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The Maths Itembanking Project: a work in progress

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THE MATHS ITEMBANKING PROJECT: A WORK IN PROGRESS

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The Maths Itembanking Project: A Work in Progress

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Introduction

An Itembank can be defined as:

> *a collection of items for a particular assessment, subject or educational sector, classified by metadata which facilitates searching and automated test creation.*

An "item" consists of the question itself as well as elements such as responses available to the candidate, feedback, scoring information and metadata describing the item.

The Scottish Qualifications Authority (SQA) has been itembanking in various subjects in paper form since the 60s. In the 80s this was enhanced by the introduction of a computer database to hold the item usage data, however the questions themselves are still held on paper. Currently live itembanks using objective items are held in Computing, Information Technology, Biology, Chemistry, Physics, Bio-chemistry and Human Biology and SQA is looking to extend its use of objective testing (McAlpine, 2004) in order to benefit from the recorded increases in reliability through more accurate marking; opportunities for broader syllabus sampling; potential of a benchmarking component for year-on-year comparability purposes, and enhanced quality assurance through pre-testing (Ward, 1981)

In 2004, it was decided to re-introduce an objective (multiple choice) paper into the Maths Higher examinations from 2008 onwards, after this element had previously been dropped in this subject favour of constructed responses. The main drivers for this were to facilitate a return to returning to calibrated items to better monitor standards.

It was decided that, given SQA's commitment to exploring the potential of new technology to enhance the assessment production and delivery process, it would be advantageous if this bank were stored in an electronic format. It has been recognised for some time that paper based itembanks are unwieldy and not as flexible as we would like. Additionally as we move to computer based testing, there is recognition that developing an electronic itembank in a form which can be imported into a computer delivery package would allow us to

anticipate and prepare for the arrival of such testing but place no demands on our centres or candidates. That said, it was not an objective of this project to produce functional on-line assessment, merely an electronic store for items to be delivered on paper.

Key considerations in this project were the security of the items, the format in which they were stored and the processes which could be used both in migration of existing banks and the commissioning and entry of new items.

Security

The security of the items was a key concern in this project. There are debates about what is an appropriate level of security around an itembank. SQA takes the view that all items in the bank are potentially live items and thus the security of an itembank should be comparable to question paper security. It was envisaged that the solutions which were chosen for this project would also be applicable for other items including those in large banks and those which were native computer items, hence the solution had to be both scalable enough to accommodate all of those which might be inserted and flexible enough to cope with increasingly diverse items.

Until this project, items were not stored or transferred electronically within SQA[1] except at question paper production stage. The solution that we settled on was to store the files on a secure and hidden party of the internal network with restricted access. Although that meets our requirements for security, it is not as flexible as we would like, and this issue will need to be reconsidered at some point in the future.

Encoding the Item Content

Although there were no immediate plans to enable computer assisted delivery of the items, it was hoped that at some future point this may be a possibility. Thus storage in a manner which would be easily imported into an assessment delivery system was considered desirable. The IMS Question and Test Interoperability (QTI) specification is widely adopted by such systems as an import format thus it was decided that this should be adopted as the storage format. Version 2.0 had just been released at public draft stage at the commencement of the project, and although there were concerns that there may be changes between the public draft stage and the final release, we felt that the benefits of native adherence to the latest specification outweighed the stability of version 1.2.

This then raised the issue of how the items should be input into this format, coding the items by hand – although possible, is not desirable and as Version 2 of QTI was so new, there was little available to encode in that format. We

[1] Although item-writers may send in their questions on disc

are indebted to the University of Cambridge Local Examinations Syndicate (UCLES) for allowing us to use their Java application which generates QTI files from a form based interface. This tool will only encode MCQ items at present, which makes it suitable for use for this project only. However, there are ongoing negotiations with UCLES for us to develop a model for the development of this tool allowing other types of items to be authored.

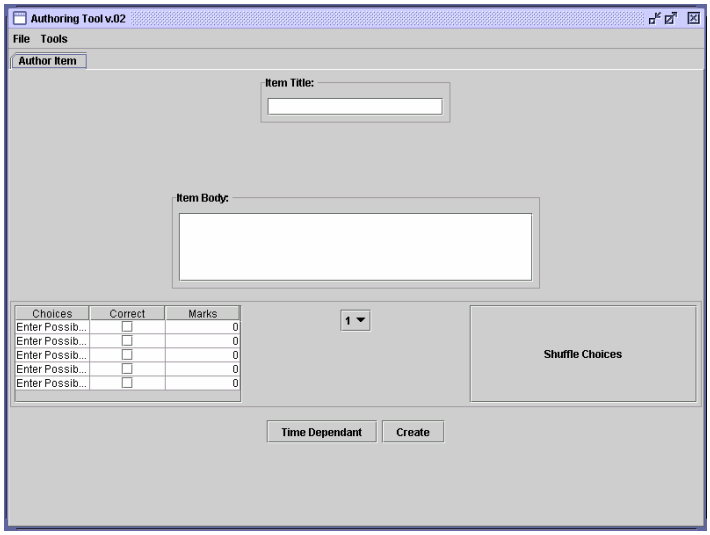


Figure 1.

Screenshot from the UCLES QTI Version 2.0 Editor, used for item coding in the Maths Itembanking Project.

Encoding Maths Notation

Maths questions pose particular problems with rendering given their reliance on appropriate formatting of mathematical notation. Three possible solutions were considered – gifs (images of mathematical notation); LaTex (a coding mechanism for formatting) and content MathML (a direct encoding of the relationships between the elements), presentation MathML having already being discarded as having the difficulties associated with content MathML however none of the ease of input of LaTex. Content MathML was quickly settled upon as the most desirable format, as it can provide culturally contextualised mathematical notation by varying the stylesheet which controls the display and also facilitate parameter randomisation through its direct encoding of mathematical relationships.

WebEQ was used to create the content mathML which allows equation building and editing to generate content MathML from directly inputted equations which were then exported and manually copied into the QTI file.

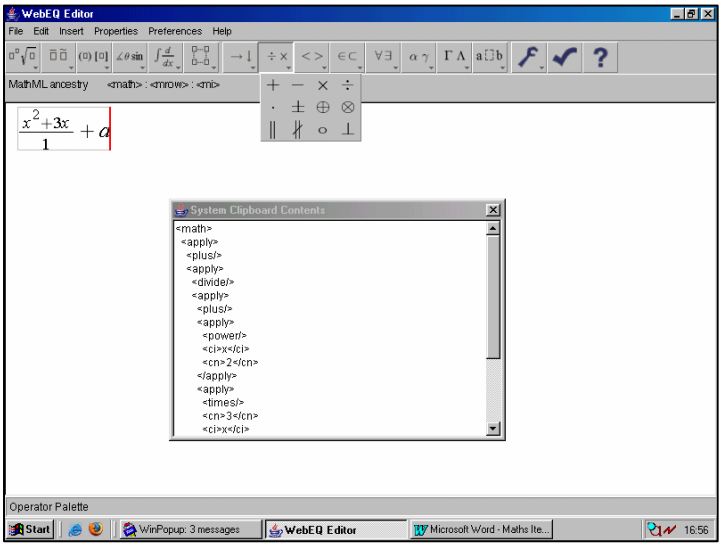


Figure 2.

Screenshot from the WebEQ Maths notation editor: - used for coding the maths notation in the Maths Itembanking Project. Note that the main window shows the pull-down menus, for notation editing, while the pop-up window shows the exported MathML file.

Encoding Graphical Representation

Traditionally graphics are presented on the web through gif or jpg formats. Although these technologies work well on screen, they do not work well on paper, and a different version must be created for these. A new XML standard called Scalable Vector Graphics (SVG) which encodes the graphics directly into the webpage and then generates the image on the fly, is being used for images in this project. This technology has no depreciation between screen and paper formats and as the name suggests can be scaled without loss of rendering, making it an appropriate technology for use when considering candidates with additional requirements. It also has the added advantage that graphics can be rendered directly from their mathematical parameters, opening up the possibilities for parameterised graphical items. This technology is very new and there are currently no moves in SQA towards using parameterised items of any form, much less graphical parameterised items however in the interests of future proofing it is clear that this would be a desirable technology to utilise.

The image files were generated in Adobe Illustrator, which has the capacity to export in an SVG format. These were then linked to from the QTI file.

Metadata & Usage Data: Search and Retrieval

The IMS has developed a specification for the description of learning objects in a standardised way. This has been further refined by CanCore and the UK Lom Core and has been adapted for assessment item use by the IMS QTI specification. Building on this, a further refinement of the metadata was created following consultations with key members of staff within SQA to produce a specialised SQA Application Profile, as a specialised instantiation of the UK Lom Core. Assessment items have further issues with usage data

(statistical information on item performance) which means that standard content packaging tools cannot be used.

Together with Strathclyde University, SQA is working to develop a software system which will accept metadata for items (including the QTI extensions) according to a specified profile; encode usage data for items and content package them according to international specifications for archive, storage and transfer. We are also developing a database which would hold the metadata and usage data for the items to facilitate effective searching and retrieval. The project is due to be completed by September 2005, with the software available under an open source licence.

Rendering the items

Once the Items were encoded within QTI and the MathML embedded, we had considerable difficulties rendering them (and consequently identifying whether they were correctly encoded). We explored three emerging QTI 2.0 renderers:

Graham Smith at Leeds University has been trialling a QTI 2.0 renderer, this was initially hopeful, especially as it had been specifically trialled with Mathematical extensions to the QTI and could render MathML encoded notation. However, the software was only available on a remote server and as these were live bank items we could not allow copies to be sent to an external server for rendering.

APIS - developed by Niall Barr and Rowan Young at Strathclyde University. This is a webservice, which calls the files from a designated drive on the server through APISTestHost, as our items were live, we needed this installed on a local server, which Niall Barr was kind enough to facilitate. However we found that the method in which this was rendered meant that it was incompatible with additional XML schemas, such as MathML.

Manolis Mavrikis at Edinburgh University had also produced a renderer, specifically for trialling mathematics questions, and was kind enough to allow us to use it. Although there are still some small outstanding issues, the vast majority of questions are viewable in full in a standard browser.

Future Areas of Exploration

This first phase of computerised itembanking is now complete, and we have addressed many fundamental issues with storage, metadata, encoding, search, retrieval and rendering. However we are aware that our objectives of the first phase were necessarily limited and do not provide full operational solutions. In continuning this work we have identified three further areas which we would like to concentrate on in Phase 2.

Review of Item Security

Although we are confident that our items are secure, the solution which we have implemented is neither scalable nor flexible enough to be implemented operationally as it relies on a single itembank adminstrator with limited network access working on a single machine.

Extending the range of item types

At the moment, we are only able to bank Multiple choice and multiple response questions due to the limitations of our input software, however we have a number of other question types held in a variety of of proprietary format s which would benefit from the advantages that banking could provide – we are actively seeking to extend the range of item types that can be authored into the bank.

Migration of paper itembanks

As was mentioned at the start of the paper, itembanking is not a new development for SQA and we already hold significant numbers of items in a paper based format. We would like to start the process of migration so that these banks can benefit from the increased search and retrieval powers that an electronic format can bring. Particular challenges are anticipated with the rendering of chemical formulae, genetics notation and the depiction of molecular structures, however we are confident that these can be overcome.

Conclusion

The advent of usable stable standards for assessment is providing confidence for large scale developments in itembanking, which can only be to the benefit of candidates, given the increased reliability and feedback which can be gleaned from calibrated items. This project is a first step in this direction.

References

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Ward (1981) *Preparing and Using Objective Testing*, Stanley Thornes, Cheltenham. ISBN 0859504387