqurate continued;
- MathAssess, which began the development of the Mathqurate editor;
- FETLAR, under which development of Mathqurate continued.



These editors, and others, have used the structures provided by the IMS Question and Test

Interoperability specification (QTI)['] as the basis for the features they provide for users. This approach requires users to have some knowledge of the QTI specification. We are exploring the alternative approach of providing the functionality that users require, without (necessarily) introducing them to the QTI specification.

The Elephant in the Room

Uniqurate[⁻] is a new project in the current JISC Assessment and Feedback programme under strand C, Technology Transfer. Currently ongoing and scheduled to run between September 2011 to February 2013, the primary goal of the project is to increase usage of QTI in HE by transferring technology into a number of "client" institutions who have no prior experience of either QTIbased eassessment or the existing tools. An integral part of this technology transfer would involve the redesign of existing tools and potentially the construction of new tools in order to decouple the software from the maths subject area and make it more accessible to QTI naïfs.

There has been a considerable amount of continuity of personnel from project to project. This continuity has been very important not only for the projects themselves but for the QTI community in general, because it has led to the creation of a team within this community with a wide range of disparate skills, ranging from software development in learning technology, eassessment content authoring, the QTI specification itself, and pedagogy and course design. Although there has been the occasional new member joining this team, by and large it has remained relatively unchanged from project to project.

However, this continuity has come with a price. The projects adopted a usercentered design approach and all could have been said to have fulfilled the three criteria originally outlined by Gould & Lewis (1985), i.e. early focus on users and tasks, empirical measurement, and iterative development. Agile methodologies were used throughout. In the case of the original Aqurate, a dedicated HCI usability laboratory was used for user testing, with the application tested for usability and against user expectations.

However, over the course of the projects users became highly knowledgeable of the QTI specification, and as a result user expectations shifted. In later projects, this shift led to the tools being designed primarily for those who "spoke" QTI. This negated the need for a simpler UI and led towards an authoring tool where content could only be expressed in terms of QTI elements. This is not, of itself, a restriction, since QTI is designed to express a very wide variety of assessment capabilities, but it did require users to know the standard. At the same time, the focus moved towards maths, where the user base is commonly accustomed to using complex notations

e.g. LaTeX. The additional features required for handling mathematics were added using the QTI extension capabilities, and were, of course, present in the authoring tools as well as the delivery software.

^IIMS Question and Test interoperability specification: <u>http://www.imsglobal.org/guestion/index.html</u> accessed 04/05/2012.

²Uniqurate:

http://www.jisc.ac.uk/whatwedo/programmes/elearning/assessmentandfeedback/Uniqurate.a spx accessed 03/05/2012.



Consequently, later tools were only accessible to those competent in the QTI standard, and heavily coupled with the Mathematics subject area. User testing was highly successful in that the group of now expert users felt the software product was very much in keeping with their expectations. However, one of the primary goals of the later projects was to increase usage of QTI in Higher Education (HE). Here, the projects met with less success and found it difficult to establish themselves beyond the institutions with which the team members were affiliated.

Interoperability: the other elephant in the room

In the past the "killer" feature of QTI had always been portrayed as interoperability, and those who worked on previous projects held the importance of this to be selfevident. Some had had negative experiences with closedformat content, such as that which occurred with the CALMAT system. CALMAT (Cook & Hornby 1995) was a very successful eassessment system for maths that was widely adopted by a variety of institutions and in several contexts. However, as a closedformat and closedsource project, when the project was discontinued these users were left unsupported. Initially this was not a problem – the tool was mature and continued to provide pedagogic value. Although the system is still in use at some institutions, it is becoming increasingly incompatible with newer operating systems, and a stage will be reached where continued use wais impractical.

Early requirements gathering for Uniqurate revealed, however, that interoperability is only seen as a priority if users have previously experienced such a disaster. These new clients were unimpressed by the established research personnel proselytizing on interoperability. Instead, questions such as "what will this tool give me that QuestionMark Perception does not?" were the order of the day. This question is pertinent not because of any answer that might have been given –perhaps the only answer that could have been given at that time would have been "whatever you ask for – now can you please go ahead and ask!" Rather, the question was important because it exposed the fact that the uninitiated had a completely different set of priorities to those already deeply embedded in the area.

There are already a variety of tools available for creating electronic assessment content for both formative and summative purposes. Further discussions revealed that, among some of the new clients, the interest had never truly been about interoperability, but far more to do with the project presenting an opportunity to able to shape the form of a new eassessment authoring tool according to their own needs. They wanted eassessment resources to be quick and easy to construct, yet still result in innovative, rich content for both formative and summative purposes something they felt their existing tools did not provide.

Davis' Technology Acceptance Model (Davis et al. 1989) essentially states that user acceptance of a piece of software derives from how useful it is perceived to be (U), which in turn is influenced by its ease of use (E), with both influenced by "external variables". These all combined to influence a user's attitude towards the software, leading to a "behavioral intent to use" and ultimately to "actual system use". If one accepts this model, one might also argue that one of the reasons past projects struggled to achieve their goal of increasing "actual system use" of QTI solutions within British HE was because the definition of "useful" by those involved – and thus the focus of their research – was unnaturally skewed towards interoperability. However, others did not perceive interoperability as intrinsically useful in its own right. Similarly, unless someone has an investment in a specific standard people are disinterested in what format their e-assessment tool works in. They see it as irrelevant. A tool that produces QTIbased assessment will not necessarily be regarded as valuable because it produces QTIbased assessment per se, but because it produces assessments which people want to use.



Uniqurate: a 'new-user' centered approach

This all contributed towards a different approach being taken for the Uniqurate project. Here, the user experience and the requirements of uninitiated users are paramount. We describe this as a 'newuser' centered approach, i.e. an approach centered around new users with no prior QTI experience (as opposed to a new approach centered around an established group).

On past projects, a requirement such as "we need to be able to support the graphicGapMatch interaction" would have been perfectly acceptable. In contrast, in this project, use of QTI terminology or mapping features directly onto QTI interactions is actively discouraged. Instead, requirements must be expressed in plain English and include a context. This comes naturally to the new partners, less so to those who have been working in QTI for some time, but is important if the resulting tool is to be useful and usable in its own right as an eassessment authoring package rather than as a showcase for the breadth of the QTI standard.

Users are also being encouraged to think of material in terms of "question components", which are defined as any part of a question that provides communication to and from the student. These may map onto QTI interactions, but they may not, hence we use the term "question component". Definitions of question components are being sourced in two ways. Firstly, by decomposing existing eassessment content into constituent parts; secondly, by examining existing eassessment content, detaching from its current subject discipline, and considering whether any components present have a general applicability.

Uniquiate has three modes of operation – the friendly, userdriven mode, intermediate mode, in which only the HTML within the question can be edited, and expert mode.



Figure 1. Authoring a multiple choice question in Uniqurate's friendly mode



In the "friendly" mode, the user can choose from a list of question components and drag them into any order in the question framework. A crucial aspect of our requirements analysis is to identify question components that provide the best crossdisciplinary benefit. The components identified and implemented to date are

• Text area: an area in which text, images, tables, MathML, etc. can be displayed;

• Multiple Choice Question: the basic but versatile quiz question type of input; feedback can be set for each option;

• Maths Triangle: this is a question type which is frequently encountered in STEM subjects and other numerate disciplines; an equation equivalent to a=b+c forms the basis of the component, the values of two of the variables are given random values and the student is asked for the value of the third variable. The author can choose the variable names, the quantities they represent (if any) and the randomised values.

The client institutions have identified further components as possibilities for the next phase of development:

• "Units" – a component intended for the creation of questions that test students on their ability to convert from one unit of measurement to another

• "General maths" – a customisable component for simple maths equations that do not fit specifically identified components such as the Maths Triangle.

• "Excel" – a spreadsheetlike grid into which students are expected to supply missing values

and still more can be easily anticipated as mainstays of electronic assessment, for example, text input, image positioning, answer grouping/pairing, etc.

| Question components | Menu | Question | Preview | | | |
|------------------------|---|------------------------|----------------------------|----------------------|--|--|
| | Distance, Speed and Tim | e | | | | |
| universe, and even "22 | | (e)(e), for | parties 21 | | | |
| Charles Dickees | B / U AN 新 著 潮 ■ Portfanly * PortSte 注 注 注 注 | | | | | |
| Geoffrey Arche | This is a question about speed, using the ec | - 2 X, X' juation | | | | |
| | $d = s \times t$ | | | | | |
| | | | | | | |
| | et axied by positive re- | | | | | |
| | Preview: If distance is 2km and speed is 4kph, what will time be? | | | | | |
| | Names of variables | Units | Ranges | Calculations | | |
| | d d: dstance | d:km s:koh | 6 : 10 - 100 8 : 2 - 20 | Both Multiply | | |
| | s t t: time | t : h | t:1 -100 | O Divide | | |
| | | | Integers only: | Score for correct: 2 | | |
| | | | | | | |
| | | to and to | | | | |
| | | | | | | |

Figure 2. Authoring a "maths triangle" question in Uniqurate

A question can have more than one component. If we consider a question dealing with Ohm's Law, for example, a multiple choice component might ask a student to identify what V, I and R stood for and then a "maths triangle" might ask the student to calculate the value of one of the variables based on randomized values of the others. Although the individual components are relatively simple in nature, the ability to combine them within a question means that immersive and engaging electronic assessment resources can be created. The ability to combine components, and thus to have several interdependent inputs in the same question, is a feature which is very unusual in currentlyavailable authoring systems.



In expert mode, the user can edit the QTI XML directly, and create a package containing the question itself and any media files that are required by the question. Although on the surface this may not appear to be in keeping with the ethos previously described, it still provides a crucial function. Firstly, there is still a need to provide the existing community with a useful tool. Abstracting the UI and particularly the question components from the underlying format means that those new to QTI do not have to become familiar with it, but it can be intrusive for those who are au fait with "raw" QTI. The expert mode provides a convenient method for editing the pure QTI while still providing tools to assist in the more mundane aspects of question authoring and packaging.

| (Fields) | lex.nollex.pu | | | | |
|-----------------------------|---|--|--|--|--|
| /¥eta(○ uq-question.xml | equation.wi discrete in the question with the provided induced with the question of the question without the question by Face Rever, Ringston University, hassed on a demo question written by Dick Baccon, University of Durrey, 18,08 The comments in the question body making university of Durrey, 18,08 The comments in the question body making university of Durrey, 18,08 The comments in the question body making university of Durrey, 18,08 The comments in the question body making university of Durrey, 18,08 The comments in the question body making university of Durrey, 18,08 The comments in the question body making university of Durrey, 18,08 The comments in the question body making university of Durrey, 18,08 The comments in the question body making university of Durrey, 18,08 The comments in the question body making university of Durrey, 18,08 The comments in the question body making university of Durrey, 18,08 The comments in the question body making university of Durrey, 18,08 The comments in the question body making university of Durrey, 18,08 The comments in the question body making university of Durrey, 18,08 The comments in the question body making university of Durrey, 18,08 The comments in the question body of the during university of Durrey, 19,17 The comments and the during university of the dur | | | | |
| | <pre></pre> | | | | |

Figure 3. "Raw" QTI authoring in expert mode

Expert mode is also seen as a crucial training step. Although most users will spend the majority of their time in "friendly" mode, once they are familiar with the tool, users will be supported and encouraged to switch over to expert mode and make minor tweaks to the code in order to finetune questions, particularly in terms of the logic required to deliver tailored feedback.

The third mode, Intermediate, allows a user to edit the humanreadable parts of the question without disturbing its underlying structure. The HTML sections are displayed within a WYSIWYG editor similar to those in the Text Area component in "friendly" mode. The surrounding XML is hidden. This feature is expected to attract a number of colleagues who want to adapt sophisticated questions which already exist, but who neither want nor need to get involved in editing the XML. For example, there is a substantial collection of questions in mathematics which can be contextualized to a variety of disciplines by changing, or adding to, the visible part of the question. The importance of contextualization in engaging students with essential subjects such as mathematics, which may not be their chosen area of study, makes this facility particularly valuable.



| Field | uq-question.xml | |
|-----------------|---|--|
| uq-question.xml | I I | |
| | What colour is the sky? | |
| | Red | |
| | Blue | |
| | Green | |
| | | |
| | Wrong! The sky is not red, it's blue! | |
| | Well done! The sky is indeed blue! | |
| | Wrono! The sky is not green, it's blue! | |

Figure 4: Intermediate mode

Documentation and Training

The project partners have been using the prototype Uniqurate editor for several months now, and are introducing it to novice colleagues within their institutions. A new project, QTIPET, has been funded recently, and this will provide the opportunity to create online training resources for Uniqurate as well as for other tools in related projects. These will include step by step demonstrations with voiceover as well as written documentation. Live online training sessions are also planned, in which partners in the current projects will use video conferencing and screen sharing techniques to guide colleagues in the new project in using the tools. It is expected that there will be some spare capacity in these sessions which could be taken up by "interested outsiders".

Evaluation

While the editor is under construction, evaluation is ongoing as the partners critique the emerging application, and the results feed back into the development during each cycle. However, it is intended that, towards the end of the project, the tool will be evaluated by means of questionnaires asking both the project partners and new users their views on the functionality and usability of the application. The report from this evaluation is a project deliverable.

Conclusion

This new approach to standardsbased authoring provides novice authors with a tool which enables them to construct questions with the features they require. The Uniqurate editor can be used by people who are completely unfamiliar with QTI – there is no need for them to be trained in using the specification. This is likely to make it suitable for creating studentauthored content. The small library of question components is growing slowly as users identify new question designs which they wish to create. Readers of this paper are most welcome to try out the editor in its latest form. Assistance with using the tool and with adopting QTI is available at the QTI Support Site³, where sample questions and tests, demonstrations of the tools and a variety of documentation can be found.



References

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