IMS Question & Test Interoperability Specification: A Review

A QTI White Paper from IMS

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Summary

In this white paper we present a review of the IMS Question & Test Interoperability specification. The first version of this specification was formally released in May 2000 and consists of three documents: the Information Model, the XML Binding and the Best practices & Implementation Guide. The primary objective of this specification is to allow systems to exchange questions (formally termed Items) and tests (formally termed Assessments). The specification has a powerful set of features that enable it to exchange a wide range of question types plus a number of extension facilities that allow it to be support proprietary features. However, the specification is structured so that it is very easy to support the classical multiple-choice question (which accounts for the large majority of computer based learning questions). As part of this paper we present the QTI-XML required to capture a multiple-choice question. This example is an excellent template for users wishing to create their own QTI-XML multiple-choice questions.

1. The IMS Global Learning Consortium

1.1 Statement of Purpose

The IMS Global Learning Consortium, headquartered in Burlington Massachusetts, is a specification authoring organization comprised of distributed computer learning system vendors, publishers, digital content vendors, government agencies, universities, schools, training organizations, and other interested parties. IMS specifications are intended to evolve into globally adopted open standards for Learning Management Systems (LMS) vendors and content authors. All IMS specifications are open, and are realised in Extensible Markup Language (XML) to facilitate unrestricted understanding and adoption.

The time has come for ubiquitous, high quality learning opportunities on the Internet. The Internet has provided an enabling infrastructure, but Learning Management Systems have not yet been able to exploit it effectively. Distributed learning products and services enjoy tremendous demand in a nascent marketplace, but largely unrealized market and technological potential. One of IMS' central objectives is to facilitate working relationships among LMS vendors, content authors and learning consumers to foster a mutually beneficial and thriving marketplace around open Internet standards.

In IMS' view, the growth and stability of the learning products and services market depends on alignment among content producers and LMS vendors around open standards that have been defined in part by content consumers, learning institutions, and industry. Fractious standards prevent institutions of all sizes and types from investing confidently in learning solutions. Non-standard content thwarts authors from realizing the market potential of their output, and therefore limits their ability to contribute. The availability of content, its quality, and capturing in libraries is similarly restricted. A lack of widely adopted standards significantly handicaps consumers in gaining access to the broadest range of high quality content.

1.2 Benefits of common standards

Common data models and Application Program Interfaces (APIs) will foster market growth in the learning marketplace in several ways.

- Standard-adoptive content safeguards investment in digital content for both producers and consumers by guaranteeing reusability, portability, platform independence, and longevity;
- Standard-adoptive content creates its own marketplace, which in turn stimulates production and participation. Markets leads to public and private collections and libraries, improved quality, and useful comparisons between assessment items;
- Interoperability encourages modularization, diversification and specialization among LMS's, and enables them to move beyond cumbersome vertical product designs. Vendors are encouraged to specialize and innovate rapidly through market forces rather than occupy uncompetitive niches with proprietary systems;
- Specifications improve software vendor time-to-market performance by furnishing detailed insight and ready-to-use templates in the form of data models implemented in XML. Aspects of product analysis and design can be greatly simplified when already addressed by a specification;
- Products can emerge rapidly to meet changing and heterogeneous requirements. The overall market size grows as products specialize, diversify, and find new audiences.

1.3 Specifications

There are many domains that will benefit from standards adoption within the distributed learning marketplace. No single specification can cover all domains. Currently IMS is actively releasing specifications that address the following logically bounded domains:

- Question & Test Interoperability (released May, 2000);
- Content Management;
- Content Packaging (released May, 2000);
- Content Meta-Data (released October, 1999);
- Enterprise Interoperability (released November, 1999);
- Learner Information.

2. Question & Test Interoperability Specification

The Question & Test Interoperability (QTI) specification describes a basic structure for the representation of question (item) and test (assessment) data. Therefore, the specification enables the exchange of this test and assessment data between Learning Management Systems, as well as content authors and content libraries and collections.

The QTI specification is defined in XML to promote the widest possible adoption. XML is a powerful, flexible, industry standard markup language used to encode data models for Internet-enabled and distributed applications. The QTI specification is extensible and customizable to permit immediate adoption, even in specialized or proprietary systems. Leading suppliers and consumers of learning products, services and content contributed time and expertise to arrive at the final specification.

The QTI specification, like all IMS specifications, does not limit product designs by specifying user interfaces, pedagogical paradigms, or establishing technology or policies that constrain innovation, interoperability, or reuse.

2.1 Terminology

Despite its name, the QTI specification details more than how to tag questions and tests. The standard Question types e.g. multiple choice, fill in the blank, or true/false choice, etc. can be constructed using a core set of presentation and response structures, and results of questions can be collected and scored by using a variety of methods. To represent these options, the QTI specification defines the 'Item'. Items contain all the necessary data elements required to compose, render, score and provide feedback from questions.

Similarly, the 'test' is an instance of an Assessment. Assessments are assembled from Items that are contained within a 'Section' to resemble a traditional test. Additionally, Assessments might be assembled from blocks of Items that are logically related. These groups are also defined as 'Sections' and so Assessments are composed of one or more Sections which themselves are composed of Items, or more Sections.

To avoid limitations associated with words like user, student, or learner the QTI working group adopted the term 'participant' to refer to the person interacting with an assessment.

- **Item** – A combination of interrogatory, rendering, and scoring information
- **Section** – A collection of zero or more items and/or other Sections
- **Assessment** – A collection of one or more Sections
- **Participant** – The user interacting with an assessment

Example

To assess whether a participant knows that the capital of England is London, an item can be constructed to pose the simple question "What is the capital of England?" and then present a list of cities as multiple-choice selections. Alternatively, the item could contain the additional information required to render a map of England along with the list of cities. The participant could be asked to mark the map where London is located rather than simply identify the city.[1]

In turn, a Section, could be composed of many world capital multiple-choice questions. Similarly, the Assessment could consist of a set of Sections focussed on assessing a participant's knowledge of geography in general.

2.2 The Documents

The QTI specification comprises three separate documents:

The Information Model

The QTI Information Model document is comprised of several sections. The first section contains use cases in which the underlying usage, processing control, and core data structures of the QTI specification are described. It also details the taxonomy of responses, as well as their relationship to questions type and the larger class of 'items'.

[1] This example demonstrates how the same question can be offered in two different formats. The educational objective for each of the formats is different. The QTI specification is a way in which systems exchange Assessment, Section and Item data structures. The ways in which these structures are used educationally is beyond the scope of the specification.

The basic information model itself is outlined in conceptual terms by using a tabular layout of the Assessment, Section, and Item objects in terms of their elements, sub-elements and attributes. The Item, Section, and Assessment meta-data, which are used to catalog these objects, are also described. In addition, the document contains a conformance statement to be used by vendors who plan to implement the specification; we have adopted a descriptive approach to conformance thereby enabling vendors to implement subsets of the full specification. A detailed class and object model for the Assessment, Item and Section objects is also included in an appendix to the document.

The XML Binding Document

The XML Binding document describes the implementation of the QTI information model in XML. XML is introduced by outlining XML basics, including a conceptual discussion of the XML schema. The Document Type Definition (DTD) of the QTI specification (IMS_QTIv1p01.dtd) defines the Assessment, Section, and Item as XML elements.

An example schema for Assessments, Sections, and Items is included, along with details of the meta-data used to catalog Assessment, Sections, and Items. The XML Binding document also includes, as appendices, a copy of the uncommented DTD, as well as the uncommented XDR. The XDR document is a Microsoft Corporation XML schema implementation.

The Best Practices & Implementation Guide

This document is intended to provide vendors with an overall understanding of the QTI specification, the relationship of the QTI specification with other IMS specifications, and a best practices guide derived from experiences of those using the specification.[2] Example Item types supported by the specification, examples of composite Item types, and a complete XML example for presenting an Assessment, Section, and Item is included.

The Best Practices & Implementation Guide also includes a significant number of actual examples that describe how vendors can make the best use of the QTI specification. These examples, approximately eighty, are also useful as a starting template for each of the different forms of Assessment, Section and Item. Appendices provide the range of available DTD's and XDR's, as well as a glossary of key terms and elements used throughout the specification.

2.3 Use-Case Scenarios

A College and University Perspective

Colleges and universities are free to purchase authoring, delivery and reporting systems from different vendors whose products most closely match the individual requirements of each task domain. Products from various vendors can be mixed to assemble optimal solutions. For example, industry or institutions seeking tools to author and deliver scientific learning materials could choose tools that are specialized and optimized for rendering and/or handling scientific data.

Educators and institutions could buy, sell, or trade assessments in an open marketplace. Libraries and collections designed specifically to provide materials for courses or certifications would emerge. In addition to providing a potentially significant revenue stream, this new marketplace and unrestricted availability of learning materials would shorten the time required to develop a course or certification. Moreover, mutually available content enables refinement and evaluation of content, eliminating over time invalid or poorly constructed assessments. Assessment libraries can be standardized so that their contents can be compared and discussed across institutions.

A Business Perspective

Companies are free to purchase authoring, delivery and reporting tools from vendors whose products most closely match the individual requirements of their particular industry.

Companies, divisions, business partners, and customers can develop assessment content for products and services using non-proprietary authoring tools and exchange the content easily. Assessments developed for employees and customers can be shared independent of the intended delivery infrastructure. Companies are freed from investing in short-lived, expensive delivery technology.

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[2] We recommend that new users of the QTI specification start with the Best Practices & Implementation Guide. The examples in this document show how we intend the specification to be used whereas the other two documents (the Information Model and XML binding) contain the formal description of the structures, their syntax and semantics.

Product certifications and training assessments can be easily assembled from a library of existing assessments based on the particular role, function, or expertise of the participant being assessed. Fine-tuning ensures objective, precise and reliable measurements of skill levels and competencies, which in turn can increase the effectiveness of employee training or hiring programs.

A Publishers Perspective

Publishers can tag existing content for delivery in a new electronic marketplace. Since they are independent of delivery engines, publishers can focus on their core strength: creating the best the digital content possible. Old content finds new life, and new content can more easily find a marketplace.

Publishers can assemble and market assessment products from libraries to match any request or need. Valid assessments add value to all learning materials. Assembling highly precise and comprehensive companion assessments to learning products is greatly simplified and accelerated.

Software Vendor Perspective

LMS vendors can invest in development knowing that their systems interoperate with complementary systems. As the specification gains momentum, the market will begin to demand IMS QTI adoption to safeguard investment. Separation of "Authoring", "Delivery" and "Reporting" systems allows for focus, specialization, and excellence.

2.4 Simple Examples of QTI-XML

Multiple Choice

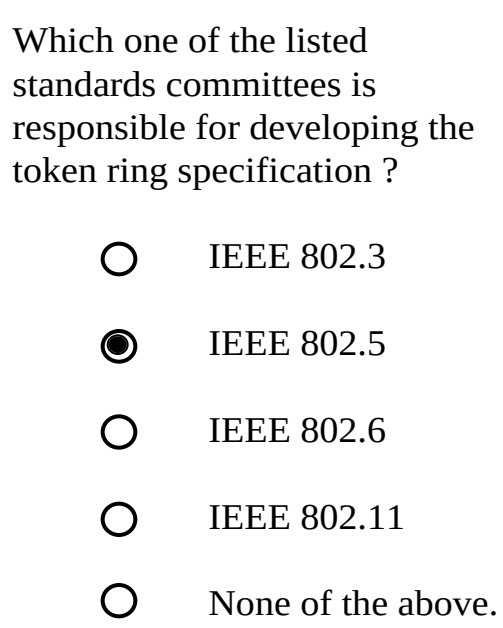
Consider the multiple-choice example shown on the right. Here is a question with five possible responses - the correct response is the second one down. The order of the first four possible responses is to be varied each time the question is asked but the fifth option must always appear at the end. This question has three basic structures, namely:

1) The actual question itself i.e. the text 'Which one of the listed standards committees is responsible for developing the token ring specification';

2) The five responses that are to be made available to the learner. By implication that shows that the question is a multiple choice requiring either one or more correct responses;

3) The scores that are to be assigned to each of the possible responses that can be selected. This information is not normally made available to the learner;

4) The feedback that is to be displayed to the user once their response has been analysed. This feedback can take the form of a hint, the solution itself or a statement on the correctness of the learner's response.



The corresponding QTI-XML is shown overleaf - this XML includes the corresponding response processing as well as the presentation instructions. Here the question is framed as a single 'Item' data structure. The core features of the 'Item' are:

- Presentation (lines 8 to 34) - the instructions for the presentation of the question and the associated possible responses;
- Response processing (lines 35 to 46) - the instruction on how to process the selected response and to allocate the corresponding score;
- Feedback (lines 36 to 49) - the information to be displayed to the learner if they answer the question correctly. No corresponding feedback is given if they get the answer wrong.

```
1       <questestinterop>
2           <qticomment>
3               This is a simple multiple choice example.
4               The rendering is a standard radio button style.
5               Response processing is incorporated.
6           </qticomment>
7           <item title="Standard Multiple Choice Item" ident="IMS_V01_I_BasicExample002b">
8               <presentation label="BasicExample002a">
9                   <material>
10                      <mattext>
11                          Which one of the listed standards committees is responsible
12                          for developing the token ring specification ?
13                      </mattext>
14                  </material>
15                  <response_lid ident="MCb_01" rcardinality="Single" rtiming="No">
16                      <render_choice shuffle="Yes">
17                          <response_label ident="A">
18                              <material><mattext>IEEE 802.3</mattext></material>
19                          </response_label>
20                          <response_label ident="B">
21                              <material><mattext>IEEE 802.5</mattext></material>
22                          </response_label>
23                          <response_label ident="C">
24                              <material><mattext>IEEE 802.6</mattext></material>
25                          </response_label>
26                          <response_label ident="D">
27                              <material><mattext>IEEE 802.11</mattext></material>
28                          </response_label>
29                          <response_label ident="E" rshuffle="No">
30                              <material><mattext>None of the above.</mattext></material>
31                          </response_label>
32                      </render_choice>
33                  </response_lid>
34              </presentation>
35              <resprocessing>
36                  <outcomes>
37                      <decvar  vartype="Integer" defaultval="0"/>
38                  </outcomes>
39                  <respcondition title="Correct">
40                      <conditionvar>
41                          <varequal respident="MCb_01">B</varequal>
42                      </conditionvar>
43                      <setvar action="Set" >1</setvar>
44                      <displayfeedback feedbacktype="Response" linkrefid="Correct"/>
45                  </respcondition>
46              </resprocessing>
47              <itemfeedback ident="Correct" view="Candidate">
48                  <material><mattext>Yes, you are right.</mattext></material>
49              </itemfeedback>
50          </item>
51      </questestinterop>
```

The key features of the QTI-XML are:

- The actual question itself is identified in lines 9 to 14. All content information must be encapsulated in the <material> element;

- The Item is identified as requiring the selection of one or more answers by combination of the <response_lid> and <render_choice> elements (lines 15 and 16 respectively). The usage of the 'shuffle="Yes"' attribute on the <render_choice> element, line 16, allows the response set to be shuffled each time the Item is attempted;
- The attributes for the <render_lid> element indicate that only one response is expected from the user (the rcardinality="Single" statement) and that theer is no time limit on the attempt (the rtiming="No" statement);
- Each possible response is identified using the <response_label> element. Note that the <response_label> on lines 29 to 31 have the attribute 'rshuffle="No"' which is used to over-ride the previous shuffle statement and ensures that this is always presented as the last choice;
- In the response processing (lines 35 to 46) the test condition for the correct answer is defined by lines 39 to 45. The test is made to see if the user chooses logical response 'B' (line 41). Note that due to shuffling of the responses this does NOT mean the second response offered to the learner. If the correct response has been made then the score is set to 1 (line 43). In this case the score is held in the default variable as defined by the specification - this variable was defined as an integer and preset to zero (line 37);
- If the question has been answered correctly then the feedback defined in lines 47 to 49 is displayed. This feedback is triggered as part of the response processing - see line 44.

2.5 The Future

Future releases of the QTI specification will elaborate on the current data model (in particular we intend to add 'Results Interoperability' thereby complementing the current specification structure) and propose appropriate APIs. As the market matures, new question types, response types, and other data elements will be incorporated. The QTI specification continues to evolve and develop in parallel with the emerging market.

It is IMS's view that valid assessments will add value to learning materials, and foster a whole new marketplace in learning materials, their distribution, and universal access.