



LACE

Learning Analytics Community Exchange

Specifications and Standards - Quick Reference Guide

Public Working Document

By: Adam Cooper

Published: 31 December 2015

Keywords: learning analytics, interoperability, standards, specifications

This document presents a list of standards and specifications, including research work, which may be relevant to people building learning analytics systems. A brief summary of the capabilities of each is presented, along with notes on adoption to-date. The aim in writing this guide is to raise awareness of existing technical specifications, and to support a process of due diligence through exploration of prior art when learning analytics systems are designed.

Audience: this is a relatively technical document aimed at readers with experience in software development and architecture, or development of interoperability standards, etc.

Contents

1.	Introduction	1
	Background to Learning Analytics Interoperability	1
	A Note on Terminology: interoperability, specifications, standards	1
	The Motivation for a Quick Reference Guide	1
	Status of This Document and Call to Contribute	2
2.	How to Use this Quick Reference Guide	2
	Online Counterpart, the Mendeley Group	2
	Structure of the Guide	2
	Evaluating Specifications and Standards	4
3.	The Quick Reference Guide	6
	Specifications to support analytics, independent of domain of application	6
	Data Exchange	6
	Models and Methods.....	8
	Specifications dealing with human activity generally	9
	Logging.....	9
	Communication	11
	Specifications dealing with learning-related activity, or rooted in education or training	11
	Objectives and Assessment	11
	Biographical	13
	Contextual and Referential	14
	Multi-purpose Specifications.....	14
	Other Specifications.....	16
	Privacy	16
	Protocols.....	16
4.	Glossary of Abbreviations	16
5.	References	18
6.	About	26

1. Introduction

Background to Learning Analytics Interoperability

The Institute of Electrical and Electronics Engineers (IEEE) defines interoperability to be:

“the ability of two or more systems or components to exchange information and to use the information that has been exchanged.”

As learning analytics moves from being a research topic to an ICT-supported service at scale, the property of interoperability becomes more important. The LACE Briefing “Learning Analytics Interoperability – The Big Picture in Brief” [1] outlines a range of both short-term and long-term benefits arising from increased interoperability.

A Note on Terminology: interoperability, specifications, standards

As the IEEE definition above indicates, “interoperability” is a property a collection of systems. It may be achieved using a range of technical and non-technical means, with written technical specifications – data definitions, HTTP REST APIs¹, XML bindings, etc. – only being part of the recipe for achieving practical interoperability. The focus of this document is on these technical specifications.

It is common for the term “standard” to be applied to some kinds of technical specifications, but there is no uniformity of usage; different organisations have different definitions of what they consider to be a standard, and there is much looseness in terminology when the word is used outside formal standardisation processes. This document does not adopt a hard-and-fast definition of what comprises a “standard” and takes an inclusive view of the kinds of technical specification that are in scope, captured in the title as “specifications and standards.”

The Motivation for a Quick Reference Guide

The aim of the author in writing this guide is to raise awareness of existing technical specifications, and to support a process of due diligence through exploration of prior art when designing learning analytics systems. The guide is intended to reduce the incidence of unintentional invention or deviation from what already exists. The author does not assume that any of these specifications are fit for use as they stand. In all cases, it will be necessary to undertake an application- and context-specific evaluation (see the section “Evaluating Specifications and Standards”, below), and it may well be the case that an existing specification provides only some inspiration for a new approach, or the definitions for some concepts. Such inspiration and definition-borrowing moves us in the direction of evolved, and possibly convergent, thinking. It takes us in the direction of interoperability, even if not to the destination.

This guide is a catalogue² of technical specifications that may be of relevance to implementations of learning analytics. For each, it sets out to provide a brief summary of the scope and purpose of the technical specification, along with references to evidence of implementations, experiences from use,

¹ In general, abbreviations for technical terms will not be expanded on in the text. A glossary is provided as

² Another source of information, supported by the Open Knowledge Foundation and oriented towards open data is a web page entitled “Web-oriented Data Formats” and, may be found at <http://dataprotocols.org/data-formats/>.

critique, etc. Evidence from use for learning analytics is prioritised, and the approach taken is one of providing indicative evidence rather than a comprehensive account.

Status of This Document

A “public draft for comment” of this document was published 9 December 2014. The draft was released as a useful, but incomplete, work in the hope that it will:

1. bring existing work of relevance to learning analytics interoperability to the attention of more people;
2. stimulate contribution from people with knowledge and experience; and
3. stimulate experimentation and reporting on the results of trials.

Based on feedback from the community and work in the Interoperability work package of the LACE project this document has been updated (by Tore Hoel) to the current version.

Also in this version of the guide, evidence is frequently lacking. This is partially a consequence of the stage of investigation; however, the shortage of evidence is also contributed to by a failure to publish the results of experimentation – both successes and failures - or due to absence of practical experience of using the specification in a learning analytics system.

2. How to Use this Quick Reference Guide

Online Counterpart, the Mendeley Group

The Guide is an augmented snapshot of the contents of the Mendeley Learning Analytics Interoperability Group **Error! Bookmark not defined.** The LACE project has added to the contents in the process of ongoing desk research. The Mendeley Group references are browsable by “tags” that match the structure of this document, but also uses tags to distinguish between technical specifications, consensus-based “standards”, evidence, and to identify the specification by name/abbreviation³. In this case, the label “standards” indicates a subjective assessment of whether or not a technical specification has been arrived at by some kind of, maybe limited, consensus process. The author finds this distinction to be the most useful *prima facie* way of prioritising specifications for review (but see the comments on evaluation, below).

Structure of this Guide

This Guide includes specifications with general applicability to analytics through to those that are specific to the domain of learning, education, and training. Within this spectrum are specifications that capture human activity but are not purely relevant to learning analytics. These distinctions have informed the approach to structuring the catalogue of specifications, which borrows from the broad categories outlined in the “Big Picture” [1]. The structure is as follows, and it should be noted that the terms in quotation marks match tags used in the Mendeley Group.

³ The tags used are documented at <http://bit.ly/1wmc7Gc>

Specifications to support analytics, independent of domain of application

- “Data exchange” - general purpose formats and structures for accessing or transferring data, including computed results, predictions, and statistical metadata. This category is only used when no domain-specific category would be sensible.
- “Models and methods” - the specification deals with analytical method (algorithmic, or workflow) and models produced (statistical or machine-learning).

Specifications dealing with human activity generally

- “Logging” – in which high level semantics are specified, possibly with an option to include application-specific vocabularies. This covers everything from atomic activity capture through to capture of compound kinds of activity. Technology-level logs such as web-servers produce are not included. This category is reserved for cases where the specification is not targeted at a particular kind of activity⁴.
- “Communication” - the focus of attention is activity in forums, chat, collaborative editing, etc, and there are specific references to the semantics of such activities in the specification.

Specifications dealing with learning-related activity, or rooted in education and training

- “Objectives and assessment” - there is specific reference to the semantics of assessment, including statements of achievement, in the specification. This category also includes intended learning outcomes, inferred knowledge, data pertaining to the assessment instrument, and also to records of self-regulated learning.
- “Biographical” – the specification expresses data about people other than their actions. Some of this would be described as "demographic" for population-level studies. This includes, for example, social relations.
- “Contextual and referential” - this is a very loose class of data that may assist in the interpretation of activity data (e.g. identification of the course being studied, the access device used) and which may sometimes exist without anyone engaging in tracked learning (e.g. learning designs, national curriculum standards). Content metadata would appear in this category, but resource metadata specifications are not currently included in the Guide.

Other Specifications

These do not naturally fit into the above structure but are nonetheless of relevance to learning analytics:

- “Privacy” – specifications concerned with disclosure and use of person-related information. General information security specifications are not in scope for this Guide.
- “Protocol” – the specification includes, or largely deals with, the methods by which data is exchanged, i.e. APIs.

⁴ Specifications are classified and presented in the most specialised class when this can be determined. For example, although there is a clear conceptual hierarchy moving from data exchange -> logging -> resource use -> objectives and assessment, QTI Results only appears in “objectives and assessment”.

Evaluating Specifications and Standards

This Guide has intentionally avoided presenting any value-laden comments on the listed specifications for several reasons:

1. There will usually be a number of factors arising from the application in question, and the context of use, which determine relevance.
2. The Guide is intended to support activity across a spectrum ranging from adoption with intent to conform to an existing specification, through to gaining inspiration for a technical design.
3. The strength of evaluation, and how it is parameterised, should depend on risk, and risk varies by many orders of magnitudes between a private learning-experiment and a multi-million Euro/Dollar investment.

In practice, it will usually be necessary to make decisions about the relevance of a technical specification in a richer way than simply asking whether or not it meets a particular set of criteria in a definition of “a standard”. For high risk settings, the Common Assessment Method for Standards and Specifications (CAMSS) [2] provides a useful template. This was designed for selection, and possibly mandation, of standards by European governments; the typical scale of cost for adoption, and hostility from many in the software industry and the press, demands a defensive stance. It is used, for example, by the UK Government Open Standards Board⁵. The current author is rather cautious about checklist-based standards evaluation, particularly in the absence of a pilot project to properly understand the issues, although checklists provide a useful set of prompts of aspects to consider [3].

Key questions to ask typically revolve around:

1. Copyright, licence and patent considerations. What freedoms do you have? The lowest risk scenario is that all contributors to a specification have explicitly waived all rights, and the IPR is owned by an organisation with long-term sustainability and a commitment to find an entity to inherit specifications should they wind down, and with a liberal licence to implement the specification. Reality is often some distance from this ideal scenario, and there are also issues where an overtly-acceptable idea such as FRAND (fair, reasonable and non-discriminatory) terms are limiting in practice (in this case it is that Open Source Software enshrines the freedom to re-distribute which is at odds with requirements for royalty payment, no matter how “reasonable”).
2. Technical Quality may be best judged from experience but useful proxies include: the extent of participation in the specification development and the degree to which there is evidence of meeting requirements from multiple stakeholders (which is one reason why consensus process in general and Open Standards⁶ are important); the existence of independent implementations; evidence of use in an equivalent context and for a similar application to the one for which the specification is being evaluated.
3. Level of adoption. Since the point of adoption is to promote interoperability, value scales as some function of adoption. This is not to say that wide adoption is a hard requirement; an existing specification with some evidence of technical quality is likely to be a good point of

⁵ <https://gds.blog.gov.uk/2013/05/17/open-standards-board-sets-the-direction/>

⁶ See, for example the “Open Stand Principles”, <http://open-stand.org/about-us/principles/>

reference for a one-off system integration, no matter how widely implemented, and a new specification that solves real problems may quickly become widely implemented.

4. Stability and persistence. This is often coupled with the previous three points; a widely adopted specification founded on collaboration among multiple stakeholders with clear IPR and transparently governed is trustable. A specification from, and largely used by, a single entity should be treated with caution because there is minimal barrier to change or abandonment.
5. Fit to your technical architecture, although even in cases of poor fit, it may be possible to borrow and adapt patterns, data definitions, etc.
6. Fit to your organisational and operational context. What assumptions does the specification make about workflow, patterns of activity, roles, etc?

3. The Quick Reference Guide

Note: the descriptions below are taken from the specification when a suitable abstract is available.

Specifications to support analytics, independent of domain of application

Data Exchange

These data exchange specifications collectively cover a wide range of application scenarios from being input formats for batch data mining through to feeding live data to dashboard widgets, for use as publishing formats or for archival and audit, etc.

ARFF – Attribute-Relation File Format

An ARFF (Attribute-Relation File Format) file is an ASCII text file that describes a list of instances sharing a set of attributes. ARFF was developed by the Machine Learning Project at the Department of Computer Science of The University of Waikato for use with the Weka machine learning software. ARFF files can be treated as CSV once the header metadata is removed.

Technical

Specification [4]

Evidential

Repository of more than 600 ARFF datasets [5]

Software

ARFF originated with Weka, a suite of machine learning software developed at the University of Waikato [6]
Also support in several other tools, e.g. R [7]

CSV+ - Model for Tabular Data and Metadata on the Web

Tabular data is routinely transferred on the web as "CSV", but the definition of "CSV" in practice is very loose. This document outlines a basic data model or infoset for tabular data and metadata about that tabular data. It also contains some non-normative information about a best practice syntax for tabular data, for mapping into that data model, to contribute to the standardisation of CSV syntax by IETF. Various methods of locating metadata are also provided.

Technical

W3C Working Draft [8]

Evidential

The Working Draft is backed up by a compilation of use cases and requirements [9]

DSPL – Google DataSet Publishing Language

A DSPL dataset is a bundle that contains an XML file and a set of CSV files. The CSV files are simple tables containing the data of the dataset. The XML file describes the metadata of the dataset, including informational metadata like descriptions of measures, as well as structural metadata like references between tables. Datasets described in this format can be processed by Google and visualized in the Google Public Data Explorer.

Technical

DSPL XML Schema [10]

Evidential

Google Public Data Explorer uses DSPL [11]

JSON-stat

The JSON-stat format is a simple lightweight JSON format for data dissemination. It is based in a cube model that arises from the evidence that the most common form of data dissemination is the tabular

Technical

Specification [12]

Evidential

form. In this cube model, datasets are organized in dimensions. Dimensions are organized in categories.	<p>Adopters of JSON-stat include statistics agencies in the UK, Norway, Sweden, Catalunya, and Galicia⁷.</p> <p>Software JavaScript toolkit [13]s R package [14]</p>
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GraphML	
GraphML is a comprehensive and easy-to-use file format for graphs based on XML. It consists of a language core to describe the structural properties of a graph and a flexible extension mechanism to add application-specific data. This document specifies syntax and processing rules for the GraphML language core (structural layer) and two GraphML extensions that allow adding base-type attributes and parsing information.	<p>Technical Specification version 1.1 [15]</p> <p>Evidential Implemented in SNAPP⁸ [16]</p> <p>Software Gephi⁹ implementation of GraphML [15]</p>

There are several other formats for social network data, GraphML has been selected because of its popularity and support in tools already used for learning analytics.

OData	
<p>The OASIS OData TC [Technical Committee] works to simplify the querying and sharing of data across disparate applications and multiple stakeholders for re-use in the enterprise, Cloud, and mobile devices. A REST-based protocol, OData builds on HTTP, AtomPub, and JSON using URIs to address and access data feed resources. It enables information to be accessed from a variety of sources including (but not limited to) relational databases, file systems, content management systems, and traditional Web sites.</p> <p>OData consists of a suite of specifications. OData was formerly a Microsoft Open Specification Promise specification.</p>	<p>Technical Working group home page [17]</p> <p>Evidential Use in Questionmark Open Assessment Platform [18]</p> <p>Software Catalogue of OData producers and consumers [19]</p>

Piwik Reporting API	
<p>The Piwik Reporting API provides access to typical web analytics report data.</p> <p><i>NB: this is a single supplier specification but Piwik is Open Source Software.</i></p>	<p>Technical Reporting API developer documentation [20]</p> <p>Evidential Pilot project using Piwik for a learning analytics dashboard [21]</p>

RDF Data Cube Vocabulary	
There are many situations where it would be useful	Technical

⁷ Links to these examples may be found at <http://json-stat.org/>

⁸ SNAPP is the Social Networks Adapting Pedagogical Practice tool, which performs real-time social network analysis and visualization of discussion forum activity. <http://www.snappvis.org/>

⁹ Gephi is a cross-platform interactive visualization and exploration platform for all kinds of networks and commonly used for social network visualisation. <http://gephi.github.io/>

to be able to publish multi-dimensional data, such as statistics, on the web in such a way that it can be linked to related data sets and concepts. The Data Cube vocabulary provides a means to do this using the W3C RDF (Resource Description Framework) standard. The model underpinning the Data Cube vocabulary is compatible with the cube model that underlies SDMX (Statistical Data and Metadata eXchange), an ISO standard for exchanging and sharing statistical data and metadata among organizations. The Data Cube vocabulary is a core foundation which supports extension vocabularies to enable publication of other aspects of statistical data flows or other multi-dimensional data sets.	<p>W3C Recommendation [22]</p> <p>Evidential</p> <p>Study on using RDF Data Cube for Linked Open Data, including references to learning analytics [23]</p> <p>List of implementations and conformance reports [24]</p>
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SDMX – Statistical Data and Metadata eXchange	
The Statistical Data and Metadata Exchange (SDMX) initiative sets standards that can facilitate the exchange of statistical data and metadata using modern information technology, with an emphasis on aggregated data. SDMX is sponsored by the Bank for International Settlements, the European Central Bank, EUROSTAT (Statistical Office of the European Union), the International Monetary Fund, the Organization for Economic Co-operation and Development, the United Nations, and the World Bank. The specifications include XML and UN/EDIFACT syntaxes, a registry specification and web service guidelines.	<p>Technical</p> <p>SDMX version 2.1 [25]</p> <p>Evidential/Software</p> <p>SDMX implementations [26]</p>

See also: PAR (return of predictions to partner institutions).

In addition to these ways of exchanging the data, there are also several specifications intended to be used to describe datasets or dataset catalogues, such as DCAT [27] and a proposal to WebSchemas [28]. These have potential roles for archival and publishing.

Models and Methods

PMML – Predictive Model Markup Language	
The Predictive Model Markup Language (PMML) is an XML-based language which provides a way for applications to define statistical and data mining models and to share models between PMML compliant applications.	<p>Technical</p> <p>Predictive Model Markup Language v4.2 [29]</p> <p>Evidential</p> <p>A white paper on standards in predictive analytics [30]</p> <p>Open Academic Analytics Initiative (OAAI) project findings [31]</p> <p>Paper on OAAI in Journal of Learning Analytics [32]</p> <p>An educational data mining example [33]</p> <p>Software</p> <p>PMML is supported by a range of software from desktop, e.g. Knime, to cloud-based, e.g. Zementis PMML package for R [34]</p> <p>PMML pre-processing and Google prediction API [35]</p>

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VTL – Validation and Transformation Language (SDMX)

The purpose of the VTL is to allow a formal and standard definition of algorithms to validate statistical data and calculate derived data. The validation is assumed to be a particular case of transformation, therefore the term “Transformation” is meant to be more general and to include also the validation.

Technical

Version 1.0 published in 2015 [36]

Specifications dealing with human activity generally

Logging

Activity Streams

This specification details the serialization of a stream of social activities using the JSON or Atom formats. Activities are important in that they allow individuals to process the latest news of people and things they care about.

Technical

Version 1.0 specifications (JSON and Atom) [37]
JSON Activity Streams 2.0 [38]

Evidential

Activity Streams provides some of the foundation for xAPI (see below).
Learning Registry Paradata Specification [39]
See also “Additional resources”, below.

Software

Activity Streams 2.0 Java Reference Implementation [40]

Caliper Analytics

IMS Caliper Analytics provides Learning Metric Profiles as standardised descriptions of actions and related contexts. Learning Sensor APIs communicate with Learning Events Store to aggregate metrics. The specification leverages existing IMS specifications, like Learning Tool Interoperability (LTI) specification, Learning Information Service specification, and Question & Test Interoperability specification

Technical

Published documents and code: IMS Caliper Analytics Background; IMS Caliper Analytics Best Practice Guide; IMS Caliper Analytics Implementation Guide; IMS Caliper Analytics Conformance and Certification Guide v1.0, and Caliper Analytics v1 Public Repos for Sensor APIs [97]

Evidential

IMS Global offers Conformance Certification for members.

Software

Caliper Event Store is available as a GitHub download

CAM – Contextualised Attention Metadata

Contextualized Attention Metadata (CAM) enables the capture of user interactions with learning environments, allowing modelling of a user's handling of digital content across system

Technical

CAM Schema [41]

Evidential

boundaries. As CAM was developed to describe as many types of attention metadata as possible, CAM records of a user cannot merely describe the user's foci of attention but rather his entire computer usage behaviour. CAM can be analysed to provide an overview about where (i.e. with which application) and when an action takes place and what happens in the environment. CAM analyses enable the discovery of popularity, usage bursts and trends of tools. It can also uncover patterns like applications becoming unpopular, rising stars and new applications taking over older applications. Information about when an action takes place can be useful in controlled environments such as formal learning environments where activities are usually scheduled.

A trust-based recommender for teachers [42]
 Use in a Personal Learning Environment [43]
 Book chapter [44]
 See also "Additional resources", below.

TMF – Pittsburgh Science of Learning DataShop Tutor Message Format

This guide is intended for a software developer who wants to evaluate, implement, or update logging in an educational tutoring [ITS] application, or convert existing logs created by a tutoring application. In addition, a developer working on a learning environment could describe the application's events in the format described in this document.

Technical

Specification v4 [45]

Evidential

DataShop, an online repository and analytical tools using TMF [46]
 Book chapter on DataShop [47]

xAPI - Experience API

The Experience API [also known as Tin Can API] specification describes a data model and web service that allows statements of experience to be delivered to and stored securely in a Learning Record Store (LRS). These statements of experience are typically learning experiences, but the API can address statements of any kind of experience. The Experience API is dependent on Activity Providers to create and track these learning experiences; this specification provides a data model and associated components on how to accomplish these tasks.

Technical

Version 1.0.2 specification [48]
 Tin Can Registry of vocabularies [49]

Evidential

xAPI has been widely implemented, including some pilots focussing on learning analytics [21] [50]

XES – eXtensible Event Stream

Event logs, as they occur in practice and research, can take a plethora of different forms and instantiations. Every system architecture that includes some sort of logging mechanism has so far developed their own, insular, solution for this task. XES is an XML-based standard for event logs. Its purpose is to provide a generally-acknowledged format for the interchange of event log data between tools and application domains. Its primary purpose is for process mining, i.e. the analysis of

Technical

XES v2.0 [51]

Evidential

IEEE CIS Task Force on Process Mining include activity to standardise XES [52] . Draft of October 2015 is published¹⁰

Software

ProM v6.4 (Process Mining Framework) [53]

¹⁰ http://www.win.tue.nl/ieeetfpm/doku.php?id=shared:20151002_xes

operational processes based on their event logs. However, XES has been designed to also be suitable for general data mining, text mining, and statistical analysis.

ProM has been used for learning analytics but with a fore-runner data exchange format [54]

Additional resources comparing several of the above, discussing of requirements and issues, describing prototypes, etc:

- “Aggregating social and usage datasets for learning analytics: data oriented challenges” [55]
- “An Overview of Usage Data Formats for Recommendations in TEL” [56]
- “A Survey on Linked Data and the Social Web as facilitators for TEL recommender systems” [57] (also refers to SIOC, see below)

Communication

Atom Syndication Format

Atom is an XML-based document format that describes lists of related information known as "feeds". Feeds are composed of a number of items, known as "entries", each with an extensible set of attached metadata. For example, each entry has a title. The primary use case that Atom addresses is the syndication of Web content such as weblogs and news headlines to Web sites as well as directly to user agents.

Technical

IETF RFC4287 [58]

Evidential

Atom is widely used (see e.g. Activity Streams, OData, Leap2A)

SIOC

The SIOC (Semantically-Interlinked Online Communities) Core Ontology provides the main concepts and properties required to describe information from online communities (e.g., message boards, wikis, weblogs, etc.) on the Semantic Web.

Technical

SIOC Core Ontology Specification [59]

Evidential

List of SIOC implementations (2009) [60]
Book chapter on linked data for recommender systems [57]

Argumentation Interchange Format [61], which “represents a consensus ‘abstract model’ established by researchers across fields of argumentation, artificial intelligence and multi-agent systems” may be relevant to special cases.

See also Activity Streams and xAPI

See also the section “Multi-purpose Specifications”, below.

Specifications dealing with learning-related activity, or rooted in education or training

Objectives and Assessment

EuroLMAI – European Learner Mobility Achievement Information

The European Learner Mobility Achievement

Technical

Information Model (EuroLMAI) aspires to address the identified need for a harmonized solution to the recording and exchange of learner mobility information within the European Education Area. The results of this work will contribute to the effort towards interoperable European-wide IT systems that manage and exchange learner achievement information. The EuroLMAI work has its roots in the European transparency tools and especially in the Europass framework for the transparent description of qualifications and competences. Europass provides the common basis for the well-structured recording of all life-long learning opportunities taken, including European Higher Education structures and learners' private and institution-owned information.	<p>CEN Workshop Agreement [62] (CWA, open access) European Standard [63] (based on CWA, fee due)</p> <p>Evidential Outline of use with UK Higher Education Achievement Report [64]</p>
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IMS LIS (Learner Information Services) Outcomes Management	
This document contains the IMS Global Outcomes Management Service v1.0 Information Model. This service is used to exchange information about Outcomes. The Outcomes data model is based upon results that can be grouped together to reflect an assessment activity for a Course. The Outcomes data model is based upon Lineltems, Results and ResultValues. The business transactions include the simple create, read, update, delete and simple searching of the Outcomes data model. This document contains the definition of the abstract application-programming interface for the Outcomes Management Service.	<p>Technical Version 1 data model and API (full LIS model) [65] Public draft v1.0 of a data-compatible service for use with IMS LTI [66]</p> <p>Evidential Implementations include Blackboard¹¹ and Oracle PeopleSoft¹².</p>

IMS QTI (Question and Test Interoperability) Results Reporting	
This document is a reference guide to the data model for reporting the results of an assessment, and provides detailed information about the model and specifies the associated requirements on delivery engines.	<p>Technical Version 2.1 specification [67]</p> <p>Evidential -</p>

InLOC – Integrating Learning Opportunities and Competences	
InLOC provides a model for the information defining both intended Learning outcomes and Work competences (LOCs). That information is important to personal, professional and vocational development, human resources and employee performance management, training and education,	<p>Technical CEN Workshop Agreement (part 1) [68]</p> <p>Evidential Python/Django source code [69]</p>

¹¹ https://help.blackboard.com/en-us/Learn/9.1_2014_04/Administrator/070_Server_Management_and_Integrations/System_Integration/Student_Information_System_%28SIS%29/030_SIS_Integration_Types/030_LIS

¹² <http://www.oracle.com/us/industries/education-and-research/056908.pdf>

whether in the workplace or in school, vocational or higher education. InLOC helps with the management and exchange of learning outcome and competence information, by defining common characteristics of learning outcomes and competences and modelling them in formats that can be shared.

Open Badges¹³ – Mozilla Open Badge Specification (Assertions)

Open Badges is an initiative by the Mozilla Foundation to help recognize and support lifelong learning through a badge ecosystem. Assertions are representations of an awarded badge, used to share information about badges that you've earned with the Backpack. With the 1.0 release of the OBI (Open Badge Infrastructure), there are two types of assertions: hosted and signed.

Technical

Assertions specification [70]

Evidential

Source code for Open Badge Infrastructure on GitHub [71]

There is also a workshop paper on Human Performance Markup Language [72], but no public technical specification is available.

See also the section “Multi-purpose Specifications”, below.

Biographical

FOAF – Friend of a Friend

FOAF is a project devoted to linking people and information using the Web. Regardless of whether information is in people's heads, in physical or digital documents, or in the form of factual data, it can be linked. FOAF integrates three kinds of network: social networks of human collaboration, friendship and association; representational networks that describe a simplified view of a cartoon universe in factual terms, and information networks that use Web-based linking to share independently published descriptions of this inter-connected world. FOAF does not compete with socially-oriented Web sites; rather it provides an approach in which different sites can tell different parts of the larger story, and by which users can retain some control over their information in a non-proprietary format.

Technical

FOAF Vocabulary Specification 0.99 [73]

Evidential

A trust-based recommender for teachers [42]

IMS LIS (Learner Information Services) Person

This document contains the IMS Global Person Management Service v2.0.1 Information Model. This service is used to exchange information about individuals including name, address, etc. The business transactions include the simple create, read, update and delete of the Person data model for a single instance. The corresponding data model

Technical

Specification v2.0.1 [74]

Evidential

See entry for IMS LIS (Learner Information Services) Outcomes Management

¹³ <http://openbadges.org/>

from the IMS Global Learner Information Package (LIP) v1.0 specification has been combined with the original data model in version 1 of the IMS Global Person Management Service specification.	
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See also the section “Multi-purpose Specifications”, below.

Contextual and Referential

ASN – Achievement Standards Network Vocabulary

The Achievement Standards Network Core RDF namespace provides URIs for vocabulary terms useful in RDFa markup and in development of application profiles in the manner defined by Dublin Core. Custom Application Profiles for competency frameworks that meet particular national or project needs can be designed using: (1) properties and classes from the ASN Core namespace, (2) locally defined sub-classes and sub-properties of the ASN terms; and (3) other RDF schemas and ontologies useful in the context of the application profile.

Technical

Class and term definitions [75]

Evidential

US educational standards in ASN form [76]

Australian national curriculum in ASN form [77]

CEF – Curriculum Exchange Format

This European Standard is applicable to the digital exchange of information about terms or concepts relating to curriculum information. This includes values to be used in metadata to describe learning resources and learner profiles. The main uses of CEF instances and related services are expected to be the provision of: controlled vocabularies; navigation structures; additional curriculum information; mappings.

Technical

European Standard [78]

Evidential

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See also: Activity Streams, xAPI, IMS LIS Person, and InLOC.

See also the section “Multi-purpose Specifications”, below.

Multi-purpose Specifications

This sub-section contains specifications that support more than one of the categories: objectives and assessment, biographical, contextual and referential, and communication. National/state dataset definitions, as used by local and national government education departments (e.g. CEDS [79] and CBDS [80]), are also typically multi-purpose and express data at the level of the individual. These are not included in this Guide because they typically model data according to local education system idiosyncrasies, and because comparison would be a considerable exercise with minimal benefits. Having said this, for a single-jurisdiction implementation, these national standards are valuable sources of guidance about information that is likely to be available, and of relatively high quality, in the IT systems of educational establishments.

Leap2A – ePortfolio Portability and Interoperability

Leap2A represents portfolio information as an Atom feed, with optional attachments. It permits exchange of three different kinds of information that are often included in portfolios: digital artefacts made or jointly made by the portfolio holder information about the portfolio holder, their abilities, achievements, experiences, activities, goals, plans and such like; things written that are not specifically about one of the things above — these may include blog posts, comments, reflections, etc.

Technical

Leap2A specification [81]

Evidential

Import/export supported in Mahara ePortfolio [82]

MOOCdb

MOOCdb is a shared data model standard for the data emanating from Massive Open Online Courses. The data model is platform agnostic and is based on some basic core actions that students take on an online learning platform. Students usually interact with the platform in four different modes: Observing, Submitting, Collaborating and giving feedback.

Technical

The MOOCdb schema [83]

Evidential

Workshop proceedings describing the development of MOOCdb [84]

OAAI (Open Academic Analytics Initiative) Dataset Format

This is the dataset documentation from the Open Academic Analytics (OAAI) Project. OAAI developed, deployed and released an open-source ecosystem for academic analytics, designed to increase student content mastery, semester-to-semester persistence and degree completion in postsecondary education.

Technical

Project technical document [85]

Evidential

Paper on OAAI in Journal of Learning Analytics [32]

PAR – Predictive Analytics Reporting Framework Data Cookbook

The PAR Framework is a non-profit multi-institutional data mining collaborative comprised of two-year, four-year, public, proprietary, traditional and progressive institutions contributing their anonymized student data and expertise to identify common factors contributing to student loss and find effective practices that measurably improve student momentum and progression in U.S. higher education.

Technical

Cookbook [86]

Evidential

The data cookbook is an operational tool for PAR.

There are a number of other resources that do not merit an entry of their own, either because the published work lacks sufficient detail, or because they describe a single implementation or research activity:

- Chatti, Dyckhoff et al [87] [88] describe the development and use of a cross-platform data model to support learning analytics, but give no technical details.
- Merceron et al [89] describe a data structure to be used across LMS platforms to express basic activity data.

- The OpenEdX Datastage [90] describes a lossless translation from the OpenEdx platform tracking logs to a relational database structure.

Other Specifications

Privacy

PMRM - Privacy Management Reference Model and Methodology

The Privacy Management Reference Model and Methodology (PMRM) addresses the reality of today's networked, interoperable capabilities, applications and devices and the complexity of managing personal information (PI) across legal, regulatory and policy environments in interconnected domains.

Technical

Privacy Management Reference Model and Methodology (PMRM) V1.0 [91]

Evidential

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Although PMRM is not an interoperability specification, it is included in the Quick Reference Guide because of the significance of the topic of privacy when building interoperable systems. OASIS is also the venue for some related work, the "Privacy by Design Documentation for Software Engineers (PbD-SE)" Technical Committee, which has recently published draft privacy governance and documentation standards for software engineers [92].

UMA – User-Managed Access

User-Managed Access (UMA) is a profile of OAuth 2.0. UMA defines how resource owners can control protected-resource access by clients operated by arbitrary requesting parties, where the resources reside on any number of resource servers, and where a centralized authorization server governs access based on resource owner policy.

Technical

User-Managed Access (UMA) Profile of OAuth 2.0 [93]

Evidential

User Managed Access (UMA) Case Studies [94]

Protocols

IMS Learning Tools Interoperability

The IMS Learning Tools Interoperability™ (LTI) specification enables the implementation of systems in which remote tools and content are integrated into a Learning Management System (LMS). Version 1.x is the next iteration of the Basic LTI specification that was released in May 2010, while version 2.x adds more sophistication to the specified interactions.

Technical

Version 1.1.1 (Final) [95]

Version 2.0 (Final) [96]

Evidential

Numerous v1 implementations certified by IMS¹⁴

Pilot use for learning analytics [21]

See also these specifications which include API description: OData, xAPI, IMS LIS Person, and IMS LIS Outcomes.

4. Glossary of Abbreviations

A note about audience: this is a relatively technical document aimed at readers with experience in software development and architecture, or development of interoperability standards, etc. This glossary is intended to assist readers who are relatively less technical in reading the document, rather than providing full definitions.

¹⁴ <http://www.imsglobal.org/cc/statuschart.cfm>

Abbreviations for specifications and standards that are described in the body of the text are not included.

API	Application Programming Interface, the means by which software components exchange data or direct processing.
CEN	the European Committee for Standardisation.
CSV	Comma Separated Values (also generalised to Character Separated Values), a simple textual representation of tabular data.
CWA	CEN Workshop Agreement, a pre-standardisation consensus document produced by a CEN Workshop, an expert-based forum.
HTTP	HyperText Transport Protocol, defines how messages between devices on the web are formatted and exchanged “on the wire”.
IEEE	the Institute of Electrical and Electronics Engineers, which is responsible for some standards.
IETF	the Internet Engineering Task Force, a long-established internet standardisation body with an open process by which people submit “Requests for Comment (RFC)” to the IETF community and select RFCs are published as de-facto standards.
IMS	short for IMS Global Learning Consortium, a membership organisation that issues consortium standards.
ISO	the International Organisation Standardization, the standards body recognised by the UN. Information technology standards are developed by ISO/IEC JTC1, a Joint Technical Committee (JTC) with the International Electrotechnical Commission (IEC).
ITS	Intelligent Tutoring System.
JSON	JavaScript Object Notation, a textual human-readable, and light-weight exchange format favoured by web developers because the data is immediately accessible to JavaScript code in a web page.
OAuth	an open standard for authorisation over the web, widely used to provide secure delegated access without disclosing passwords to third-party services (e.g. to allow an app to access your twitter account).
RDF	Resource Description Framework, a family of W3C standards for expressing information on the web in a machine-readable way. RDF is core component of the “semantic web”.
RDFa	Resource Description Framework in Attributes, a W3C standard for expressing RDF concepts in various kinds of web-native documents (typically web pages).
REST	REpresentational State Transfer, an architectural style for APIs that exploits the architecture of the web, notably the use of HTTP and URLs.

- UN/EDIFACT** United Nations/Electronic Data Interchange For Administration, Commerce and Transport, an approach to data exchange that pre-dates XML and JSON.
- URI** Uniform Resource Identifier, the means by which resources are identified on the web. In practical applications, the URIs used are actually URLs.
- URL** Uniform Resource Locator, a particular kind of URI that gives the “address” of a resource on the web. A URL is also known as a “web address”.
- W3C** the World Wide Web Consortium, the principal organisation developing standards for the web.
- XML** eXtensible Markup Language, a textual and human-readable representation of structured information. An “XML binding” defines the way conceptual data elements are represented in XML, and may be expressed in a machine-readable form known as an XML Schema using XML Schema Language.

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6. About ...

Acknowledgements

The author would like to thank Tore Hoel for contributing references to the Mendeley Group and for reviewing the first draft. Rebecca Ferguson made some helpful suggestions to improve reader-friendliness, and Brian Kelly provided me with the benefit of a thorough review on points of style and clarity.

This document was produced with funding from the European Commission Seventh Framework Programme as part of the LACE Project, grant number 619424.



About the Author

Adam works for Cetus, the Centre for Educational Technology and Interoperability Standards, at the University of Bolton, UK. He rather enjoys data wrangling and hacking about with R. He is a member of the UK Government Open Standards Board, and a member of the Information Standards Board for Education, Skills and Children's Services, and is a strong advocate of open standards and open system architecture. Adam is leading the workpackage on interoperability and data sharing.



About this document

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The LACE project brings together existing key European players in the field of learning analytics & educational data mining who are committed to build communities of practice and share emerging best practice in order to make progress towards four objectives.

- Objective 1 – Promote knowledge creation and exchange*
- Objective 2 – Increase the evidence base*
- Objective 3 – Contribute to the definition of future directions*
- Objective 4 – Build consensus on interoperability and data sharing*

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