

AN XML-BASED QUESTION BANK USING MICROSOFT OFFICE

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Abstract

This paper describes the development context and the main features of an XML-based Question-Bank (QB) application being created at the University of Manchester as part of a CBA project that uses Microsoft Office as both the authoring tool and the storage system.

The use of MS office significantly reduces the workload of question authors because QB items are created, stored and automatically extracted within the familiar format of MS Word documents. This approach facilitates the easy inclusion of diagrams, images and other types of multimedia components within questions as the elements of the question are marked-up with either HTML or XML tags using an authoring toolbar that is added to the standard MS Word toolbar.

When a Word document, containing one or more marked-up questions, is loaded into the QB the tagged question meta-data is extracted by the application parser and stored in a Microsoft Access database. By making use of the stored meta-data the assessor has a wide range of methods by which to select questions. This includes, for example, the use of specified or random questions and selections based on keywords or topics.

The CBA system uses the Assessment Transformation Tool (ATT), which was developed as part of the project, to deliver MS Word based assessments, marked-up in either HTML or XML, directly to Question Mark Perception (QMP) for delivery via the web. Assessments produced using the XML QB can also be output to paper for a traditional form of assessment or for use with an Optical Mark Reader (OMR).

The XML Question Bank already offers the potential to export to the IMS QTI standards through its interface to QMP. If the system is adopted it will be further developed to directly support the QTI standards for both import and export with other question banks.

Introduction

The demand for some form of easily accessible Computer Based Assessment (CBA), for the use of both on-campus and distance students, is likely to expand in the near future. This is because staff are recognising the benefits of using more objective assessments as part of their testing procedures. This is particularly true in first and second year courses with large numbers of students. The increasing adoption of Virtual Learning Environments (VLEs), such as WebCT and Blackboard, provides the opportunity to deliver assessments via the VLE. However, some staff are interested in forms of CBA for diagnostic, formative and summative assessments of the type that only dedicated CBA systems, such as Question Mark Perception (QMP) (Belton & Kleeman, 2001) or the TRIADS system (Mackenzie, 1999) can provide.

There is a significant degree of asymmetry between the students and staff in the level of effort required to use CBA. Many institutions already provide the facilities to ensure that their students have the ability to use a web-browser and other basic I.T. skills at an early stage in their course. In contrast, the staff must find enough resources to:

- Learn to use new systems when both creating and delivering their assessments.
- Create pedagogically sound and objective questions that test the students at least as effectively as that achieved by traditional methods.
- Justify the costs of developing and maintaining a bank of high-quality objective questions.

The attraction for staff of using CBA is that once these systems have been mastered, and the questions have been created, there are potentially large benefits from the significantly reduced marking effort required. This is particularly true when coupled with the ability to provide more frequent automated formative testing opportunities for the students through question re-use. It is also possible that the true value of item banks, particularly those with evidence of their past performance, will be welcomed for the tremendous resource they represent, and that some form of recognition of the author's effort will follow.

This paper describes the development of a CBA project at the University of Manchester that leverages the current skills of staff and re-uses the investment in their existing questions in order to help them create assessments without the need to learn complex new software.

The Manchester Computing CBA Project

To gain some understanding of the problems and opportunities associated with Computer Based assessment (CBA) the University's Computing Department began a pilot project (Daly, 2000) using Question Mark Perception (QMP) to deliver CBA to a number of strategic departments on the campus.

The QMP software is both powerful and feature-rich, consequently, it is difficult to control. From the start of the pilot phase, two junior staff members have been assigned as part of the CBA team. Their role has been to directly

support departmental staff using CBA facilities, manage the QMP server software, and provide advice to staff when creating their assessments. To ease the adoption of CBA we have used a bureau style approach in the project and therefore departmental staff do not interact directly with QMP.

The main attraction of the project is that questions and assessments are created in the familiar environment of Microsoft Word, although they are delivered via the Web or more traditional routes. As a result, all the normal formatting and graphics required by the author can be used as part of the assessment. The user benefit from the cargo of attributes that are carried by using the MS word format, such as font size, typeface, without the need to explicitly track them. One of the other benefits of this methodology is that the question author retains ownership of the source document, with all of the original formatting and image contents, in a form with which they are familiar.

The first phase of the project involved the development of a system to support the use of HTML mark-up for the different elements of the questions. We also designed the Assessment Transformation Tool (ATT) in order to transfer the assessment to QMP.

In outline, the process works in the following way. Departmental staff create their assessments and mark them up and then email it to the CBA team, who convert it using the Assessment Transformation Tool (ATT). If errors are found during this process an email containing information is sent back to the author. If the assessment contains no errors it is converted and loaded into QMP and made available solely to the staff member on the web. Once the assessment is available on the web the author may inspect it and make modifications to their own local MS Word source document and then email the file back to the CBA team, who once again convert and load it. Once all corrections have been made the assessment is scheduled and student usernames and passwords are set-up, ready for the actual assessment. After the assessment has been run the CBA team email the processed results directly back to the staff member in an easily digested form within an Excel workbook.

Once the HTML mark-up and exam delivery process was in place and working successfully we took the opportunity to review the supporting systems. Clearly the methods that we had developed provided ease of use for the staff. However, to be certain that we were protecting the investment of the staff we began the process of developing a system based on a more rigorous mark-up using XML. This was to anticipate the adoption of the IMS QTI standards (Lay & Sclater, 2001). We extended the specifications of the XML system so that it would include the use of a local question bank. The design of the bank is simple enough to be used by a single staff member on their own machine, and sufficiently structured that it could be used by a large group of staff all sharing the facilities.

The following sections outline the main features of the CBA system that support the use of the XML question bank in delivering and marking assessments via the web or paper.

Question Authoring

The question author uses MS Word as the authoring tool with a floating tool bar to mark-up the elements of the question with tags. Therefore the layout of the question and the inclusion of diagrams and other multimedia elements is controlled by the familiar MS Word document format. This technique can be applied retrospectively to existing text, or template filling can be used when new text is being added if this is more appropriate.

There are currently 8 standard forms of objective question that may be included in this format. These types range from MCQs, Multiple Response Questions, free text fields, numeric answers up to compound MCQs that have several sub-questions. The authoring tool bar allows for general question feedback tags, and for responsive feedback to be provided, depending upon which question option was chosen. We have also found that, at most, a 10-minute training session is required for staff before they are able to download, install and use the tagging tool with MS Word if they were not already familiar with the concept of templates.

The amount of tagging that is required to mark-up questions has been deliberately minimised so as to provide an acceptable ratio of tags to content, rather than the fully specified approach of the QTI standard. For instance, we have not yet included the ability for question shuffling within assessments or re-ordering of the question options.

Adding Questions to the bank

The author may store one or more tagged questions in each MS Word file before loading the file into the bank. The number and types of questions in each file is completely arbitrary. The bank assigns no special meaning to the files other than being a container for one or more questions. In practice however, we expect that questions will be created in topic groups within a file (see below).

Before a file is added to the Question Bank the system runs a number of integrity checks to ensure that the file contents are correctly tagged. If any of the integrity tests fail no changes are made to the bank and the system generates an error report for the author to help identify the problem in the file.

If a file passes the integrity checks a copy of the author's original file is made which has extra meta-tags added to it that are used for QB control functions. It is at this stage that each question in the file is assigned a unique bank number. These extra tags do not intrude into the XML layers already placed around each item by the question author. Rather, they add extra layers of XML wrapping for each question within that file. This meta-tagged file is then stored within the directory tree of the bank. During this process the contents of some of the tags are extracted into the database. For example, the tagged list of keywords, supplied by the question author, is extracted so that it can then be searched during the process of question selection in order to identify a list of questions dealing with similar subjects.

The date/time stamp of the meta-tagged file and its relative path from the top node in the QB is also recorded in the bank's database for use during question retrieval. To impose some structure on the questions the authors may use the topic tag. This is tracked by the database and can be used to divide up the questions into separate domains if required. The structure within the topic is that of parallel branching trees with the nodes separated by the '/' character. This is more or less like the reference to a file path in a standard disk directory structure. This imposed structure is in contrast to the free text entries that are used in the 'Keywords' tag.

Some planning is required if the use of the hierarchical topic tag is to be beneficial. If the field is used in a question the contents can either be a root node which does not contain the '/' character, or a branch node, which contains one or more occurrences of the '/' character. The restriction is that nodes above the terminal node in this path must be already defined in the database. This restriction is imposed so that terminal values can not become detached from the trees. By default, if no topic field is supplied the question is effectively placed at the root of the NULL topic tree.

By default, the QB will suggest a directory using the Topic of the first question within the file. The actual directory structure used for the bank is left to the user. This means that all of the MS Word files could be stored in one directory, or individual authors might wish to have personal directories. The only stipulation is that the bank directories are kept together with the other sub-directories that are used by the QB as part of its internal processing. As part of the process of file import the system generates an ACF file (see below) for the questions that have just been added to the bank. In one test the automatic loading into the bank of 3000 questions from a legacy database, that had been previously marked up automatically, required about 15 minutes on a mid-range computer.

Modifying Items in the Bank

At times it may be necessary to modify an item that is already in the bank. To permit the edit of a question the whole file containing the relevant question is signed out of the Bank. As part of this process a copy of the meta-tagged file stored in the bank directory tree is made available to the user for modification. With a file in a signed-out state none of the other questions within the file can be used in any other assessments until the file is signed back into the bank.

When the edits have been completed the file is signed back into the bank. The incoming file must meet the relevant referential integrity checks to ensure the consistency of the bank before it is accepted to replace the original file and the new date stamp is recorded. During this process the structure of the file being signed back in is compared with the original copy of the file already in the bank. There are different criteria in force if the edited question has never been used. In that case changes within the XML tagging in the question are permitted. However, if the question has been used previously, no change in the XML is permitted. The question may be marked as withdrawn in the database so that it is no longer available to be included in assessments,

although it still retains its historical and referential integrity. A new version of the question could then be added for future use.

Assessment Creation

When an assessment is to be created the assessor uses the VB application program to query the Access database containing the extracted meta-data from all of the items within the bank. As the assessor selects items for their assessments, their bank Ids are added to an Assessment Configuration File (ACF). This ACF not only contains the list of question Ids, it may also include other information, including optional starting seed values, to select random questions using keywords or Topics. There is also the ability to specify a list of Ids and have random selections made from this list. The ACF files may contain references to other ACFs to allow for the incremental creation of large or sectioned exams.

Once the ACF is complete it is processed by the application to create the Assessment Definition File (ADF) which is a fully resolved list of item Ids. After this stage the assessor chooses in which format the assessment will be delivered as the session file. The formats available allow for it to be loaded into QMP or a MS Word document that is added to a selected MS template file suitable for printing for a traditional delivery. The system will also output a file containing the required information to support software systems capable of automatically create Optical Mark Reader (OMR) forms.

Response storage

At the moment there is no facility within the bank to hold student responses. The data is currently stored by the user in files on an ad-hoc basis within the QB directory tree. When the system is fully developed the data will remain in files, but these response files will be tracked by the QB system in a form that maintains the appropriate level of referential integrity. It will then be possible to automate the analysis more fully because the Session file will be linked to both the ADF file and the Response files.

Assessment Analysis

The QMP package does include reports to perform different types of analysis of the data. However, we have developed our own automatic approach to analysis. This is because we receive response data from a number sources, such as Optical mark reader (OMR) output, electronically delivered assessments of various kinds and even a data-prep bureau. To accommodate the different sources of data we have designed a standard data set on which all subsequent analysis is based for all types of assessments, irrespective of their origin. To accept data from many sources and formats we have created a series of transformation programs to reorganise the data into a standard form so that we can provide a similar form of analysis. When a new data source is encountered a new translation program is created. In some cases, for example, we will not have the original marked up questions available in an electronic format. As files containing this are a required part of the analysis input data set, the transformation process creates dummy files so that the standard analysis can proceed. In this way it is possible for us to provide an

analysis service to staff who are using legacy systems. This also allows us to perform test analysis on historical data to ensure that our system is accurate.

The results of the analysis process are delivered to the user in the form of a multi-page Excel workbook. The first page of the workbook lists all of the other pages within the workbook, along with a short explanation of their content. We always include a page that holds all of the raw data from the assessment, so that the user may perform further processing.

One of the pages within the workbook includes a list of student names, library cards numbers, section scores and final score. This page is designed to be directly usable as a result sheet on a notice board. Particular columns, such student name, may be easily deleted within the workbook before posting if required by local exam regulations.

We have used this approach so that we will be able to add new forms of analysis if it is required. By incorporating into the default set all future users will benefit.

As part of the item analysis we provide a stacked bar chart showing the responses of the students in different quartiles of the exam overall to the options available for that question. In some forced choice assessments it is possible to see that particular questions have not performed correctly. This may be because the question is badly phrased, technically unsound, pedagogically inappropriate or, quite commonly, incorrectly marked-up because the question author has specified the wrong option as the correct one. The analysis we provide is designed to identify these kinds of problems at or before the examiners meeting (see Appendix A).

We do not include any active formulae in the workbook but supply only numeric and textual data. Therefore, in the event that a question has to be withdrawn from the assessment, we re-run the analysis rather than expect the users to make complicated adjustments in the workbook.

A number of users with legacy systems for data processing are already in the process of utilising our analysis service to remove the need to maintain their own.

Surveys

The HTML mark-up has already been used to deliver on-line survey through QMP to very large number of participants. The analysis used on these data is similar to that required for summative and formative assessments. The results are also provided in an Excel workbook. These are accompanied, if necessary, by a MS Word document listing the responses elicited from any free text fields within the survey.

Conclusion

The project has been very well received and all of the authors who have used the system appreciate the ease with which it is possible to create assessments. Consequently, we have delivered a very wide range of diagnostic, formative and summative assessments and surveys. When we have fully developed the question bank it is likely that we will be able to comfortably support a very significant increase in the amount of CBA delivered across the campus.

One of the limitations of the project is that it utilises MS Word 97 as the authoring tool which will not be supported long term. We may need to devise a suitable plan to mitigate this risk. One future objective would be to be able to load assessments directly into the popular VLEs and be capable of receiving student response data so that it could be subjected to our own analysis process.

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Appendix A - Item analysis

This appendix illustrates the type of analysis provided for a single question. The figure shows a graphical representation of the distribution of answers for each of the possible multiple choice responses for a simulated multiple-choice question which is marked up using HTML tags, and includes some general and responsive feedback. Different colours (greys in the black and white image) have been used in the stacked bar chart to indicate the choices made by the students in different quartiles (27% in this case) in the exam overall. We have also incorporated the two standard question metrics of Facility and Discrimination as raw figures to show how well the question was able to differentiate between the stronger and weaker students

As part of the checking process the original HTML marked-up text of the question is also included in order to help to identify any problems with the students' understanding of the question or detect errors in the question, such as having the wrong option being marked as correct.



