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DCC | Digital Curation Manual

Instalment on
"Learning Object Metadata"

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About the DCC

The JISC-funded Digital Curation Centre (DCC) provides a focus on research into digital curation expertise and best practice for the storage, management and preservation of digital information to enable its use and re-use over time. The project represents a collaboration between the University of Edinburgh, the University of Glasgow through HATII, UKOLN at the University of Bath, and the Council of the Central Laboratory of the Research Councils (CCLRC). The DCC relies heavily on active participation and feedback from all stakeholder communities. For more information, please visit www.dcc.ac.uk. The DCC is not itself a data repository, nor does it attempt to impose policies and practices of one branch of scholarship upon another. Rather, based on insight from a vibrant research programme that addresses wider issues of data curation and long-term preservation, it will develop and offer programmes of outreach and practical services to assist those who face digital curation challenges. It also seeks to complement and contribute towards the efforts of related organisations, rather than duplicate services.

DCC - Digital Curation Manual

Editors

Peer Review Board

Preface

The Digital Curation Centre (DCC) develops and shares expertise in digital curation and makes accessible best practices in the creation, management, and preservation of digital information to enable its use and re-use over time. Among its key objectives is the development and maintenance of a world-class digital curation manual. The *DCC Digital Curation Manual* is a community-driven resource—from the selection of topics for inclusion through to peer review. The Manual is accessible from the DCC web site (http://www.dcc.ac.uk/resource/curation-manual).

Each of the sections of the *DCC Digital Curation Manual* has been designed for use in conjunction with *DCC Briefing Papers*. The briefing papers offer a high-level introduction to a specific topic; they are intended for use by senior managers. The *DCC Digital Curation Manual* instalments provide detailed and practical information aimed at digital curation practitioners. They are designed to assist data creators, curators and re-users to better understand and address the challenges they face and to fulfil the roles they play in creating, managing, and preserving digital information over time. Each instalment will place the topic on which it is focused in the context of digital curation by providing an introduction to the subject, case studies, and guidelines for best practice(s). A full list of areas that the curation manual aims to cover can be found at the DCC web site (http://www.dcc.ac.uk/resource/curation-manual/chapters). To ensure that this manual reflects new developments, discoveries, and emerging practices authors will have a chance to update their contributions annually. Initially, we anticipate that the manual will be composed of forty instalments, but as new topics emerge and older topics require more detailed coverage more might be added to the work.

To ensure that the Manual is of the highest quality, the DCC has assembled a peer review panel including a wide range of international experts in the field of digital curation to review each of its instalments and to identify newer areas that should be covered. The current membership of the Peer Review Panel is provided at the beginning of this document.

The DCC actively seeks suggestions for new topics and suggestions or feedback on completed Curation Manual instalments. Both may be sent to the editors of the *DCC Digital Curation Manual* at curation.manual@dcc.ac.uk.

Seamus Ross & Michael Day.
18 April 2005

Biography of the Author

Lorna has been involved in developing and supporting the use of learning technologies and interoperability standards to facilitate teaching and learning since 1997 through a wide range of national research and development projects. She is currently the Assistant Director of JISC CETIS with responsibility for the Activities and Content for Education domain. Lorna regularly provides technical and strategic advice on metadata, packaging formats, digital repositories, identifiers, vocabularies and reusable content in the domain of e-learning.

Through JISC CETIS, Lorna has represented the UK FE/HE sector on a range of national and international standard and specification development bodies including the IMS Global Learning Consortium, as a member of the Implementation Committee and the Meta-data and Content Packaging Working Groups; CEN/ISSS Learning Technologies Workshop and the British Standards Institute.

In addition to contributing to the development of formal standards and specifications Lorna is also the primary author and maintainer of the UK LOM Core, an application profile of the IEEE Standard for Learning Object Metadata designed for use across all UK educational sectors.

Introduction and Scope

The primary aim of this chapter is to introduce the concept of learning object metadata and to explore its potential for the curation of digital objects used in the context of teaching and learning. The chapter will focus specifically on the IEEE Learning Object Metadata Standard and will discuss a range of topics relevant to this standard including a brief exploration of the term learning object, an overview of the structure of the LOM conceptual data schema, an introduction to application profiles and their role in implementing the standard and specific bindings and encodings of metadata instances. In addition, an example of the "topic in action" will be provided in the form of a short case study of the UK LOM Core application profile, which has been developed to facilitate interoperability across educational sectors within the UK.

A Brief Introduction to "Learning Objects"

An in-depth discussion of the nature of learning objects is not the primary objective of this chapter, as this topic will be covered elsewhere in this manual. However, in order to discuss learning object metadata and its potential for the curation of digital objects it is necessary to have some familiarity with the concept of learning objects. Since the term "learning object" gained common currency within the domains of learning, education and training there has been considerable ongoing debate as to what exactly constitutes such an object and whether such an object differs fundamentally from other types of digital objects.

In the domain of higher education some consensus has started to emerge as to what constitutes the key characteristics of such a resource. In this context learning objects are generally held to be granular, reusable, interoperable digital resources formed by aggregating one or more digital assets (Campbell, 2003). Granularity refers here not to the file size of the object but to the educational concepts encapsulated within it. Learning objects should be large enough to make educational sense but small enough to be flexibly reused. Learning objects should be pedagogically meaningful individual units that address a single educational concept, they may have pre-requisites and they *should* be associated with metadata.

However, the IEEE Standard for Learning Object Metadata provides a quite different explanation of the term learning object, which is defined in the conceptual data schema of the standard as follows:

"For this standard, a learning object is defined as any entity—digital or non-digital—that may be used for learning, education, or training." (IEEE, 2002, p1).

While many critics have argued that such a generic definition is at best unhelpful and at worst confusing it is important to note that the key phrase in this definition is "*For this standard…*". The authors of the standard are not asserting that this is a blanket definition of the term "learning object" that should be adhered to regardless of domain or context. Rather they are stating that this metadata standard may be used to describe the characteristics of any digital or physical object used to facilitate learning education or training. This pragmatic definition neatly sidesteps the complex and frequently circular debate regarding what distinguishes an educational resource from any other type of resource. Following this definition it may be argued that it is the act of repurposing a resource for use in an educational context and the creation of metadata describing educational characteristics that transforms a resource into an educational resource or a learning object.

While this definition provides implementers with enormous flexibility as to the type of resources they may apply the standard to, it also raises significant problems in relation to digital curation as learning object metadata records, or instances, which may quite legitimately be created for resources that may be regarded quite differently in other domains and which may also be accompanied by other domain or context specific metadata instances. Consequently it is advisable to regard learning object metadata as metadata that describes any type of resource that has been used in an educational context regardless of whether or not the resource was originally created specifically for educational purposes. So while a digital image may be associated with metadata describing its format it may also be associated with a quite separate metadata instance describing its use in one or more educational contexts.

As this chapter primarily focuses on the IEEE Standard for Learning Object Metadata and its application, the definition of the term "learning object" provided by the standard will be applied throughout and will be taken to encompass any resource used to facilitate learning, education or training.

IEEE Standard for Learning Object Metadata

Introduction to the LOM

The IEEE Standard for Learning Object Metadata, commonly referred to as "LOM", is an internationally recognised open standard that specifies the syntax and semantics of learning object metadata, which may be defined as the attributes required to fully/adequately describe a learning object[1]. This is a multipart standard, which is currently composed of the following parts:

- 1484.12.1-2002 IEEE Standard for Learning Object Metadata[2].

"This Standard specifies a conceptual data model that defines the structure of a metadata instance for a learning object"[3].

- 1484.12.3-2005 IEEE Learning Technology Standard - Extensible Markup Language (XML) Schema Definition Language Binding for Learning Object Metadata.[4]

"This Standard defines a World Wide Web Consortium (W3C) Extensible Markup Language (XML) Schema definition language binding of the learning object metadata (LOM) data model defined in IEEE 1484.12.1–2002 Standard for Learning Object Metadata. The purpose of this Standard is to allow the creation of LOM instances in XML. This allows for interoperability and the exchange of LOM XML instances between various systems. This Standard uses the W3C XML Schema definition language to define the syntax and semantics of the XML encodings"[5].

These standards have been produced by the IEEE Learning Technology Standards Committee (LTSC), which is chartered by the IEEE Computer Society Standards Activity Board to develop accredited technical standards, recommended practices, and guides for learning technology.[6] The standards are derived from specifications submitted jointly to the IEEE LTSC in 1998 from the US IMS Project[7] and the EU ARIADNE Project[8], and

[1] IEEE Learning Technology Standards Committee, Working Group 12: http://ieeeltsc.org/wg12LOM/

[2] Softcover format: IEEE Product Number SH95001, ISBN 0-7381-3297-7. PDF format: IEEE Product Number SS95001, ISBN:0-7381-3298-5.

[3] *Shop*IEEE: http://shop.ieee.org/ieeestore/Product.aspx?product_no=SH95001

[4] Softcover format: IEEE Product Number SH95339, ISBN 0-7381-4079-5. PDF format: IEEE Product Number SS95339, ISBN:0-7381-4710-9.

[5] *Shop*IEEE: http://shop.ieee.org/ieeestore/Product.aspx?product_no=SH95339

[6] IEEE LTSC: http://ieeeltsc.org/

[7] Incorporated as the IMS Global Learning Consortium in 1999. http://www.imsglobal.org/, IMS has continued to release Learning Resource Meta-data Specifications based on updates of the IEEE LOM conceptual data schema. These specifications are composed of a data model, an XML binding and a best practice and implementation guide. For further information on IMS Meta-data specifications see http://www.imsglobal.org/metadata/index.html

[8] Followed by ARIADNE II, these projects formed the basis of the current ARIADNE Foundation, http://www.ariadne-eu.org/

also build on work undertaken by the Dublin Core Metadata Initiative[9] (IEEE, 2002, piii).

The IEEE LTSC[10] identify the aims and objectives of the LOM standard as being:

- To enable learners or instructors to search, evaluate, acquire, and utilize learning objects.
- To enable the sharing and exchange of learning objects across any technology supported learning systems.
- To enable the development of learning objects in units that can be combined and decomposed in meaningful ways.
- To enable computer agents to automatically and dynamically compose personalized lessons for an individual learner.
- To complement the direct work on standards that are focused on enabling multiple learning objects to work together within an open distributed learning environment.
- To enable, where desired, the documentation and recognition of the completion of existing or new learning and performance objectives associated with Learning Objects.
- To enable a strong and growing economy for learning objects that supports and sustains all forms of distribution; non-profit, not-for-profit and for-profit.
- To enable education, training and learning organizations, both government, public and private, to express educational content and performance standards in a standardized format that is independent of the content itself.
- To provide researchers with standards that support the collection and sharing of comparable data concerning the applicability and effectiveness of learning objects.
- To define a standard that is simple yet extensible to multiple domains and jurisdictions so as to be most easily and broadly adopted and applied.
- To support necessary security and authentication for the distribution and use of learning objects.

[9] The Dublin Core Metadata Initiative: http://www.dublincore.org/

[10] IEEE LTSC Working Group 12: The Learning Object Metadata Standard - Purpose of Proposed Project: http://ieeeltsc.org/wg12LOM/lomDescription

The LOM Conceptual Data Schema

1484.12.1-2002 IEEE Standard for Learning Object Metadata describes the syntax (the structure) and semantics (the meaning) of the LOM conceptual data schema, also known as the data model; it does not provide guidelines on binding or encoding this model as this information is contained in 1484.12.3-2005 IEEE Learning Technology Standard - Extensible Markup Language (XML) Schema Definition Language Binding for Learning Object Metadata. The LOM conceptual data schema specifies what characteristics of a learning object may be described and how these characteristics should be recorded. It also defines how the conceptual data schema can be customised by adding extensions (e.g. new vocabularies) or constraints (e.g. restricting the number of elements that may be used).

Structure of the Conceptual Data Schema

The LOM conceptual data schema differs significantly from metadata schemata such as the Dublin Core Metadata Element Set in that it has a hierarchical tree structure composed of the following nine categories:

1. *General*: information that describes the learning object as a whole.
2. *Lifecycle*: history and current status of the learning object and those who have contributed to its creation.
3. *Meta-metadata*: information about the metadata describing the learning object, as opposed to the learning object itself.
4. *Technical*: technical requirements and characteristics of the learning object.
5. *Educational*: educational and pedagogic characteristics of the learning object.
6. *Rights*: intellectual property rights and conditions of use of the learning object.
7. *Relation*: relationship between the learning object and other related objects.
8. *Annotation*: comments on the educational use of the learning objects, including when and by whom the comments were created.

9. *Classification*: classification schemes used to describe different characteristics of the learning object.

These categories group together data elements, of which there are two types:

- Aggregate elements (also described as container elements) which contain other data elements and which do not have individual values.
- Simple data elements (the "leaf" nodes of the hierarchical "tree" structure), which have individual values.

The hierarchical "tree" structure of the LOM conceptual data schema can be represented as follows:

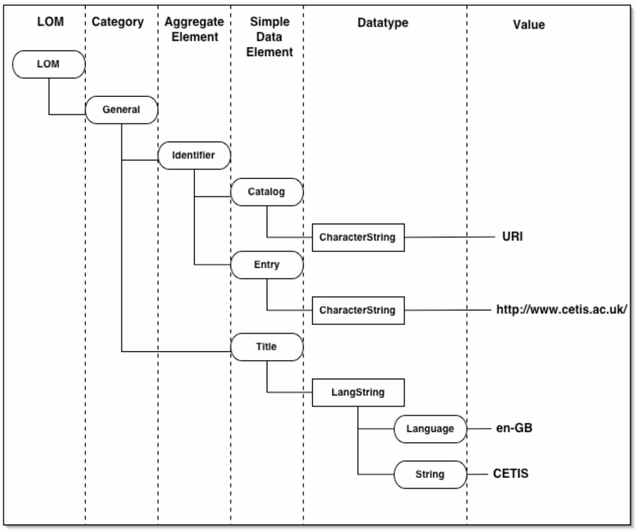

Fig 1. Part of the LOM Conceptual Data Schema Structure

As a result of this hierarchical structure the semantics, or meaning, of a simple data element is determined by its context in the LOM hierarchy. For example the conceptual data schema includes six distinct *Description* elements appearing in each of the following categories: *General, Educational, Rights, Relation, Annotation* and *Classification,* and another two appearing in the *DateTime* and *Duration* Datatypes. Each of these *Description* elements derives its context from the category and aggregate elements that it is contained by, and in the case *Classification.Purpose* from neighbouring elements in the same category.

Clearly there are drawbacks to this structural approach. If a *Description* element is divorced from the hierarchy of container elements and categories that define its semantics then it is impossible to judge what characteristic is being described. Such problems may arise as a result of bindings or implementations, such as registries, that attempt to "flatten" the structure of the LOM conceptual data schema or a LOM instance. In addition, problems of semantic ambiguity may result if attempts are made to combine LOM data elements with elements from "flat" metadata schemata such as the Dublin Core Metadata Element Set or when LOM instances or application profiles are cross walked with other schemata. Clearly the peculiarities or the LOM hierarchical conceptual data schema also present particular challenges in relation to digital curation as in order to maintain the semantics of a LOM metadata instance it is also necessary to maintain its hierarchical syntactic structure.

Datatypes

The LOM conceptual data schema also specifies the datatypes and value spaces for each simple data element. The datatype describes the form of the information that is associated with each element. The LOM identifies and defines the following data types (IEEE, 2002, pp23-30):

- *LangString*: "…value may include semantically equivalent character strings, such as translations or alternative descriptions." This is an aggregate element composed of the following two simple elements *Language*: "The human language of the character string" and *String*: "The actual string". This aggregate element may be repeated and is unordered (IEEE, 2002, p 24).
- *DateTime*: This datatype is composed of two simple elements *DateTime*: "A point in time with accuracy at least as small as one second" and *Description*: "Description of the string". The occurrence of each element is 1; neither may be repeated (IEEE, 2002, p26).

- *Duration*: This datatype is composed of two simple elements *Duration*: "An interval in time with an accuracy at least as small as one second" and *Description*: "Description of the duration." The occurrence of each element is 1; neither may be repeated (IEEE, 2002, p28).
- *Vocabulary*: This datatype is composed of two simple elements *Source*: "'LOMv1.0, or an indication of the source value, for instance through a URI." and *Value*: "The actual value". The occurrence of each element is 1; neither may be repeated (IEEE, 2002, p30).
- *CharacterString*: "The LOM v 1.0 base schema does not specify encodings for CharacterString (in the case of non-restricted CharacterString values, reference is made to the repertoire of ISO/IEC 10646-1:2000)" (IEEE, 2002, p6).
- Undefined.

Value Spaces

The value space describes the actual information that is associated with each element and defines any restrictions that may be placed on this information. Value spaces may be:

- Repertoire of ISO/IEC 10646-1:2000[11] – any string of Unicode characters.
- Language ID – a language code from ISO 639-1:2002[12] or ISO 639-2:1988[13] which may be accompanied by an optional country code from ISO 3166-1:1997[14].
- A vocabulary – a list of recommended terms or numbers.
- IMC vCard 3.0[15] – structured text that describes the kind of information commonly found on a business card.
- MIME types based on IANA registration[16] – describes the digital format of a resource. If the resource is not digital the value space is "non-digital" (IEEE, 2002, p13).

Further Guidelines

For further information on LOM datatypes and value spaces see the IMS Meta-data Best Practice and Implementation Guide for IEEE 1484.12.1-2002 Standard for Learning Object Metadata (IMS, 2004, pp7-8).

Conformance

The LOM conceptual data schema (IEEE, 2002, pp6-6) defines *instance* conformance as follows:

- "A strictly conforming LOM metadata instance shall consist solely of LOM data elements.
- A conforming LOM metadata instance may contain extended data elements.
- A LOM instance that contains no value for any of the LOM data elements is a conforming instance.

In order to maximize semantic interoperability, extended data elements should not replace data elements in the LOM structure. This means that an organization should not introduce new data elements of its own that replace LOM data elements. As an example, an organization should not introduce a new data element "name" that would replace 1.2:General.Title.

Note: In order to maximize semantic interoperability, users of this Standard are encouraged to carefully map their metadata information to the data elements of this Standard. For example, the user should not map an element to describe the fonts used in the document to the data element 1.2:General.Title." (IEEE, 2002, pp6-7)

Furthermore the conceptual data schema also states: "All data elements are optional. This means that a conforming LOM instance may include values for any data element defined in

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[11] Universal Multiple-Octet Coded Character Set.
[12] Codes for the Representation of Names and Languages – Part 1: Alpha-2 Code.
[13] Codes for the Representation of Names and Languages – Part 2: Alpha-3 Code.
[14] Codes for the Representation of Names of Countries and their Subdivisions – Part 1: Country Codes.
[15] IETF RFC 2425:1998, http://www.ietf.org/rfc/rfc2425.txt
[16] RFC 2048: 1998, http://www.iana.org/assignments/media-types/

Clause 6." (IEEE, 2002, p4) where Clause 6 refers to the base schema structure. However it also adds that as the conceptual data schema imposes a hierarchical structure, simple data elements may only occur as a component of the aggregate elements that they are contained by (IEEE, 2002, p4).

It is important to note that these conformance statements refer only to LOM *instances*, which, in this context, may be regarded as individual metadata records. The conceptual data schema does not define conformance for applications that implement the LOM standard or expose or consume LOM instances, nor does it provide guidance on creating conformant application profiles.

Smallest Permitted Maximum

Although the LOM conceptual data schema does not define application conformance it does define smallest permitted maximum values for both aggregate elements and data elements with the datatype *CharacterString* or *LangString*. Smallest permitted maximum refers to the minimum number of instances of an element or characters in a string that an application shall process. Therefore if the smallest permitted maximum of an element is 10, then applications must process a minimum of 10 repetitions, or occurrences, of this element but need not process any more.

Implications for Digital Curation

This particular feature of the LOM has considerable implications for data curation as it means that there is no guarantee that every occurrence of an element will be processed, represented or preserved as an instance passes through different applications. Creators of LOM metadata should also be aware that if their metadata instance includes more than the smallest permitted maximum number of occurrences of a particular element there is no guarantee that all these occurrences will be processed. Furthermore as repeated occurrences of some elements are ordered and others are unordered it is difficult to predict what information may be lost. Similarly with *CharacterStings* and *LangString*s, if the number of characters exceeds the smallest permitted maximum then there is no guarantee that applications will process the entire string and as a result the string may be cut short and data may be lost.

Extending the LOM Conceptual Data Schema

The LOM conceptual data schema is designed in such a way that it may be extended in order to meet application and community specific metadata requirements.

There are two primary mechanisms that may be used to extend the schema:

- New vocabularies may be added to existing LOM elements.
- New elements and element categories may be added.

Extending Vocabularies

If new terms are added to existing LOM vocabularies they must be identified as coming from a source other than LOMv1.0 (IEEE, 2002, p5). If a new vocabulary is used in conjunction with a LOM element that is already described by a LOMv1.0 vocabulary then it is recommended that, where possible, metadata creators select a term from the custom vocabulary in addition to the closest equivalent term from the LOMv1.0 vocabulary in order to help facilitate semantic interoperability.

Extending the* Classification *Category

Current recommended best practice is to use the *Classification* category to accommodate extensions and community specific requirements. This category is composed of three simple data elements; 9.1

Classification.Purpose, 9.3 *Classification.Description* and 9.4 *Classification.Keyword* and one aggregate element 9.2 *Classification. Taxon Path*. The value space for 9.1 *Classification.Purpose* is a vocabulary[17] that identifies the characteristic of the object being classified. Implementers may then specify a classification scheme or taxonomy relevant to their own particular community requirements in order to describe the characteristic identified by element 9.1. By adding new terms to the *Classification.Purpose* vocabulary and identifying classification schemes to describe these terms it is possible to accommodate characteristics of an object that may not be covered by the base schema.

Extending Base Schema Elements

It is also possible to extend the LOM schema by increasing element repetitions, smallest permitted maximums, and the length of *CharacterStrings* and *LangStrings.* However the conceptual data schema also states "Extensions to the LOM v1.0 base schema shall retain the value space and datatype of data elements from the LOM v1.0 base schema. Extensions shall not define datatypes or value spaces for aggregate data elements in the LOM v1.0 base schema" (IEEE, 2002, p4).

Further Guidelines

For further guidelines on extending the LOM conceptual data schema see the IMS Meta-data Best Practice and Implementation Guide for IEEE 1484.12.1-2002 Standard for Learning Object Metadata (IMS, 2004, pp10 & 17).

Implications for Digital Curation

Although there are range mechanisms that may be used to extend the LOM conceptual data schema it is important to recognise that all extensions have a significant impact on semantic interoperability and consequently are also likely to have negative implications for digital curation. Extensions, by their nature, are community specific and therefore there is no guarantee that they will not be processed by applications outwith their immediate domain. For example a repository that imports metadata instances that include customised extensions may not necessarily have the ability to process or represent this community specific information. At best the repository may preserve these extensions and transmit them on export, however the worst case scenarios are that the repository will fail to recognise the metadata records as being valid instances or that it will fail to store the extensions or transmit them on export resulting in the community specific information being lost.

Community specific vocabularies also represent a particular challenge in relation to data curation if they are not appropriately maintained and identified by globally unique persistent identifiers. In addition, in a dynamic domain such as e-learning where practice is developing and evolving rapidly, it is not uncommon for practitioners to feel that it is necessary to develop multiple community specific vocabularies as more formal established classification schemes may fail to encompass new concepts and terminology. While the development of new vocabularies in the field of e-learning may be valuable in helping to articulate and communicate evolving practice there is a significant risk that many vocabularies may lack the maintenance strategies that accompany more established classification schemes. As a result although it may be possible to preserve metadata instance that include terms from customised community specific vocabularies it may be much more difficult to preserve the vocabularies from which these terms are drawn.

For a discussion of issues relating to pedagogical vocabularies and an inventory of such vocabularies see Currier, S., Campbell,

[17] These terms are: discipline, idea, prerequisite, educational objective, accessibility restrictions, educational level, skill level, security level, competency.

L.M, and Beetham, H., (2005) Pedagogical Vocabularies Review[18].

Binding and Encoding the LOM

Although it is possible to encode metadata instances in many different formats, e.g. HTML, XML, RDF, it is beneficial to use a standard binding format if the intention is to exchange these instances between applications.

In order to facilitate the exchange of interoperable metadata instances or records the IEEE have published an XML binding standard for the LOM conceptual data schema: 1484.12.3-2005 IEEE Learning Technology Standard - Extensible Markup Language (XML) Schema Definition Language Binding for Learning Object Metadata.

As this is a relatively new standard it has not been widely implemented at the time of writing. Until recently most implementations of the LOM within the domain of learning, education and training were based on the IMS Learning Resource Meta-data specification. All versions of the IMS LRM specification[19] up to version 1.2.2 are composed of a normative Information Model, which is analogous to the LOM conceptual data schema, an XML Binding and an informative Best Practices and Implementation Guide along with accompanying informative XSD schema files and examples. Metadata implementers commonly used the XML Binding specification to express their community specific profile of the Information Model and the schema to validate the resulting metadata instances. The IMS schema files are also of particular significance as they have been widely used to develop metadata applications such as packaging tools and learning objects repositories. To some extent the informative schema files have been widely regarded by implementers as a crucial normative component of the specification.

The new IEEE XML binding standard adopts a somewhat different approach from the IMS specification however. The standard is also composed of a normative document that specifies how to create an XML binding of the LOM conceptual data schema and accompanying informative schemata, however it does not provide a single schema to validate instances against. Instead the binding document details how implementers can create their own validating schema.

Following publication of the IEEE 1484.12.1-2002 and IEEE 1484.12.3-2005 IMS has taken steps to harmonise its Learning Resource Metadata specification with the LOM standards. IMS LRM v. 1.3 public draft replaces the Information Model with IEEE 1484.12.1-2002 and the XML Binding with IEEE 1484.12.3-2005. The Best Practices and Implementation Guide has been revised to refer specifically to the LOM, new examples have been produced and an XSL Transform and accompanying support files have been created to help transform implementations of IMS Learning Resource Meta-data to IEEE LOM 1.0.

As the new IEEE binding has not been widely implemented or adopted to date it is too early to ascertain what the implications of this new approach will be for interoperability and digital curation. The IEEE XML binding standard is certainly more flexible than the IMS specification however it could also be argued that, as implementers must create their own validating schema, there is a greater danger of interoperability problems occurring and important information being lost.

For further discussion of the implications of the IEEE XML binding standard see “It's a LOM binding, Jim, but not as we know it” (Kraan, 2005)[20]

[18] Currier, S., Campbell, L.M, and Beetham, H., 2005, Pedagogical Vocabularies Review http://www.jisc.ac.uk/elp_vocabularies.html

[19] IMS Learning Resource Meta-data Specification: http://www.imsglobal.org/metadata/index.html

[20] Kraan, W.G., 2005, It's a LOM binding, Jim, but not as we know it, http://www.cetis.ac.uk/content2/20050609101645

Application Profiles

As with many other standards and specifications, implementations of the Learning Object Metadata standard are normally based on community or domain specific application profiles. Although different definitions of the term "application profile" exist within the domains of learning, education and training, two distinct strategies have emerged for the creation of such profiles. One involves combining elements from different metadata schemata and the other constraining and extending a single schema (IMS, 2004, p12).

As an example of this first hybrid approach the DCMI Glossary defines an application profile as follows:

"In DCMI usage, an application profile is a declaration of the metadata terms an organization, information resource, application, or user community uses in its metadata. In a broader sense, it includes the set of metadata elements, policies, and guidelines defined for a particular application or implementation. The elements may be from one or more element sets, thus allowing a given application to meet its functional requirements by using metadata elements from several element sets including locally defined sets."[21]
Similar definitions are proposed by Heery and Patel:

"Application profiles are tailored for particular implementations and will typically contain combinations of sub-sets of one or more namespace schemas." (Heery and Patel, 2002).[22]

And the British Standards Institute in BS 8419[23]:

"**application profile**
schemas consisting of data elements drawn from one or more namespaces, combined together by implementers and optimized for a particular local application." (BSI, 2004).

The second strategy of constraining and extending a single schema is recommended by the IMS Global Learning Consortium in their Application Profiles Guidelines Overview[24], which defines an application profile as being:

"A description of the use of a single technical standard to meet the needs of a particular community." (IMS, 2005, p4).

It should be noted that these two approaches should not be regarded as being in opposition. The approach selected by an application profile developer is likely to be influenced by the requirements of their community of practice and the metadata schema that they choose as their originating or source schema. This position is most clearly articulated in the paper *Metadata Principals and Practicalities*[25], collaboratively authored by members of the IEEE Learning Technology Standards Committee and the Dublin Core Metadata Initiative, which states:

"Application profiles provide the means to express principles of modularity and extensibility. The purpose of an application profile is to adapt or combine existing schemas into a package that is tailored to the functional requirements of a particular application, while retaining interoperability with the original base schemas." (Duval *et al*, 2002).

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[21] Dublin Core Metadata Initiative DCMI Glossary http://dublincore.org/documents/usageguide/glossary.shtml#A

22 Heery, H. and Patel M., 2000, Application profiles: mixing and matching metadata schemas, Ariadne Issue 25, http://www.ariadne.ac.uk/issue25/app-profiles/

[23] BS 8419-1 Interoperability between metadata systems used for learning, education and training. Code of practice for the development of application profiles. ISBN 0 580 45242 5. http://www.bsi-global.com/ICT/Security/bs8419-1.xalter

[24] IMS Application Profile Guidelines http://www.imsglobal.org/ap/index.html

[25] Duval, E., Hoddgins, W., Sutton, S., and Weibel, S.L., 2002, Metadata Principals and Practicalities, Dlib Magazine, April 2002, Volume 8, Number 4, ISBN 1082-9873. http://www.dlib.org/dlib/april02/weibel/04weibel.html

Application Profiles of the LOM

As the LOM conceptual data schema is already relatively extensive, application profiles based on the standard generally "restrict the elements used, designate certain elements as mandatory or optional, specify vocabulary usage and interpretation, and add organization or community specific classification schemes. Implementers may also constrain the data model by dictating the way in which elements are used and repeated." (IMS, 2004, p13).

Although application profiles are be their nature domain specific there are two profiles of the LOM that have considerable significance outwith their original communities of practice: the CanCore Guidelines for the Implementation of Learning Object Metadata[26] and the Shared Content Object Reference Model[27]. These examples also offer an interesting comparative case study into different approaches that may be adopted when creating application profiles.

CanCore

The stated aim of the CanCore Learning Resource Metadata Initiative, which is funded by the e-Learning Marketplace Strategy Group of Industry Canada's e-Learning Directorate and supported by TeleUniversite and Athabasca University is to:

"…enhance the ability of educators, researchers and students in Canada and around the world to search and locate material from online collections of educational resources."[28]

A significant output of this initiative has been the creation of the CanCore application profile, more formally known as the CanCore Guidelines for the Implementation of Learning Object Metadata. These guidelines are a set of best practice recommendations that focus on the semantic
interpretation the LOM conceptual data schema. The definition of "application profile" adopted by CanCore is taken from Lynch[29]:

"…customizations of [a] standard to meet the needs [of] particular communities of implementers with common applications requirements." (Lynch, 1997).

However the authors qualify this definition by noting that the "guidelines emphasize refinement and explication rather than customization or modification, and have been intentionally developed to meet the needs of a broad range of communities."[30]

All CanCore Guidelines are informative, as opposed to normative, and the documentation focuses on facilitating interoperability rather than defining conformance. CanCore does identify a subset of elements for the purpose of data interchange, but these are a recommendation only. This element set is not accompanied by a binding, however the Guidelines do provide XML examples illustrating how each element may be encoded.

The real value of CanCore is in the comprehensive and detailed semantic guidelines, interpretations and examples that they provide for every element of the LOM conceptual data schema. As a result the CanCore Guidelines have been widely adopted and are regarded in several domains and communities as *the* best practice guidelines for implementing the IEEE LOM.

The UK LOM Core application profile, which is introduced in the *Learning Object Metadata in Action* section below, has been heavily influenced by the work of the CanCore

[26] CanCore Guidelines 2.0 Documents http://www.cancore.ca/en/guidelines.html
[27] Advanced Distributed Learning SCORM® http://www.adlnet.org/scorm/index.cfm
[28] CanCore Homepage http://www.cancore.ca/en/

[29] Lynch, C.A., 1997, The Z39.50 Information Retrieval Standard. Part I: A Strategic View of Its Past, Present and Future, DLib Magazine, April1997, ISSN 1082-9873, http://www.dlib.org/dlib/april97/04lynch.html
[30] CanCore FAQ, 5. What is an application profile? http://www.cancore.ca/en/faq.html

initiative and draws on the CanCore Guidelines throughout.

SCORM®

Developed by the Advanced Distributed Learning (ADL) Initiative and sponsored by the US Department of Defence, SCORM® is "a collection of standards and specifications adapted from multiple sources to provide a comprehensive suite of e-learning capabilities that enable interoperability, accessibility and reusability of Web-based learning content."[31] SCORM® incorporates a range of specifications and standards including IMS Content Packaging, IMS Simple Sequencing and the IEEE LOM. The reference model identifies specific elements from the LOM conceptual data schema that must be used to describe particular types of content objects. The reference model is regarded as being normative and is accompanied by a Conformance Suite designed for self-testing. Although SCORM® has not been widely implemented in the UK HE sector it has significant global uptake across training and other educational sectors. As a result, it incorporates what is probably the most widely implemented application profile of the IEEE LOM standard in the world today.

For further information on SCORM® see the CETIS standards briefing series[32] "*What is* ADL SCORM?"[33]

Further Guidelines

For further guidelines on the creation of LOM application profiles see the IMS Best Practice and Implementation guide for IEEE 1484.12.1-2002 Standard for Learning Object Metadata (IMS, 2004, pp12-13) and British Standard 8419 Interoperability between metadata systems used for learning, education and training. Code of practice for the development of application profiles (BSI, 2004).

Application Profiles, Registries and Implications for Digital Curation

While the creation of application profiles provides developers with a pragmatic approach to enable them to create metadata schemata that meet the requirements of their own particular communities of practice while retaining some interoperability with the standards and specifications on which these profiles are based, the creation of application profiles is likely to have significant implications for data curation.

In the paper previously cited Duval *et al* state that:

"One of the benefits of this approach is that communities of practice are able to focus on standardizing community-specific metadata in ways that can be preserved in the larger metadata architectures of the Web. It will be possible to snap together such community-specific modules to form more complex metadata structures that will conform to the standards of the community while preserving cross-community interoperability." (Duval *et al*, 2002).

While this is an admirable goal, it is doubtful whether application profiles will be preserved in the confusion of the Web unless they are recorded in a standard format and deposited in an appropriate registry, repository or archive with established maintenance procedures. Although most application profile developers recognise the necessity of maintaining and registering their profiles, in reality there are few suitable registries of sufficient stability and longevity to accommodate metadata application profiles with any degree of constancy.

This is particularly the case in terms of application profiles based on the IEEE LOM. While there has been considerable research into

[31] Advanced Distributed Learning SCORM® http://www.adlnet.org/scorm/index.cfm
[32] CETIS briefings on e-learning standards http://www.cetis.ac.uk/static/briefings.html
[33] Bailey, W., 2005, What is ADL SCORM? CETIS standards briefing series, http://www.cetis.ac.uk/lib/media/WhatIsScorm2_web.pdf

the development of RDF based registries designed primarily to host profiles of Dublin Core[34] these registries are not well suited to accommodating profiles based on the hierarchical LOM conceptual data schema. This problem is further compounded by the fact that LOM application profiles may take many different formats. Some LOM profiles are expressed as formal data models that determine the syntax of metadata instances e.g. by enforcing the ordering of elements or by requiring the use of a particular binding or encoding format. Others may appear more like cataloguing rules that provide guidelines on the semantics of the data model e.g. by recommending how elements should be used, by requiring the use of community specific vocabularies or by specifying the definition of vocabulary terms for a particular community of practice. Still others may take the form of XML schema unaccompanied by human readable guidelines or documentation.

In recognition of this problem standards and specifications outlining guidelines for the creation of application profiles have proliferated of late. Recent publications include the IMS Best Practice and Implementation guide for IEEE 1484.12.1-2002 Standard for Learning Object Metadata, the IMS Application Profile Guidelines and British Standard 8419 Interoperability between metadata systems used for learning, education and training, all of which are referenced above. In addition, the CEN/ISSS Learning Technologies Workshop have published a CEN Workshop Agreement (CWA) on “Guidelines and support for building application profiles in e-learning”[35]. While it is hoped that these guidelines will make a significant contribution in helping developers to create application profiles that are clearly and rigorously documented and expressed, the problem of lack of stable registries that can accommodate LOM profiles remains.

The JISC IE Metadata Schema Registry

In an attempt to address this issue within the UK JISC have funded the creation of the JISC Information Environment Metadata Schema Registry (IEMSR)[36]. The aim of the IEMSR is to act as the primary source for authoritative information about metadata schemas recommended by the JISC Information Environment. The Registry will provide users with a single point of referral for recommended schemata and will enable the publication of application profiles in order to make them available to others. This will help to encourage a degree of uniformity alongside necessary divergence, support the sharing of common approaches and avoid unnecessary duplication of effort.[37]

The IEMSR is a series of applications based on the Resource Description Framework consisting of:

- **The registry server**

The server provides interfaces to the other applications, a persistent data store and an API for uploading data to the data store and querying its content.

- **The registry website**

The website is a presentational service that offers 'read-only' access to the registry server by allowing users to browse and query the data in the registry.

- **A data creation tool**

Allows users to submit application profiles to the registry server in the form of RDF data sources.

[34] Past initiatives include the DESIRE Metadata Registry http://desire.ukoln.ac.uk/registry/index.html, the SCHEMAS Registry http://www.schemas-forum.org/registry/, the CORES Project http://www.cores-eu.net/, the MEG Registry http://www.ukoln.ac.uk/metadata/education/regproj/ and the DCMI Registry Working Group http://dublincore.org/groups/registry/

[35] CEN Workshop Agreement 15555, June 2006, Guidelines and support for building application profilesin e-learning, ICS 35.240.99 ftp://ftp.cenorm.be/PUBLIC/CWAs/e-Europe/WS-LT/cwa15555-00-2006-Jun.pdf

[36] Information Environment Metadata Schema Registry http://www.ukoln.ac.uk/projects/iemsr/

[37] JISC IE Metadata Schema Registry homepage http://www.ukoln.ac.uk/projects/iemsr/

Within the context of the IEMSR application profiles are recorded in the form of information models only, the registry does not record how to represent these models or bind them to a particular machine readable syntax, as a single profile may have multiple bindings, e.g. XML, RDF, HTML.

For a detailed overview of the IEMSR functionality and technical architecture see Johnston, P., 2005, "What are your terms?"[38]

Although the IEMSR is in its second phase it is still a development project as opposed to a fully supported service so there is no guarantee at this point in time whether or not the Registry will be supported in the future. However the IEMSR is a particularly significant development as, from the outset, it has been designed to accommodate application profiles based on "flat" metadata schema such as Dublin Core and hierarchical schema such as the IEEE LOM.

Learning Object Metadata in Action – The UK LOM Core[39]

The development of the UK LOM Core originated from a position paper presented to the UK Metadata for Education Group in April 2002[40]. This paper called for the formation of a community of practitioners to identify common UK practice in the use of metadata in packaged e-learning content. A subsequent comparison was undertaken of twelve metadata schemata based on IEEE 1484.12.1-2002 Standard for Learning Object Metadata and IMS Learning Resource Meta-data, including those produced by SCORM[41], CanCore[42], FAILTE[43], the National Learning Network[44] and UfI[45]. As a result of this comparison, an application profile composed of a minimum required core element set was produced along with a set of guidelines to inform UK practitioners on the implementation and use of all LOM elements and their associated value spaces. From its inception the UK LOM Core was designed to be applicable to *all* UK educational communities including pre-school, primary, secondary, FE, HE and adult and community learning. The UK LOM Core is developed and maintained by the JISC Centre for Educational and Interoperability Standards (JISC CETIS)[46] and supported by a number of additional UK agencies including UKOLN[47], the British Educational Communications and Technology Agency (Becta)[48] and Learning and Teaching Scotland[49].

The primary objective of the UK LOM Core is to increase the *interoperability* of metadata instances and application profiles created within the UK educational sector. In this context interoperability may be defined as:

"….the ability of two or more systems or components to exchange information and to use the information that has been exchanged." (IEEE, 1990)

Facilitating interoperability does not necessarily imply that all communities must use the same metadata standard or specification. The application profile stresses the importance of differentiating between requirements for metadata that is stored *internally* within an application and requirements for metadata that will be *exposed* to the outside world and exchanged with other applications. If an educational community

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38 Johnston, P., 2005, "What are your terms?", Ariadne, Issue 43, April 2005, http://www.ariadne.ac.uk/issue43/johnston/

39 This sub-section has previously been published as the introduction to a work in progress draft of the UK LOM Core 0.3_1204, http://www.cetis.ac.uk/profiles/uklomcore/wip/uklomcore_v0p3_1204.doc

40 Duncan, C., Campbell, L.M., Graham, G. and Slater, J., 2002, Using Metadata in Packaged e-Learning Content: Common Practice in the UK. Appendix 1 of UK Learning Object Metadata Core, Draft 0.1, July 2003. http://www.cetis.ac.uk/profiles/uklomcore/uklomcore_v0p1.doc

41 ADL SCORM® http://www.adlnet.org/

42 CanCore http://www.cancore.ca/

43 Facilitating Access to Information on Learning Technology for Engineers. http://www.failte.ac.uk/

44 National Learning Network http://www.nln.ac.uk/

45 Ufl http://www.ufiltd.co.uk/

46 CETIS http://jisc.cetis.ac.uk/

47 UKOLN http://www.ukoln.ac.uk/

48 Becta http://www.becta.org.uk/

49 Learning and Teaching Scotland http://www.ltscotland.org.uk/

does not intend to share its resources and metadata with other domains then they are free to choose what characteristics of their resources they describe, what labels and vocabularies they use to describe these characteristics and how this information is gathered and stored. If this community wishes to exchange information about their resources with other communities then it is beneficial for them to expose this information in a standard manner. In order to facilitate this exchange, the information required by the agreed standard will have to be gathered in an appropriate format. So while it may not be necessary for an educational community to use a standard data model and binding to gather and store metadata internally, if they wish to exchange this information then it is beneficial to have gathered and stored this metadata in such a way that it can be exposed in a standard format. The UK LOM Core helps to provide a common language (semantics) and structure (syntax) for interoperable metadata that educational communities and applications can use to enable them to exchange their resources, and information about their resources, with others.

Structure and Scope

The UK LOM Core application profile consists of two primary components:

- A minimum required Core Element Set,
- Implementation Guidelines for all LOM elements plus additional Element Requirements.

Current drafts of the UK LOM Core make no recommendations regarding binding and encoding metadata instances.

The Core Element Set

In specifying a minimum required Core Element Set the UK LOM Core has attempted to identify those LOM elements that are likely to be of greatest benefit for facilitating the exchange of adequate metadata records within the UK educational community. The primary objective of the Core Element Set is to facilitate syntactic interoperability by specifying a minimum set of LOM elements that must be present when UK educational communities, who wish to conform to this part of the UK LOM Core, create LOM application profiles and exchange metadata instances between applications. Every effort has been made to ensure that the Core Element Set is applicable to all kinds of learning objects, in the widest sense of the term. However it is necessary to be aware that there are some types of "objects" and resources that both the LOM and the UK LOM Core are less suitable for describing, e.g. collections, assessment systems, virtual learning environments, events, etc. It is also important to recognise that the Core Element Set is designed to accommodate the *minimum* information required to facilitate the exchange of learning object metadata. While a metadata instance composed of the Core Element Set represents an "adequate record", many types of resources will require additional information to be recorded. For this reason it is envisaged that many implementers will choose to build application profiles tailored to meet their own requirements based on the UK LOM Core's Core Element Set.

Conforming with the UK LOM Core's Core Element Set

The UK LOM Core identifies LOM elements as being required, recommended and optional[50]. The Core Element Set is composed of the following required simple data elements:

1.1.1 *General.Identifier.Catalog*
1.1.2 *General.Identifier.Entry*
1.2 *General.Title*
1.3 *General.Language*
1.4 *General.Description*
2.3.1 *Lifecycle.Contribute.Role*
2.3.2 *Lifecycle.Contribute.Entity*

[50] The key words must, must not, required, shall, shall not, should, should not, recommended, may and optional used throughout the UK LOM Core are interpreted as described in IETF RFC 2119: Key words for use in RFCs to Indicate Requirement Levels http://www.ietf.org/rfc/rfc2119.txt

2.3.3 *Lifecycle.Contribute.Date*
3.1.1 *Metametadata.Identifier.Catalog*
3.1.2 *Metametadata.Identifier.Entry*
3.2.1 *Metametadata.Contribute.Role*
3.2.2 *Metametadata.Contribute.Entity*
3.2.2 *Metametadata.Contribute.Date*
3.3 *Metametadata.Metadata Schema*
3.4 *Metametadata.Language*
4.3 *Technical.Location*
6.2 *Rights.Copyrights and Other Restrictions*
6.3 *Rights.Description*

In order for a metadata *instance* to conform to the UK LOM Core's Core Element Set, values must be supplied for all required elements. Container elements are regarded as required if one or more of their sub elements are required. Values for recommended elements should be provided where possible and values for optional elements may be supplied if they are deemed to meet the requirements of the user community.

In order for a metadata *application profile* to conform to the UK LOM Core's Core Element Set all required elements must be included in the profile.

In addition, conforming metadata instances and application profiles must follow the recommendations, adhere to the requirements and use the required vocabularies outlined in the UK LOM Core's Implementation Guidelines and Element Requirements. Recommended vocabularies should be used where possible.

It is also recommended that developers should publish their application profiles, including vocabularies, on a project website for example or in an application profile registry, to ensure that they are accessible to other UK LOM Core implementers.

The Implementation Guidelines and Element Requirements

In addition to specifying a minimum required Core Element Set, the UK LOM Core also outlines Implementation Guidelines for all LOM categories and elements plus additional Element Requirements, e.g. use of community specific vocabularies. Many of these Guidelines are influenced by the CanCore Guidelines discussed above. The primary objective of the Implementation Guidelines is to facilitate semantic interoperability by reducing ambiguity in the interpretation and implementation of the LOM conceptual data schema and by ensuring that elements and vocabularies are used with a high degree of consistency throughout the educational sector within the UK. The additional Element Requirements identify UK specific vocabularies that must or should be used to describe certain LOM elements e.g. the *Classification* elements. In some cases these UK specific vocabularies must be used in conjunction with a standard LOM vocabulary e.g. as with element 5.6 *Educational.Context*, which recommends the use of the UKEC[51] vocabulary. This vocabulary, which describes UK educational contexts, is comprised of the following terms: nursery, education primary, education secondary, education sixth form college, further education, higher education, continuous professional development, vocational training, community education.

Conforming with the UK LOM Core's Implementation Guidelines and Element Requirements

The UK LOM Core recognises that as a result of community specific requirements and workflows it may not be possible for metadata authors to create complete metadata instances that conform to the Core Element Set. If these instances conform to the UK LOM Core's Implementation Guidelines and Element requirements they may be aggregated with

[51] UK Educational Contexts http://www.ukoln.ac.uk/metadata/education/ukec/

other instances to form complete instances that conform to the UK LOM Core's Core Element Set.

In order to conform to the UK LOM Core's Implementation Guidelines and Element Requirements it is required that metadata instances and application profiles must adhere to these Guidelines and Requirements.

Support and Maintenance

The UK LOM Core is supported by a number of key stakeholders across the UK educational community including JISC CETIS, UKOLN, Becta and Learning and Teaching Scotland. It has already been relatively widely adopted across the UK FE/HE sector and has formed the basis of a number of diverse application profiles. One of the primary values of the application profile is that it is based on community consensus and is freely accessible to the UK educational community. All key issues regarding the profile are discussed in detail via the open fora of the JISC CETIS Metadata and Digital Repositories Special Interest Group mailing list[52] and the UK Metadata for Education Group[53] list. All documents relating to the UK LOM Core are freely available from JISC CETIS[54] and the profile is also registered in the JISC IE Metadata Schema Registry. However maintenance of application profiles is resource intensive and the UK LOM Core has to date been supported on a relatively *ad hoc* basis by JISC CETIS and UKOLN. This is reflected in the fact that the current most up to date version of the profile is a work-in-progress draft. However given the utility of the UK LOM Core and its already considerable adoption, both JISC CETIS and UKOLN are committed to ensuring that an adequately supported profile of the IEEE LOM standard continues to be freely available to the UK educational community.

Learning Object Metadata and IMS Content Packaging

A significant factor to take into account when considering the curation of learning objects and learning object metadata is that both are frequently "wrapped" using a range of packaging specifications and standards. Packaging specifications are generally designed to facilitate interoperability between applications, e.g. storage systems such as digital repositories and delivery systems such as virtual learning environments. This means that the Learning Object Metadata standard is frequently implemented in conjunction with other packaging standards and specifications and that LOM instances often occur inside packages. Day briefly introduces a range of packaging standards and specifications in his introductory Metadata chapter (Day, 2005, pp17-19), these include the Metadata Encoding & Transmission Standard (METS),[55] MPEG-21 Digital Item Declaration Language (DIDL)[56] IMS Content Packaging[57] and ADL SCORM®[58]. Of these, the most widely implemented packaging format within the domain of teaching and learning is the IMS Content Packaging specification, which also forms an integral component of SCORM®. Content Packaging focuses on defining interoperability between systems that wish to import, export, aggregate and disaggregate packages of content (IMS, 2005, p2)[59]. It enables content to be exchanged between systems while retaining information describing that content and how it is structured within the package. While an in depth technical overview

[52] CETIS Metadata and Digital Repositories SIG list archive http://www.jiscmail.ac.uk/lists/cetis-metadata.html
[53] UK MEG list archive http://www.jiscmail.ac.uk/lists/UK-MEG.html
[54] UK LOM Core http://www.cetis.ac.uk/profiles/uklomcore/

[55] METS http://www.loc.gov/standards/mets/
[56] ISO/IEC 21000-2:2003 MPEG-21 DIDL
[57] IMS Global Learning Consortium Content Packaging Specification http://www.imsglobal.org/content/packaging/index.html
[58] ADL SCORM® http://www.adlnet.org/scorm/index.cfm
[59] IMS Content Packaging Overview, Version 1.2 Public Draft, November 2005, http://www.imsglobal.org/content/packaging/cpv1p2pd/imscp_oviewv1p2pd.html

of IMS Content Packaging is beyond the scope of this chapter it is important to be aware that the specification is capable of dealing with complex objects with multiple alternative organisations and variant resources. In order to deal with such complex objects it is also necessary for the speciation to support rich metadata. Any type of metadata schema can be accommodated within an IMS content package, metadata can be added to any of the package components and the metadata itself may either be contained within the package or referenced as an external resource. Such flexibility is key to the success of IMS Content Packaging but it can also result in interoperability problems and raises issues for digital curation. When JISC CETIS tested the functional interoperability of IMS Content Packaging implementations at its first "CodeBash" event in 2002[60] it became apparent that interoperability problems frequently resulted from the way different implementations handled metadata. For example if a repository expected to find metadata attached at the organisation level but not the item level it may fail to process or ingest a package with item level metadata. Although implementations of IMS Content Packaging have matured and metadata handling has improved considerably in the intervening years this is still an issue that may have implications for digital curation. If for example an archive wished to preserve a large number of content packages and their associated metadata it would need to ensure that it could locate that metadata wherever it is located within the package. Similarly if the metadata is not contained within the package but is linked via an external reference then there is no guarantee that this link will be persistent, although it must be acknowledged that the issues of persistent linking is not unique to IMS Content Packaging. The complex issue of locating metadata within content packages is well recognised and IMS is currently revising the Content Packaging specification to clarify known ambiguities, including those relating to metadata, and to provide clearer best practice guidelines on the use and location of metadata associated with packages.

For further information on IMS Content Packaging see the IMS Content Packaging Overview and Best Practice and Guide Version 1.2 Public Draft Specification[61] and the JISC CETIS Standards Briefing Series "*What is* IMS Content Packaging?"[62]

Future Developments

IEEE LTSC "LOMnext"

Although the IEEE LOM XML binding is a relatively recent addition to the international standards catalogue the conceptual data schema, published in 2002, is considerably more mature. The LOM schema has already been extensively implemented on a global scale both as a formal standard and in draft format as the IMS Learning Resource Meta-data specification. As with all standards and specifications implementation tends to lead to the identification of ambiguities and irregularities and greater understanding of problems and issues that need to be addressed. In order to resolve these issues the IEEE Learning Technology Standards Committee has launched the "LOMnext" initiative and wiki[63]. The purpose of this initiative is to identify and record known issues and rectify these in a maintenance release, or corrigendum of the standard. In addition, issues are also being collated for potential consideration by a "next generation" version of the LOM, which is currently scheduled for 2007/2008.

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[60] Kraan, W.G., 2002, Developers content to bash code at CETIS http://www.cetis.ac.uk/content/20021120030704

[61] IMS Content Packaging Best Practice Guide Version 1.2 Public Draft, November 2005, http://www.imsglobal.org/content/packaging/cpv1p2pd/imscp_bestv1p2pd.html

[62] Wilson, S. and Currier, S., 2005, What is IMS Content Packaging? CETIS Standards Briefing Series, http://www.cetis.ac.uk/lib/media/WhatIsCP1_1_web.pdf

[63] IEEE LTSC "LOMnext" http://ieeeltsc.org/wg12LOM/LOMnext/

Joint DCMI/IEEE LTSC Taskforce[64]

As the IEEE LOM standard has matured and become more extensively implemented there has been growing concern regarding the lack of interoperability between LOM and Dublin Core (DC) metadata. Implementers are increasingly demanding the ability to mix and match multiple metadata schemata in order to meet the demands of their communities of practice. However, creating application profiles that contain both LOM and DC elements and mapping between LOM and DC profiles is a non-trivial task. This is primarily due to fundamental differences in the abstract data models on which each schema is based; the DC data model is flat, while the LOM is hierarchical. Currently the only real way to combine the two schemata is using RDF; however, while it is possible to combine RDF instances it is not possible to combine XML schema and most LOM instances are encoded using XML. A more appropriate solution would be to combine LOM and DC terms on an abstract level rather than at the encoding level, so that any binding syntax could subsequently be used. In order to explore the utility of this approach the Dublin Core Metadata Initiative and the IEEE LTSC have launched the Joint DCMI/IEEE LTSC Taskforce.

The approach currently being investigated by the Taskforce is whether LOM elements can be represented using the Dublin Core Abstract Model (DCAM). The DCMI abstract model "provides a reference model against which particular DC encoding guidelines can be compared."[65] It places strong constraints on implementation and describes permitted ways of processing metadata. If it is possible to translate LOM instances to the DCAM, then these translated instances can subsequently be combined with other DCAM descriptions and expressed using what ever binding syntax is deemed appropriate e.g. RDF, HTML, XML. In order to translate LOM instances to the DCAM it will be necessary to transform the hierarchical LOM into an entity-relationship model and to define these entities and relationships using URIs. There are several advantages to this approach; LOM elements could be reused in DC application profiles, LOM could be regarded as a basic application profile of DC and the LOM/DC translation could be separated from the specific RDF binding. This would also represent an important first step towards better alignment of the abstract models of each metadata schema.

Although much of this work has already been undertaken during the development of a draft RDF binding for the LOM there are still problematic issues that need to be addressed. The most significant being that the translation from LOM to the DCAM is a one-way translation, there is no easy way back. So while any LOM element can be translated to the DCAM, not every DC element can be mapped back to LOM, only to LOM with extensions. To further complicate matters not all LOM extensions can be mapped to the DCAM. For example while it may be possible to map all LOM vocabularies to the DCAM, it is not possible to map customised vocabularies, terms and elements.

These are all issues that the Taskforce hope to explore and investigate through a recommendation with the current working title "Recommendation for using IEEE LOM Elements in Dublin Core Metadata". The Taskforce note that this approach represents:

"…a partial and short-term solution to the overall issue, which will still be of great value in the short to medium term to implementers that are struggling with these metadata interoperability issues. The recommendation will also be of great value in the longer-term process of trying to align the abstract models of IEEE LOM and Dublin Core, as it will provide

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[64] The author would like to thank the technical editors of the Joint DCMI/IEEE LTSC Taskforce for permission to draw upon draft materials from the taskforce wiki at http://dublincore.org/educationwiki/DCMIIEEELTSCTaskforce

[65] Powell, A., Nilsson, M., Naeve, A. and Johnston, P., 2005, DCMI Abstract Model, http://dublincore.org/documents/abstract-model/index.shtml

an analysis of fundamental incompatibilities between the two models."[66]

For further information regarding this initiative see the Taskforce wiki at http://www.dublincore.org/educationwiki/DCMIIEEELTSCTaskforce and M. Nilssen's "Mapping LOM to the Dublin Core Abstract Model – an alternative to the LOM abstract binding."[67]

Conclusions

Clearly there are many significant challenges that need to be addressed when considering the curation of teaching and learning materials and the role that learning object metadata can play in facilitating their reuse, management, and long-term preservation.

Although educators have made extensive use of a wide range of digital resources to facilitate their teaching practice for many of years, the evolution of a class of "learning objects" designed specifically to facilitate teaching and learning is a relatively recent phenomena. It has been suggested that, given the lack of consensus regarding what actually constitutes a "learning object", it is debatable whether the term or the concept will have any degree of longevity. However what can be assured is that educators will continue to use digital resources to enable teaching and learning and that, as with other domains, the volume and nature of these resources will proliferate exponentially. While the entire volume of data generated, used and reused in the domain of learning, education and training may always be relatively small in comparison to other domains, such as research and eScience for example, it is important not to underestimate the challenges that facilitating the preservation of teaching and learning materials are likely to represent.

The domain of e-learning, or learning technology, is still in a rapid phase of development and both theory and practice are continually evolving. The types of digital resources used to enable learning, education and training are extremely heterogeneous, they are often structurally complex and there is little common practice regarding how to describe them or even what characteristics it is useful to describe. However although teaching practice and educational resources may be changing rapidly they are frequently situated in institutional environments that are considerably more resistant to change. Many existing institutional information management strategies and agencies are not well suited to accommodating such diverse and rapidly evolving resources and there is no clear consensus as to where digital teaching and learning materials should reside throughout their lifecycles in either the short or the long term. Certainly repositories designed specifically to accommodate learning objects are becoming more common, however it is not clear how these relate to other resource management agencies such as institutional repositories and libraries and few educational and training institutions have truly coherent information management strategies that link these multiple agencies and authorities.

In such a rapidly evolving domain as e-learning it is no little credit to bodies such as IEEE and the IMS Global Learning Consortium that they have managed to develop standards and specifications that have proved to have some utility. The IEEE LOM is often regarded as the first *de facto* international standard designed specifically for the domain of learning technology and while implementation has illustrated that there is significant room for improvement, it has been adopted on a remarkably wide scale. LOM however is first and foremost a learning technology interoperability standard, its primary aim is to facilitate the re-use of resources within learning, education and training. However

[66] DCMI/IEEE LTSC Taskforce Scope and Purpose http://www.dublincore.org/educationwiki/DCMIIEEELTSCTaskforce

[67] Nilssen, M., 2005, Mapping LOM to the Dublin Core Abstract Model – an alternative to the LOM abstract binding, http://www.dublincore.org/educationwiki/DCMIIEEELTSCTaskforce?action=AttachFile&do=get&target=2005-10-29-LOM-Orlando-LOMDCAM.pdf

given that LOM is designed to apply to an almost infinitely diverse range of resource types it must also be capable of describing a wide range of characteristics of these resources. As a result LOM in a single multipart standard attempts to fulfil all of the metadata functions identified by Day in his introductory Metadata chapter; "discovery of objects, the management of access and integration, and the documentation of object origins, life cycles and contexts – all at multiple levels of aggregation and focused on particular subject domains" (Day 2005, p7).

Although LOM may be designed to facilitate short to medium term reuse, it was not designed with the long-term preservation of either resources or metadata in mind. In terms of the potential for LOM to enable digital curation this problem is compounded by the fact that developers may not necessarily consider it a priority to create educational resources and accompanying metadata that are stable, durable and have a significant lifespan. So while the creators of learning objects may appreciate the necessity of adding metadata to their resources so that they can be accessed by their communities of practice in the short term they may be less aware of the importance of registering their metadata profiles and vocabularies to ensure that this metadata continues to have some semantic value in the future. In addition, within the domains of learning, education and training, metadata is frequently created by teachers, content developers and learning technologists as opposed to information scientists and professional cataloguers. This tends to result in some resistance to the process of metadata creation, which may often be regarded as an unwelcome chore after the resource has been created. In addition, the resulting metadata may often be of highly variable quality. The implications of this lack of quality control are discussed at length by Currier, Barton, O'Beirne and Ryan in their 2004 paper "Quality assurance for digital learning object repositories: issues for the metadata creation process".[68] While many steps are being taken to address problematic issues relating to the creation and quality control of learning object metadata one approach that is generating considerable interest currently is the automatic generation of metadata. However in the domain of teaching and learning this research is still in its infancy and it remains to be seen what implications such developments are likely to have for interoperability and digital curation.

This paper has attempted to present a brief introduction to learning object metadata and to identify some of the issues that need to be taken into account when considering the curation of both learning objects and the metadata that describes them. The term learning object metadata may fall out of fashion and over time the IEEE Learning Object Metadata standard is likely to be replaced by subsequent standards. However it is certain that the use of digital objects to facilitate teaching and learning will continue to grow and that the metadata requirements of the communities of practice that use these resources will become increasingly complex. It is also to be hoped that as the domain of e-learning and the resources it utilises stabilise and become more mature we will start to see the evolution of metadata standards that are capable of describing not only the educational characteristics and pedagogical context of a learning resource but also of encompassing the necessary information that will help ensure that both resources and metadata are accessible and reusable in the long term.

[68] Currier S., Barton J., O'Beirne R. & Ryan B., 2004, Quality assurance for digital learning object repositories: issues for the metadata creation process, ALT-J, Volume 12, Part 1.

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Terminology

ADL – Advanced Distributed Learning.

application profile – "In DCMI usage, an application profile is a declaration of the metadata terms an organization, information resource, application, or user community uses in its metadata. In a broader sense, it includes the set of metadata elements, policies, and guidelines defined for a particular application or implementation. The elements may be from one or more element sets, thus allowing a given application to meet its functional requirements by using metadata elements from several element sets including locally defined sets."(Dublin Core Metadata Initiative DCMI Glossary)

application profile – "Application profiles are tailored for particular implementations and will typically contain combinations of sub-sets of one or more namespace schemas." (Heery and Patel, 2002)

application profile – "schemas consisting of data elements drawn from one or more namespaces, combined together by implementers and optimized for a particular local application." (BSI, 2004).

application profile – "A description of the use of a single technical standard to meet the needs of a particular community." (IMS, 2005, p4).

application profile – "Application profiles provide the means to express principles of modularity and extensibility. The purpose of an application profile is to adapt or combine existing schemas into a package that is tailored to the functional requirements of a particular application, while retaining interoperability with the original base schemas." (Duval *et al*, 2002).

application profile – "…customizations of [a] standard to meet the needs [of] particular communities of implementers with common applications requirements." (Lynch, 1997).

BECTA – British Educational Communications and Technology Agency.

BSI – British Standards Institute.

datatype – "A property of distinct values, indicating common features of those values and operations on those values." (IEEE LOM, 2002, p3).

DCAM – Dublin Core Abstract Model.

DCMI – Dublin Core Metadata Initiative.

CanCore – CanCore Guidelines for the Implementation of Learning Object Metadata.

CEN/ISSS WS-LT – European Committee for Standardization / Information Society Standardization System Learning Technologies Workshop.

CodeBash – Practical interoperability testing events held by CETIS and partner organisations.

CWA – CEN Workshop Agreement.

IANA – Internet Assigned Numbers Authority.

IEEE – Institute of Electrical and Electronics Engineers.

IEMSR – Information Environment Metadata Schema Registry.

IETF – Internet Engineering Task Force.

IMS – IMS Global Learning Consortium.

IMS CP – IMS Content Packaging Specification.

IMS LRM – IMS Learning Resource Meta-data Specification.

JISC CETIS – Joint Information Systems Committee Centre for Educational Technology and Interoperability Standards.

LangString – "A datatype that represents one or more character strings. A LangString value may include multiple semantically equivalent strings, such as translations or alternative descriptions." (IEEE LOM, 2002, p3).

learning object – "For this standard, a learning object is defined as any entity—digital or non-digital—that may be used for learning, education, or training." (IEEE LOM, 2002, p1).

learning object – "…pedagogically meaningful individual units that address a single or simple educational concept, they may have pre-requisites and they *should* be associated with metadata." (Campbell, 2006, p3).

LOM – Learning Object Metadata, usually used to refer to the IEEE Learning Object Metadata Standard.

LTSC – Learning Technology Standards Committee.

METS – Metadata Encoding & Transmission Standard.

MIME – Multipurpose Internet Mail Extensions.

MPEG-21 DIDL – Moving Picture Experts Group – 21 Digital Item Declaration Language.

RDF – Resource Description Framework.

RFC – Request For Comments.

SCORM® – Shared Content Object Reference Model – developed and maintained by ADL.

smallest permitted maximum – "For implementation-defined values, the smallest permitted maximum value." (IEEE LOM, 2002, p3).

UKEC – UK Educational Contexts vocabulary, recommended for use with UK LOM Core.

UK LOM Core – UK Learning Object Metadata Core – an application profile of IEEE 1484.12.1-2002 Standard for Learning Object Metadata.

XML – eXtensible Markup Language.

Key External Resources

CanCore Metadata Initiative
http://www.cancore.ca/en/

"The CanCore Metadata Initiative assists project implementers and indexers in the development of high-quality systems and records to support the use and reuse of digital learning objects. These educational or learning objects can be as simple as individual web pages, video clips, or interactive presentations, or as comprehensive as full lessons, courses or training programs.

CanCore has been working with an expanding community of implementers since November 2000. It provides guidelines for all of the elements in the Learning Object Metadata standard, and identifies a sub-set of these elements for their special utility in resource description and discovery.

CanCore has been developed with input from educators and technology developers, and from Canadian projects and implementations internationally. The CanCore Initiative is currently funded by the e-Learning Marketplace Strategy Group of Industry Canada's e-Learning Directorate, and supported by TeleUniversite and Athabasca University. Funding and support has also been provided by CANARIE, Alberta Learning, Netera Alliance, TeleCampus.edu, and the Electronic Text Centre at the University of New Brunswick."

IEEE Learning Object Metadata Standard

IEEE, 2002, *1484.12.1-2002 Standard for Learning Object Metadata*, Institute of Electrical and Electronic Engineers, inc., NewYork.

IEEE, 2005, 1484.12.3-2005 *IEEE Learning Technology Standard - Extensible Markup Language (XML) Schema Definition Language Binding for Learning Object Metadata*, Institute of Electrical and Electronic Engineers, inc., NewYork.

IMS Application Profile Guidelines
http://www.imsglobal.org/ap/index.html

"…describes what an application profile is in the context of the IMS specifications and the benefits to be gained from undertaking such an exercise – namely more closely meeting the needs of the target user community whilst harnessing the specifications to aid integration and enhance interoperability between tools, products and services which vendors would supply to that community. Guidance is offered on the key factors for deciding whether or not to embark upon a profiling exercise and a process outlined for how to proceed with such an activity. Conformance issues around an application profile are briefly discussed, as are technology and implementation issues beyond the scope covered by the specifications.

IMS Meta-data Best Practice and Implementation Guide for IEEE 1484.12.1-2002 Standard for Learning Object Metadata
v1.3 Public Draft specification,
http://www.imsglobal.org/metadata/mdv1p3pd/imsmd_bestv1p3pd.html.

"The purpose of this document is to provide users and implementers of the IMS Learning Resource Meta-data 1 v1.3 Specification with a narrative description of the data model along with guidelines on its use, including the creation of application profiles. This Best Practice and Implementation Guide also provides a brief description of IEEE P1484.12.3 Draft Standard for Extensible Markup Language (XML) Schema Definition Language Binding for Learning Object Metadata plus guidelines on binding meta-data instances."

JISC Centre for Educational Technology and Interoperability Standards (JISC CETIS)
http://jisc.cetis.ac.uk/

JISC CETIS is funded by the Joint Information Systems Committee, the Centre's remit is to:

- Advise the JISC community on the uptake and implementation of open learning technology interoperability standards and specifications.
- Represent the interests of the UK Higher and Further education sector on a variety of national and international standards organisations including the IEEE Learning Technology Standards Committee, CEN/ISSS Learning Technology Workshop, the British Standards Institute and the IMS Global Learning Consortium.
- Provide strategic advice to JISC on eLearning futures and standards.
- Develop and support national JISC funding programmes and projects.
- Support the community and build awareness and capacity via nine special interest groups and fora covering the domains of accessibility, assessment, educational content, metadata and digital repositories, learner information and portfolios, pedagogy, enterprise, lifelong learning and technical implementation.

JISC CETIS Briefings on e-Learning Standards
http://www.cetis.ac.uk/static/briefings.html

JISC CETIS provides briefing papers on a wide range of open learning technology standards, which can be downloaded and printed form the URL above.

JISC CETIS Educational Content Special Interest Group
http://www.cetis.ac.uk/members/educational_content

The Educational Content SIG covers the IMS Content Packaging, Simple Sequencing and Learning Design specifications, all of which are aimed at enabling the development and packaging of interoperable learning scenarios. The SIG is coordinated by Sheila MacNeill at the University of Strathclyde, s.macneill@strath.ac.uk

JISC CETIS Metadata and Digital Repositories Special Interest Group
http://metadata.cetis.ac.uk/

The MDR SIG provides a forum for discussing standards, specifications and processes concerning the description of learning resources, the storage and management of these resources and their descriptions in repositories, and the social, political and policy issues associated with running such a repository. A wide range of metadata related resources are available from the SIG website at http://metadata.cetis.ac.uk/guides/ The SIG is coordinated by Phil Barker at Heriot-Watt University, philb@icbl.hw.ac.uk.

JISC CETIS *What is* IEEE Learning Object Metadata / IMS Learning Resource Metadata?
http://www.cetis.ac.uk/lib/media/WhatIsLOMscreen.pdf

This JISC CETIS briefing paper presents a short four page overview of the LOM and its structure. It is aimed at people who know a little about metadata in general but are new to the LOM data model.

JISC Information Environment Metadata Schema Registry
http://www.ukoln.ac.uk/projects/iemsr/

“The JISC IE Metadata Schema Registry (IEMSR) project is funded by JISC through its Shared Services Programme. The IEMSR project is developing a metadata schema registry as a pilot shared service within the JISC Information Environment.

Metadata schema registries enable the publication, navigation and sharing of information about metadata. The IEMSR will act as the primary source for authoritative information about metadata schemas recommended by the JISC IE Standards framework.

Metadata within the JISC IE is based largely on two key standards: the Dublin Core Metadata Element Set (DCMES) and the IEEE Learning Object Metadata (LOM) standard. The IEMSR will provide the JISC IE with a single point of referral for recommended schemas. It will allow various initiatives within the JISC IE to publish "application profiles" of these standards in a common registry, making them available to others. This provides a concrete way of encouraging sensible uniformity alongside necessary divergence. It helps avoid unnecessary duplication of effort, and supports sharing of common approaches.

The IEMSR project will build on the work of previous projects which have explored provision of information about metadata at the level of data elements, element sets or application profiles. The MEG Registry project, funded by JISC and Becta in 2002, developed an RDF-based registry and schema creation tool. The project will re-engineer the MEG software to accommodate the IEEE LOM, supporting ongoing cooperation between the Dublin Core and IEEE LOM standardisation communities.”

Joint DCMI/IEEE LTSC Taskforce
http://dublincore.org/educationwiki/DCMIIEEELTSCTaskforce
Please note: This is early draft work in progress.

“The aim of this activity is to develop a recommended representation of the metadata elements of the IEEE Learning Object Metadata Standard in the Dublin Core Abstract Model. The recommendation hopes include the specification of a number of terms, including properties, syntax encoding schemes, vocabulary encoding schemes as well as vocabularies, that may be used for expressing metadata conforming to the IEEE LOM Standard in Dublin Core metadata. The recommendation will also include the specification of namespaces to use for the terms, as well as a basic application profile describing how to combine the specified terms in a way that is compatible with the structural constraints of the IEEE LOM Standard.”

Metadata for Education FAQ
http://www.cetis.ac.uk/metadatafaq/FrontPage

This FAQ comprises answers to questions anyone dealing with educational metadata for the first time might ask, (starting with "what is metadata"). This guide has been written by members of IMS, Dublin Core and IEEE LTSC, three organizations that have taken a lead in the development of educational metadata standards, and includes contributions from members of CETIS, CanCore, ADL, and JES and Co. The intention is to continue this work and encourage participation from the wider community with the assistance of a Wiki hosted by CETIS.

UK LOM Core
http://www.cetis.ac.uk/profiles/uklomcore/

UK LOM Core is an application profile of IEEE 1484.12.1-2002 Standard for learning Object Metadata, which composed of a minimum required core element set along with a set of guidelines to inform UK practitioners on the implementation and use of all LOM elements and their associated value spaces. The primary objective of the UK LOM Core is to increase the *interoperability* of metadata instances and application profiles created within the UK educational sector. The application profile is designed to be applicable to *all* UK educational communities including pre-school, primary, secondary, FE, HE and adult and community learning. The UK LOM Core is developed and maintained by JISC CETIS and supported by a number of additional UK agencies including UKOLN, the British Educational Communications and Technology Agency (Becta) and Learning and Teaching Scotland.