Application and Policy Brief:

Efficient and Descriptive Learning Object Metadata: An Essential Component of K12 Instructional Reform

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An IMS Global position paper addressing standardization of a Learning Object metadata vocabulary and federated search process consistent with the instructional requirements of the Common Core

Organizations, standards and instructional requirements germane to the metadata standardization dialog

As U.S. state departments of education and K12 school districts continue to confront the details of RTTT (Race to the Top) and CCSS (Common Core State Standards), the potential merits of both initiatives have been argued for in the IMS Global publication, “Evolving Personalized Learning: Maximizing K12 Expenditures to Support Instructional Reform” (http://www.imsglobal.org/i3lc/201211-EvolvingK12PersonalizedLearning-FNL.pdf), but the critical factors for achieving the promise of the CCSS as well as the costs for initial deployment and sustainability need to be better understood.

Design and delivery of a sustained and immersive learning context in which students can master and understand the importance of academic skills and apply those skills to solve cognitively complex real world problems is time consuming and arduous. The capacity to provide teachers with intuitive access to an adequate quantity and comprehensive range of learning resources appropriate to this academically rigorous and relevant learning environments is among the most challenging of the CCSS ecosystem functions to establish and maintain. Failure to automate and sustain the more labor intensive and repetitive CCSS learning environment design and delivery tasks (particularly Learning Object location and assignment as well as differentiation of instruction and delivery and analysis of formative assessment) will render this evolved instructional approach more than the teacher practitioner can be expected to manage.

K12 teachers and administrators that are aware of the ongoing Learning Object metadata debate likely consider that dialog arcane or marginally useful regarding CCSS instructional design and delivery tasks. However, the effectiveness and efficiency of the Learning Object searches that teachers will conduct within their district's LMS/IMS/educational ecosystem will be directly impacted by the Learning Object metadata standards agreed upon by educational software providers (SEA, LEA, commercial, OER, public). The current and disparate nature of various efforts to standardize Learning Object metadata and discovery is symptomatic of a larger dichotomy and need for cooperation among the various educational technology and curriculum standards organizations and their initiatives (IMS, SLC, SIF, RTTT, Learning Registry, OAI, W3C, PARCC, SBAC, ASCD). See Appendix 1 containing a comprehensive glossary for use with this paper.

As a major contributor and arbiter of widely adopted standards facilitating application and resource interoperability in K12 and Higher Ed (LTI, LIS, QTI, APIP and Common Cartridge), IMS Global is vested and obliged to participate in efforts to refine industry Learning Object metadata vocabularies and harvesting techniques. This effort and dialog is particularly poignant for K12 given the profound and disruptive systemic changes that will be required by a high fidelity implementation of the CCSS. IMS Global has recognized and addressed the urgency within K12 for observance and adoption of interoperability standards to assist in delivery and maintenance of CCSS rigor and relevance through creation of the Instructional Innovation and Improvement Initiative (I3LC). I3LC currently serves as a national K12 committee and forum to air and assist in resolving K12 educational technology interoperability issues (http://www.imsglobal.org/i3lc.html).

From a technical perspective, the metadata and discovery dialog must consider work that has already occurred regarding metadata harvesting standards and the extent to which those standards have already been adopted and deployed within the current landscape of products and services (and the degree to which it is advisable to depart from rather than refine these standards). This includes harvesting methods making use of existing Learning Object vocabularies and Web service stacks to define, serialize, transport, parse, bind, and deliver information related to Learning Objects used in the instructional and assessment processes. From a pedagogical perspective, the vocabularies and service stacks chosen by educational software providers have significant implications regarding their ability to deliver the evolved harvest and search functions required by administrators and teachers to implement the CCSS. Therefore, care should be taken to ensure congruence between the technical capabilities of the eventually chosen vocabularies and service stacks and the instructional demands of the Common Core. This point will be addressed in greater detail in later sections.

See Diagram 1 providing a high level explanation of existing harvesting scenarios that should be included in the Learning Object metadata vocabulary and harvesting dialog and illustrating what a temporary inclusion of all harvesting approaches within LMS/IMS architecture would entail.

Technical review of deployed and proposed Learning Object metadata vocabularies, vocabulary encoding, and harvesting approaches

It could be argued that OAI-PMH registry nodes lie at the established end of the spectrum of harvesting stacks (employing RESTFUL Web Service queries of its content servers that store metadata and Learning Objects in separate files) and the SLC/LRMI/Schema.org nodes lie at the emerging end (employing Web Crawler extraction of machine readable metadata embedded within Learning Objects). The Learning Registry appears to lie somewhere in the middle of that spectrum (or it may be perceived as a bridge between the two approaches) in that it provides nodes that ingest any metadata vocabulary expressed in any data structure syntax from any tool or resource provider and the nodes are harvestable using a RESTFUL or SLC API approach.

Metadata Server Types and Associated Harvesting Scenarios

1 – Public, Private, OER, SEA/LEA Content Servers accepting OAI-like harvest of their metadata (through Rest /JSON/XML/ Dublin Core /IEEE LOM), Also use RESTFUL push (and SLC APIs and applications) of same metadata and announcements to Learning Registry, Learning Objects and Metadata stored separately

2 - Public, Private, OER, SEA/LEA Content Servers storing learning objects with embedded LRMI Microdata/RDFa metadata, Accept Search Engine Crawl and indexing of their LRMI Microdata/RDFa metadata (Google, Yahoo, etc.), Search Engine Index Servers use a RESTFUL or SLC API push of indexed metadata and announcements to Learning Registry

3 - Search Engine Index Servers (Google, Yahoo, etc.) use Crawl of Microdata/RDFa on SLC compatible Public, Private, OER, SEA/LEA Content Servers to harvest and expose LRMI/Schema.org metadata embedded in Learning Objects, Allows discovery of LRMI metadata through browser search engine, Also use RESTFUL or SLC API push of indexed Metadata (possibly converted to JSON) to Learning Registry, Only metadata stored

4 - SLC Learning Registry Index node accepts OAI-like harvests (Rest/JSON/XML /Dublin Core/IEEE LOM) and SLC APIs to discover metadata pushed to the Learning Registry, Only metadata and Learning Registry Announcements stored

5 - Learning Registry Nodes accept OAI-like harvests of their metadata (Rest/JSON/XML/Dublin Core/IEEE LOM), also accepts pushed metadata from Public, Private, OER, SEA/LEA Content Servers via REST and SLC APIs and applications, Only metadata and Learning Registry Announcements stored

6 - Proprietary servers (local and/or cloud-based) with content loading, access and harvesting/search processes arranged individually with clients as services and resources are purchased, Also possible to use RESTFUL push of metadata and announcements to Learning Registry, Currently most common scenario, Learning Objects and Metadata stored separately

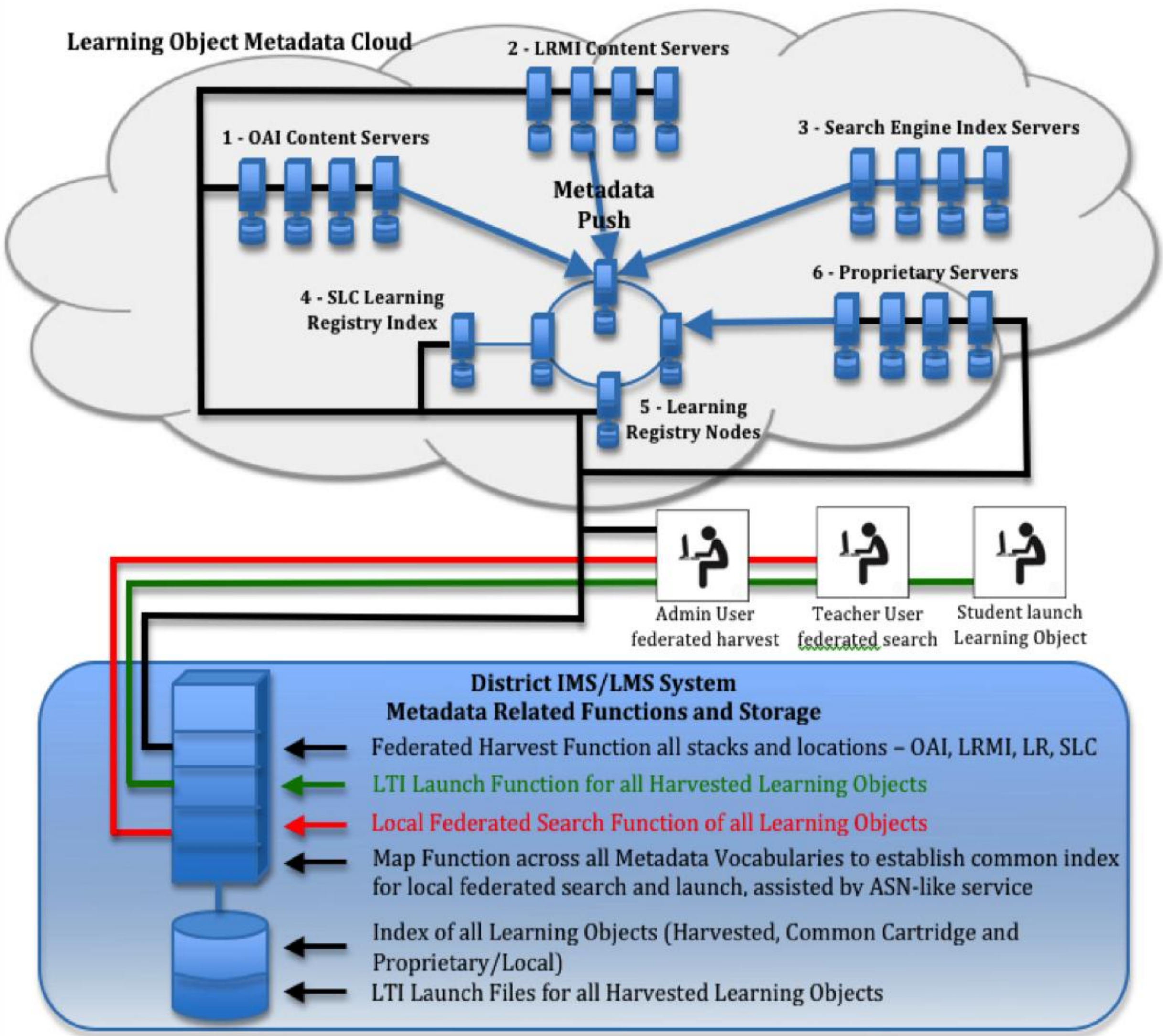


Diagram I - High level explanation of various metadata harvesting scenarios

Proposed Metadata Vocabulary Paradigm Shift

The Shared Learning Infrastructure (SLI), which is being hosted by the Shared Learning Collaborative (SLC) at http://www.slcedu.org/, is proposing a paradigm shift in the approach to Learning Object metadata vocabulary exposure and Learning Object discovery. Additionally, SLC is actively creating a series of specification documents that extend well beyond the Learning Object metadata and discovery standardization dialog. These specification documents contain language for use in RFPs to guide development and procurement of SLC application ecosystem components. These components are compliant LMS/IMS and Educational Ecosystem applications that will integrate with SLC technologies (including the SLC Data Store, SLC portal services, the Learning Registry and Learning Registry Index Node Services). Depending on the SCL ecosystem component being addressed, each specification document includes guidance regarding: a broad description of the SLC technology upon which the RFP requirements are based; approaches for integrating with the specific core SLI technology; potential configurability options; and identification of applicable standards and technologies and specification of their applicability to the component described.

Ostensibly, a combination of public and private software developer compliance with SLC specification documents and use of SLC provided APIs to enable interoperability of SLC services and systems across third party information systems, learning applications, and content will result in creation of a contiguous national educational data ecosystem. This ecosystem would aggregate SEA/LEA data within an SLC maintained Data Store. The stored data types would include: student enrollment, achievement and demographic data; teacher and staff data; and educational organizational, directory, and schedule data for use in services delivered in SLC portals. The SLC portals will deliver identity and access, academic tracking and reporting, and CCSS Learning Map services. SLC Learning Object metadata vocabulary and harvesting standardization is to be incorporated and interfaced with the SLC national educational ecosystem through use of SLC Portal identity and access and academic tracking and reporting services. This interface will inform and facilitate digital rights compliant use of appropriately assigned Learning Objects discovered through the SLC Learning Registry Index Nodes (extension of the Learning Registry). The LRMI and Schema.org initiatives will provide the metadata vocabulary used to describe the Learning Objects indexed in the Learning Registry and the SLC Learning Registry Index Nodes. Multiple vendors are currently receiving SLI/SLC contracts to work on the project, but in the long term the software is to be owned and managed by an independent nonprofit.

See Diagram 2, which is an excerpt from the SLC Project Document " Learning Registry Index Solution – RFP Guidance" January 31, 2012 (http://slcedu.org/sites/default/files/downloads/SLC_Learning_Registry_Index_Solution_RFP_Guidance_0.pdf) for a high level view of the SLC ecosystem. This document also provides additional detail regarding the cooperative and reciprocal nature of the relationship among SLC, LRMI, Schema.org, and the Learning Registry initiatives. More detail regarding the components and processes associated with the Learning Registry is available in the Creative

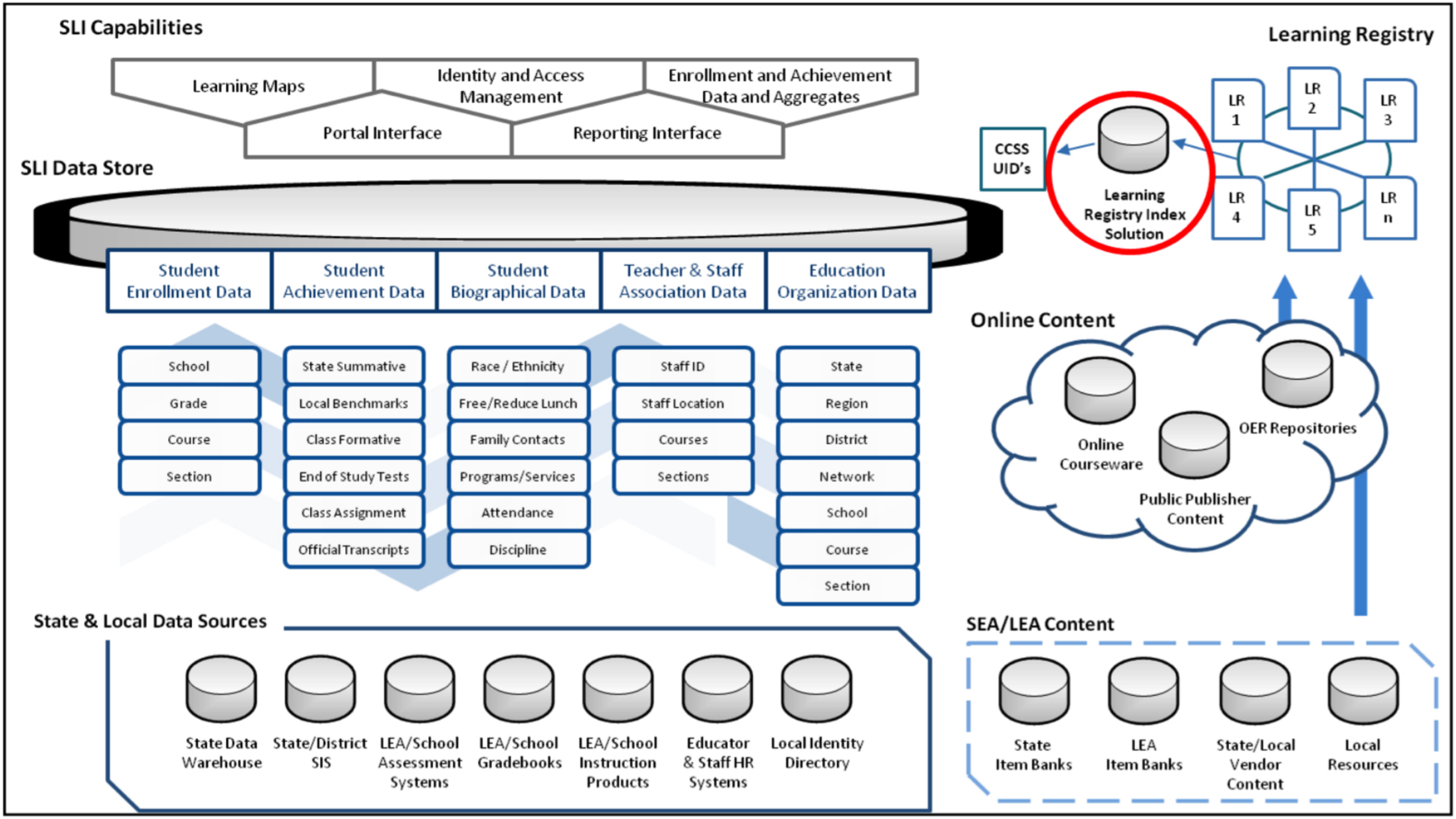


Diagram 2 – High-level view of the SLC ecosystem

Commons Document “The Learning Registry: Sharing Federal Learning Resources” 2011 (http://wiki.creativecommons.org/images/d/d6/The_Learning_Registry_-_Sharing_Federal_Resources.pdf).

Barriers to implementation of Metadata Vocabulary proposals

This comprehensive and laudable SLC effort is somewhat redundant with regard to established Learning Object discovery stacks already being employed in K12 and higher Ed applications. It is ill timed regarding SEA/LEA efforts that are already specified and underway using RTTT specifications and funding to establish educational ecosystems that closely resemble the proposed SLC Data Store and Portal Capabilities. The Florida Department of Education RTTT Local Instructional Improvement System specification (which is legislatively and statutorily mandated functionality for all K12 districts) is a case in point. This document can be viewed at: http://www.fldoe.org/ARRA/LIISMS.asp using the LIIS Minimum Standards link.

Review of this 800-line state ecosystem specification (driven by RTTT funding language) leaves little of the SLC ecosystem specification unaddressed, but there is no directive for use of SLC or any interoperability standards specifications. Florida K12 districts are working rapidly to deliver the specified RTTT functionalities within the RTTT funding period (with some cognizance and limited use of QTI, LTI, and APIP, but primarily employing proprietary or internally developed solutions). Any voluntary incorporation of interoperability standards within their educational ecosystems that has not already occurred will have to be negotiated by districts with their participating vendors as contracts are executed and/or renegotiated at expiration. The proverbial “ecosystem cow” has already left the barn in many SEA/LEA instances.

Interim solutions and potential paths to an efficient and descriptive Learning Object Metadata Vocabulary

At this point, continued cooperative refinement and implementation of interoperating file format, exchange, and launch standards (exemplified by the previously referenced and deployed IMS standards) may be the more expedient path to achievement of a de facto national educational ecosystem. SLC documentation mentions a transition period for their proposed standards and systems. The details of this transition are still emerging, but it can be assumed that some of the currently defined and deployed interoperability standards would remain relevant and others would be obviated. The ultimate traction that the various components of SLC will attain is still unclear; however, the public and private sector funding and sanction that SLC is receiving warrants serious engagement and consideration of its ideas, particularly in the Learning Object metadata and discovery dialog.

Certainly the most pressing and immediately useful of the proposed SLC ecosystem components are those that involve location and delivery of an appropriate range of Learning Objects to teachers for construction of CCSS learning environments. LRMI and Schema.org are defining the Learning Object metadata vocabulary supported by SLC. The SLC approach to encoding (data structure syntax) of the LRMI/Schema.org vocabulary and exposing of that data for discovery is through use of HTML 5 capabilities to embed machine-readable metadata within Learning Objects. Specifically, RDFa and Microdata are the sanctioned encoding methods with the less complex Microdata enjoying more enthusiastic support (although use of other vocabularies and encoding methods are accepted by SLC for harvesting and pushing metadata to the Learning Registry and SLC Learning Registry Index).

The Learning Registry initiative/nodes have the potential to act as a translator among the range of Learning Object metadata vocabularies, data structure syntaxes and service protocol approaches and could serve as a harvest/search standard within compliant and non-compliant SLC IMS/LMS applications (LR ingestion criteria is very accommodating in that any schema or metadata type is permitted: IEEE LOM, METS, Dublin Core, Schema.org and the resource data may be encoded in any form, e.g., JSON, CSV, XML, RDFa, Microdata, Binary, etc.).

Establishing consensus among the various Learning Object metadata vocabularies presents the greatest challenge for use of the Learning Registry or any other standardized approach/system for discovery and efficient ingestion of Learning Objects. Although the extensibility of the various encoding methods (data structure syntaxes) and flexibility of service protocols have an impact on the practitioner's ability to locate appropriate learning resources, if the metadata vocabulary is incapable of capturing the level of learning resource descriptive detail required in a high fidelity implementation of CCSS then the academic rigor and sustained instructional context required by CCSS will be very challenging to attain.

Given the circumstances and capabilities detailed above, the Learning Registry appears more likely to gain national traction as a stand-alone initiative as opposed to the larger more ambitious ecosystem as a whole; however, the simplicity of LRMI/Schema.org suggestions regarding the limited number of metadata terms included in their vocabulary and the limited extensibility of the associated vocabulary schema are causes for concern. The specificity that can be included in a Learning Object discovery process is at stake.

Restful and Web crawler discovery of Learning Object metadata using XML, RDFa, Microdata (and to a lesser extent JSON object classes) encoding are capable of defining highly detailed Learning Object characteristics when combined with a Learning Object vocabulary and schema that is extensible and maps easily to an extensible encoding syntax tree. IEEE LOM and Dublin Qualified are very extensible metadata vocabularies that when combined with XML or JSON encoding offer a highly specified discovery scenario. RDFa and Microdata encoding are also capable of great specificity in the discover process if the extensibility of the LRMI/Schema.org vocabulary were expanded appropriately.

The SLC Learning Object vocabulary and discovery stack definitely offer some positive changes in approach (convenience of having metadata embedded in Learning Objects; the potential to use Web browser search engines to discover Learning Object metadata that has been harvested by crawlers from Learning Objects/Web pages; employment of the Learning Registry and the Learning Registry Index to ingest and expose all vocabularies and encoding stacks for use by

IMS/LMS and educational ecosystem applications). However, for some period and perhaps indefinitely (at least until a standard metadata vocabulary and harvesting stack is established) it is conceivable that standard IMS/LMS architecture will have to include the capacity to execute each of the harvesting approaches represented in Diagram I.

The inevitability of this hybrid approach is particularly obvious when the quantity and diverse nature of the Learning Objects necessary to deliver the CCSS with fidelity are considered and the diversity of the server types in which these resources reside (K12 districts will have to take advantage of all Learning Objects sources just to be able to afford a high fidelity CCSS deployment). Universal adoption of any vocabulary or harvesting stack among these diverse providers (Public, Private, OER, SEA/LEA, etc.) will be gradual at best. This situation will require IMS/LMS capacity to map the various metadata vocabularies to one another in order to index harvested Learning Objects in a manner that will allow a federated search of all locally hosted Learning Objects and/or LTI launch files regardless of the vocabulary or data structure syntax used to locate them when initially acquired. Creation of the attendant LTI launch files that facilitate student interaction with prescribed Learning Objects should be a part of any standardized IMS/LMS harvesting process. Hopefully the necessity of accommodating all metadata vocabulary and harvesting stacks within districts' IMS/LMS/ecosystems will be a temporary but necessary expense and inefficiency.

K12 institutional and pedagogical implications resulting from the choice of a standardized Learning Object metadata vocabulary

A distinction should be made between a federated harvest and a federated search and what is driving the need for both processes to be present in IMS/LMS functionality. Teachers should not be required to routinely conduct federated harvests/searches for Learning Objects that span all of a K12 institution's available content provider servers (local and cloud-based). Continuous harvest (location/staging) of an appropriate quantity and range of Learning Objects within a district IMS/LMS for use in construction and delivery of a CSSS learning environment should be automated (to the extent possible) and orchestrated by district administrators. These administrators should understand CCSS instructional requirements and be able to apply that pedagogical knowledge when harvesting Learning Objects for use in both highly contextualized as well direct academic instruction. Teacher use of an efficient and localized federated search of previously harvested and indexed Learning Objects (facilitated by the above referenced continuous and automated federated harvest) is much preferable to requiring teachers to conduct time-consuming open-ended searches. In fact, the process for location and prescription of individualized remedial and enrichment resources should be an automated and federated search of previously harvested/ingested and locally hosted metadata and Learning Objects that is informed by a continuous flow of formative data from the IMS/LMS analytics engine (see previous IMS Global publication, "Evolving Personalized Learning: Maximizing K12 Expenditures to Support Instructional Reform" http://www.imsglobal.org/i3lc/201211-EvolvingK12PersonalizedLearning-FNL.pdf, pages 2 and 7).

Unfortunately the specific and nuanced nature of the search requirements of a CCSS instructional environment are being obscured by the increasing amount of literature describing the CCSS as merely prescriptive of a competency–based instructional approach. This designation appears to constitute either a calculated retreat from the rigorous nature of the CCSS instructional environment (both technically and pedagogically) or an over simplification of CCSS resulting from a less than comprehensive analysis of the highly contextual nature of the standards and the accompanying mandate for a profound change in instructional approach. Both situations can lead to use of a long series of virtualized "real world" Learning Objects/experiences aligned with a scope and sequence to deliver academic competencies (as suggested by SLC Learning Maps). These interpretations of the CCSS do not provide the same immersive and sustained thematically driven learning environment necessary to provide students with opportunities to collaboratively apply academic competencies at high cognitive levels to solve or propose solutions to "real world" problems (as prescribed by the CCSS to prepare students for college and career work environments). This development is confining the metadata harvesting dialog in a way that includes only a portion of the digital learning resource delivery requirements of a much richer and more relevant CCSS learning environment (constructivism is the most succinct descriptor of the pedagogical theory behind the CCSS).

For example, a search or harvest of a Learning Object based on metadata similar to that proposed in the LRMI/Schema.org vocabulary is adequate if the corresponding launch and student interaction with that object simply tracks embedded and isolated competency mastery outcomes and associates those outcomes with the appropriate teacher and class. However, if a district also requires harvested Learning Object capabilities and use to be aligned with a student's demographic profile, learning style, reading level, current thematic projects and assignments, personal interests, exceptionality, etc. then more metadata about the Learning Object is required (as well as specificity in the harvest and search process to locate the appropriate Learning Objects). This situation also applies to a teacher's intended use of Learning Objects in a constructivist learning environment (regarding cognitive complexity, semantic level/density, taxonomy, instructional methods/pedagogy, and applicability to thematic topic or sustained instructional context).

The comprehensiveness of the metadata vocabulary, the extensibility of the data structure syntax, and the flexibility of the parse and bind processes to pass highly specific data to resource location programming logic are all relevant topics in the Learning Object metadata vocabulary and federated harvesting discourse. IEEE LOM and Dublin Qualified metadata vocabularies and their vocabulary schemas (or some consensus variant) appear suited to attainment of these capabilities. See Diagram 3 for a comparison of the relative specificity that is possible within Dublin Qualified, IEEE LOM and LRMI/Schema.org. A detailed explanation of each of these Metadata Vocabularies can be found at: http://dublincore.org/documents/2012/06/14/dcmi-terms/?v=terms#, http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf, and http://www.lrmi.net/the-specification.

The level of engagement and effort required of teachers to deliver a CCSS learning environment will not allow for extraneous expenditures of energy resulting from an inability to use located Learning Objects due to circumstances such as a making required payment or entering a contractual agreement, which teachers are typically not authorized to do. Metadata harvests and Learning Object location, ingestion or acquisition are best conducted by administrators with the pedagogical, fiscal, and technical authority and knowledge to locate an array of Learning Objects appropriate to a district's curricular requirements (particularly when large banks of objects are involved). To the extent possible, any teacher conducted manual search for learning resources should be run against previously harvested, vetted, indexed and locally housed metadata. If a Learning Object is housed outside the district firewall there should be associated metadata and/or IMS/LMS logic to determine if the Learning Object should be cached to ensure adequate responsiveness.

Any attempt to achieve technical expedience through abbreviated or attempted succinctness in Learning Object metadata vocabularies will not provide impetus for content providers to produce learning resources of sufficient complexity and relevance for creation of immersive and extended learning environments consistent with the CCSS pedagogical philosophy. Nor will it provide the technical capacity to accomplish highly granular queries by a restful presentation of metadata to a content server or return an adequate variety/list of resources via a browser search of indexed Learning Object pages with embedded machine-readable metadata.

SLC Learning Map implications and inadequacies

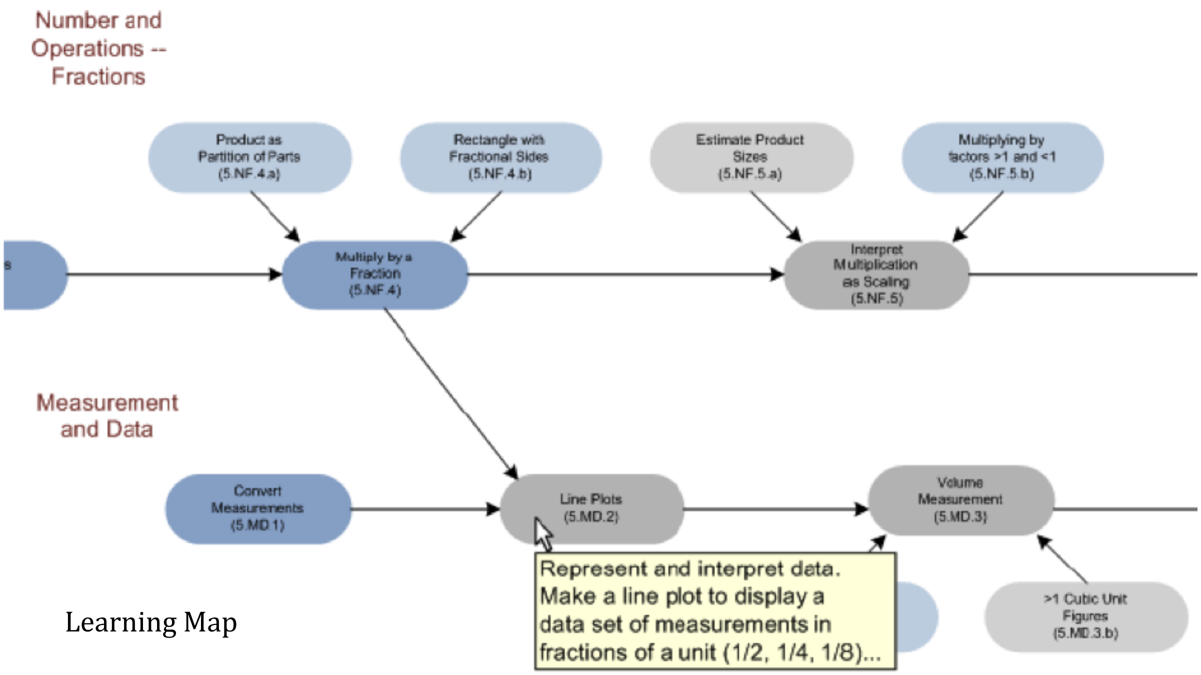
Academic competencies can be taught through student exposure to a series of contextually disconnected digital Learning Objects (such as those objects that would be located using an abbreviated metadata vocabulary), although experience to date indicates that actual attainment of mastery would occur most frequently among the more autodidactic segments of the K12 demograph. However, to productively engage the large and growing disenfranchised portion of the K12 demograph, a high fidelity interpretation of the curricular demands of the CCSS is necessary. This instructional environment should be literal (engaging/impacting communities outside the classroom through simulation or actual interaction), social (frequent opportunities for collaborative effort), academically rigorous (requires academic mastery and cognitively complex application) and technically leveraged (not exclusively virtualized). This evolved instructional environment can only be attained through sustained periods of thematic instruction that will require an appropriately comprehensive approach to Learning Object harvest/search using an appropriately comprehensive Learning Object metadata vocabulary.

Metadata Vocabulary	Terms available for describing a Learning Object, external vocabularies and descriptive schemes may be employed to extend the semantic function/interoperability of a Learning Object description
Dublin Core Elements	Contributor, Coverage, Creator, Date, Description, Format, Identifier, Language, Publisher, Relation, Rights, Source, Subject, Title, Type
Dublin Terms Qualifying Core Elements	abstract, accessRights, accuralMethod, accrualPeriodicity, accrualPolicy, alternative, audience, available, bibiliographicCitation, conformsTo, contributor, coverage, created, creator, extent, format, hasFormat, hasPart, hasVersion, identifier, instructionalMethod, isFormatof, isPartof, is ReferencedBy, isReplacedBy, isRequiredBy, issued, isVersionOf, language, license, mediator, medium, modified, provenance, publisher, references, relation, replaces, requires, rights, rightsHolder, source, spatial, tableOfContents, temporal, title, type, valid
Dublin Classes of Resource types	Agent , AgentClass , BibliographicResource , FileFormat , Frequency , Jurisdiction , LicenseDocument , LinguisticSystem , Location , LocationPeriodOrJurisdiction , MediaType ,MediaTypeOrExtent , MethodOfAccrual , MethodOfInstruction , PeriodOfTime , PhysicalMedium , PhysicalResource , Policy , ProvenanceStatement , RightsStatement , SizeOrDuration, Standard
IEEE LOM General Categories	General, Life cycle, Meta-metadata, Technical, Educational, Rights, Relation, Annotation, Classification
IEEE LOM Aggregated and Simple Elements Describing Categories	aggregationlevel, catalog, catalogentry, context, contribute, copyrightandotherrestrictions, cost, coverage, date, description, difficulty, duration, entity, entry, format, id, identifier, installationremarks, intendedenduserrole, interactivitylevel, interactivitytype, keyword, kind, language, language, learningresourcetype, location, maximumversion, metadatascheme, minimumversion, name, otherplatformrequirements, person, purpose, requirement, resource, role, semanticdensity, size, source, status, structure, taxon, taxonpath, title, type, typicalagerange, typicallearningtime, version
LRMI Education Specific Schema.org Properties	educationalAlignment, educationalUse, intendedEndUserRole, interactivityType, learningResourceType, timeRequired, typicalAgeRange
LRMI Properties with no Schema.org equivalent	isBasedOnUrl, useRightsUrl
LRMI Properties Already in Schema.org	about, author, dateCreated, inLanguage, mediaType, name, publisher

Diagram 3 – Relative specificity that is possible within the Dublin Qualified, IEEE LOM and LRMI/Schema.org Metadata Vocabularies

The SLC Learning Maps and utilities are symptomatic of and extend the issues associated with over simplification of the CCSS and the learning resources required to create and sustain an immersive and relevant learning environment. The SLC Map Maker application facilitates arrangement of learning objectives within a selected potion of the CCSS as nodes on a Learning Map (concept map or diagram) that illustrates the relationship among the learning objectives as well as a learning path through them. The SLC Visualization application can then use the Learning Map to create a Standards Navigator document with each learning objective on the Map resulting in a cited standard in the document. Each cited standard in the Standards Navigator document can then be used to locate supporting educational content through a search of the SLC Learning Registry Index. See Diagram 4, which is an excerpt from the SLC Project Document " Learning Standard Alignment in the SLC Technology: A Whitepaper" December 19, 2012 (http://slcedu.org/sites/default/files/downloads/SLC_Learning_Standards_Alignment_Whitepaper_v1.2.pdf), providing an example of a SLC Learning Map and a Standards Navigator Document.

Although the proposed Learning Maps and Standards Navigator Documents do iterate and facilitate location of Learning Objects that address mastery of the CCSS, as currently conceived these Maps and Documents do little to assist teachers in the creation of sustained social/career learning environments that offer consistent opportunities for students to collaboratively apply academic skills at high cognitive levels to solve problems of significance to them and society (as opposed to requiring only reiteration or formulaic application). Any isolated and discrete periods of social or career context that the recommended Learning Map Learning Objects create are not accompanied by any suggestions for delivery of these Learning Objects within a overarching and sustained instructional theme that reveal the practicality and desirability of attaining mastery of abstract academic skills. Nor will Learning Objects that employ brief and unrelated instructional contexts to facilitate academic mastery stimulate requisite CCSS K12 reform involving institutional acceptance of interdisciplinary teaching teams to collaboratively identify and appropriately incorporate all grade level academic skills within a year long series of interdisciplinary units.



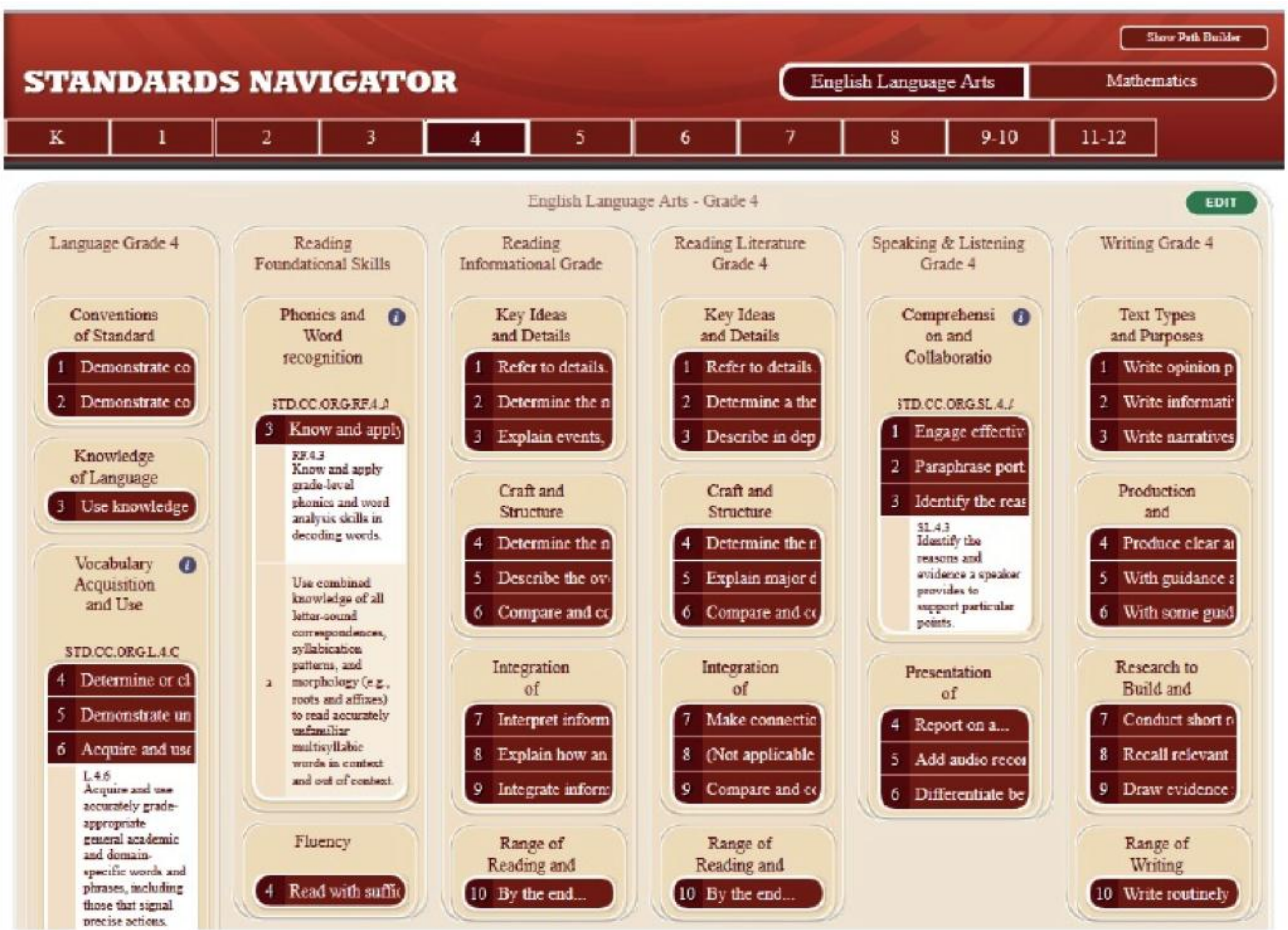


Diagram 4 – Providing examples of a SLC Learning Map and a SLC Standards Navigator Document

Consider the excerpt below from the previously cited IMS Global publication, "Evolving Personalized Learning: Maximizing K12 Expenditures to Support Instructional Reform" (http://www.imsglobal.org/i3lc/201211-EvolvingK12PersonalizedLearning-FNL.pdf).

"…project-based units do not always follow the linear approach to skills mastery stipulated in traditional scope and sequence regimens nor can they make use of their isolated approach to delivery of instruction and teaching assignments. Without permanently assigned teaching teams having representation from all core academic disciplines, the required pedagogically sound sequencing of academic skills within contexts appropriate to project-based topics would be difficult to achieve (and could result in clumsy or ineffective academic skills instruction). Relevance without academic rigor could result…"

Conclusions

If successful CCSS deployment will be declared by attainment of a learning environment that employs a series of unrelated virtualized learning experiences dictated by linear scope and sequence documents for mastery of academic competencies then K12 will not have evolved beyond a high stakes testing environment. Technology decisions (including the specificity of search techniques that will be delivered to teachers) should be driven by the most pedagogically congruent interpretation of the CCSS, which stipulates opportunities for students to: engage in metacognitive processes to guide construction of responses and solutions to problems posed in project based units of instruction; deconstruct and construct knowledge based on experiences applying newly acquired academic competencies in pragmatic situations; and to redefine self concept and capabilities through relevant and successful application of appropriate combinations of academic competencies to solve problems.

Given the sophistication of this learning environment, agreement on a metadata vocabulary and data structure syntax based on the lowest common denominator of competing vocabularies and syntaxes may not be the most efficacious approach to this standards problem. A combination of pedagogical and technological experts should be driving a carefully considered Learning Object metadata-harvesting dialog. Standards organizations such as IMS Global, SLC/Learning Registry, and ASCD are the most obvious parties to create the forums for this important dialog.

Although an IMS sanctioned recommendation for a specific set of K12 Learning Object metadata terms is not advisable at this point, a few preliminary conclusions are possible based on the assertions in this position paper.

(1) The web-based searching alternatives LRMI, SLC, Learning Registry are not fully supportive of the need to evolve pedagogy based on the CCSS .

(2) There needs to be a 2-stage approach to making content available within a school/district – it is first vetted by curriculum people and then "installed" to be readily at hand for teachers – and responsive to the automated search at a high degree of accuracy.

(3) The first two imply greater involvement of curriculum leaders stepping to the fore in terms of how to select instructionally sound curriculum and IT leaders stepping to the fore to make sure the IT infrastructure supports the rapid and seamless searching required by a high fidelity CCSS instructional environment.

Appendix 1 Glossary

The definitions provided in this glossary are intended to assist the reader with a general understanding of the acronyms and terms used in this position paper and thereby render the ideas and assertions made in the paper more lucid. The definitions are neither scholarly nor comprehensive and include paraphrased and verbatim excerpts from open Web-based sources (such as Wikipedia, World Wide Web Consortium, Shared Learning Collaborative, IMS Global, etc.). Exhaustive annotation/attribution within each definition would have lengthened the glossary significantly and rendered it difficult to use. The reader is encouraged to conduct additional research on these terms to gain further insight into the ideas and assertions made in the paper.

Term	**Definitions (technical definitions are provided in the context of this position paper)**
APIP	The Accessible Portable Item Protocol (APIP) standard provides assessment programs and question item developers with a data model for standardizing the interchange file format for digital test items. When applied properly, the APIP standard accomplishes two important goals. First, the standard allows digital Tests and Items to be ported across APIP compliant test item banks. Second, it provides a test delivery interface with all the information and resources required to make a Test and an Item accessible for students with a variety of disabilities and special needs.
ASCD	ASCD (formerly the Association for Supervision and Curriculum Development) is the global leader in developing and delivering innovative programs, products, and services that empower educators to support the success of each learner. Comprising 140,000 members—superintendents, principals, teachers, professors, and advocates from more than 134 countries—the ASCD community also includes 56 affiliate organizations. The nonprofit's diverse, nonpartisan membership is its greatest strength, projecting a powerful, unified voice to decision makers around the world.
Bind	Process that assigns the parsed Learning Object metadata values, transmitted in a discovery/harvest service request, to variables in a service’s programming logic to guide queries of the Learning Object metadata database (See Parse and Data Structure Syntax/encode).
CCSS	The Common Core State Standards (CCSS) provide consistent clear academic standards designed to be robust and relevant to the real world, reflecting the knowledge and skills that our students will require for success in college and careers ((developed and adopted by the states and working in conjunction with RTTT funding). The CCSS were developed by the National Governors Association and the Council of Chief State School Officers with funds from the Bill and Melinda Gates Foundation, the Charles Stewart Mott Foundation and others.
Common Cartridge	Common Cartridge defines an interchange format for learning content, able to run on any compliant LMS platform. Common Cartridge provides a greater choice of content by enabling the use of collections

	of learning resources of various types and sources by establishing course cartridge native formats endorsed by educational publishers and supporting a wide variety of established content formats. This eliminates platform lock-in and enables instructors to assemble lesson plans of various resources and publish those as reusable packages that are easy to create, share, and improve.
Constructivist learning	Constructivism is a [theory of learning] and an approach to [education] that emphasizes and enables the ways that people create meaning of the world through a series of changing individual constructs. Simply stated, it is a learning process which allows a student to experience an environment first-hand, thereby providing reliable, trust-worthy knowledge. The student is required to act upon the environment to both acquire and test new knowledge (consistent with the CCSS).
Data Structure Syntax/encode	The file format (XML, JSON, RDFa, etc.) into which the Learning Object metadata of a specific metadata instance is converted for transport and interaction with a discovery or harvest service (see "Serialize" for further detail)
Dublin Qualified Metadata Vocabulary	The Dublin Metadata Element Set is a vocabulary of fifteen properties for use in resource description. The name "Dublin" is due to its origin at a 1995 invitational workshop in Dublin, Ohio; "core" because its elements are broad and generic, usable for describing a wide range of resources. The fifteen element "Dublin Core" described in this standard is part of a larger set of metadata vocabularies and technical specifications maintained by the Dublin Core Metadata Initiative (DCMI). The full/qualified set of vocabularies, DCMI Metadata Terms [DCMI-TERMS], also includes sets of resource classes, vocabulary encoding schemes, and syntax encoding schemes. A memorandum of understanding exists between Dublin and IEEE LOM regarding an integrated use of their respective vocabularies. The IEEE LOM vocabulary scheme is considered hierarchical and contextual versus the Dublin Qualified vocabulary scheme being more linear and discrete with regard to the relationship among their vocabulary terms.
Educational Ecosystem	The aggregated technology systems, services, and resources deployed by a district to serve its users
IEEE LOM Metadata Vocabulary	The IEEE LOM metadata terms facilitate search, evaluation, acquisition, and use of learning objects by learners or instructors or automated software processes. This vocabulary also facilitates the sharing and exchange of learning objects, by enabling the development of catalogs and inventories while taking into account the diversity of cultural and lingual contexts in which the learning objects and their metadata are reused. A memorandum of understanding exists between Dublin and IEEE LOM regarding an integrated use of their respective vocabularies.
IMS	An Instructional Management System (IMS) combines curriculum, assessment, instructional practice tools, and student data for educators and administrators into an online system. An IMS should facilitate easy educator management and sharing of lesson plans, improve their use of

	formative assessment, provide access to a guaranteed and viable curriculum, and assist in creation and sharing of academic and behavioral intervention plans. Unlike an LMS, an IMS does not provide for delivery of appropriate instructional resources directly to an individual student interface.
IMS Global	The IMS Global Learning Consortium (IMS GLC) is a global, nonprofit, member organization that strives to enable the growth and impact of learning technology in the education and corporate learning sectors worldwide. IMS GLC members provide leadership in shaping and growing the learning industry through community development of interoperability and adoption practice standards and recognition of the return on investment from learning and educational technology.
JSON	JSON or JavaScript Object Notation, is a text-based open standard designed for human-readable data interchange. It is derived from the JavaScript scripting language for representing simple data structures and associative arrays, called objects. Despite its relationship to JavaScript, it is language-independent, with parsers available for many programming languages. The JSON format is often used for serializing and transmitting structured data over a network connection (such as Learning Object metadata). It is used primarily to transmit data between a server and web application, serving as a less extensible alternative to XML.
Knowledge Construction Deconstruction	Constructivist learning theory, from which project-based and authentic learning environments ultimately derive their validity, involves students comparing new experience with knowledge constructed from previous experience, resulting in the reinforcing or adaptation of that knowledge. Social interactions within the learning environment are an essential part of this experience and contribute fundamentally to individual knowledge construction.
Learning Object	A collection of content, practice, and assessment components designed to address a single learning objective. Learning objects offer a conceptualization of curriculum or lesson construction that employs small, self-contained, re-usable units of learning that typically have a number of different components, which range from descriptive data to information about rights and educational level. Learning object design raises issues of portability, and of the object's relation to a broader curriculum and learning management system. A key Learning Object issue is the use/requirement of consistent adequately descriptive metadata.
Learning Registry	The Learning Registry is a joint project of the US Department of Defense and US Department of Education that provides an infrastructure that enables instructors, teachers, trainees and students to discover and use the many good learning resources (both primary source materials and content explicitly created to support learning) from government, institutions and the commercial sector. The Learning Registry is a resource distribution network with open APIs to expose or consume learning resources, academic standards implementation guidelines and

	information about how they are used. The Learning Registry network hosts and shares both metadata and paradata (content about where a learning resource was used, comments, rankings, ratings, etc).
LIS	The IMS Learning Information Services (LIS) specification is the definition of how systems manage the exchange of information that describes people, groups, memberships, courses and outcomes within the context of learning.
LMS	A Learning Management System (LMS) is a software application for the administration, documentation, tracking, reporting and delivery of instruction and assessment. A robust LMS should be able to: assemble and deliver learning content, consolidate instruction and assessment on a scalable web-based platform, support portability and standards, and deliver personalized content to individual students.
LRMI	The Learning Resource Metadata Initiative (LRMI), is a project to create an Learning Object metadata vocabulary using the most common descriptions of learning resources used by existing educational metadata standards and by online publishers of learning resources in order to facilitate easier discovery of learning resources. The Association of Educational Publishers and Creative Commons co-lead the LRMI. The LRMI is actively promoting adoption and impact of their proposed vocabulary through collaboration/cooperation with search engines, learning resource publishers, repositories, and other potential distributors and consumers of education metadata.
LTI	The principal concept of Learning Tools Interoperability (LTI) is to establish a standard way of integrating rich learning applications/objects (remotely hosted and provided through third-party services) with platforms such as learning management systems, portals, or other educational environments. In LTI these learning applications are called Tools (delivered by Tool Providers) and the LMS, or platforms, are called Tool Consumers. The basic use case is to allow the seamless connection of web-based, externally hosted applications, content and Tools (simple applications like chat to learning environments for complex subjects) to platforms that present them to users.
Metacognitive Processes	In a constructivist/project-based learning environment students are required to analyze their own learning or thinking through higher cognitive processes (thinking about what they have to consider/understand) in order to construct a viable plan for solving a problem or completing an assignment
Metadata	Metadata is structured data about data. Metadata was traditionally found in the card catalogs of libraries. As information has become increasingly digital, metadata is also used to describe digital data/resources using metadata standards specific to a particular discipline. The contents and context of data/resources can be stored in a separate index registry/database (more established approach) or within the markup of the data resource itself (emerging approach). For example, a webpage may include metadata specifying what language it is written in, what tools were used

	to create it, and where to go for more on the subject, allowing browsers to automatically improve the experience of users looking for specific data/resources. Learning Object Metadata is a data model, usually encoded in XML, used to describe a learning object and similar digital resources used to support learning. The purpose of learning object metadata is to support the reusability of learning objects, to aid discoverability, and to facilitate their interoperability, usually in the context of online learning management systems.
Metadata Vocabulary	A metadata vocabulary or schema declares a set of concepts or terms and their associated definitions and relationships. The terms are often known as elements, attributes and qualifiers. The terms definitions provide the semantics that are ideally both human and machine-readable.
Microdata	Microdata is an HTML specification used to nest semantics/descriptive information within existing content on web pages. Search engines, web crawlers, and browsers can extract and process Microdata from a web page and use it to provide a richer browsing experience for users. Search engines benefit greatly from direct access to this structured data because it allows search engines to understand the information on web pages and provide more relevant results to users. Microdata uses a supporting vocabulary to describe an item and name-value pairs to assign values to its properties. Microdata is an attempt to provide a simpler way of annotating HTML elements with machine-readable tags than the similar approaches of using RDFa and Microformats.
OAI-PMH	The Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) is a mechanism for metadata repository interoperability based on widely deployed service technologies. Data Providers are repositories that expose structured metadata via OAI-PMH. Service Providers then make OAI-PMH service requests to harvest that metadata. OAI-PMH is a set of six verbs or services that are invoked within HTTP.
PARCC	The Partnership for Assessment of Readiness for College and Careers (PARCC) is a consortium of 22 states working together to develop a common set of K-12 CCSS assessments in English and math. The results of these assessments will ostensibly be an indicator of K12 students' readiness for college and careers. These new K-12 assessments will build a pathway to college and career readiness by the end of high school and track students' progress from 3rd grade up. Teachers will also be provided with timely formative achievement data to inform instruction. The PARCC assessments will begin during the 2014-15 school year.
Parse	The process for extracting the Learning Object Metadata values encoded in a data structure syntax (XML, JSON, RDFa, Microdata) transmitted in a discovery/harvest service request so those values can bind to variables in a service's programming logic to guide queries of the Learning Object metadata database or the metadata embedded in the Learning Object (See Bind and Data Structure Syntax/encode)
QTI	The IMS Question & Test Interoperability (QTI) specification describes a

	basic structure for the representation of question (item) and test (assessment) data and their corresponding results reports. Therefore, the specification enables the exchange of this item, assessment and results data between Learning Management Systems, as well as content authors and, content libraries and collections. The IMS QTI specification is defined in XML to promote the widest possible adoption. The IMS QTI specification is extensible and customizable to permit immediate adoption, even in specialized or proprietary systems.
RDF	The Resource Description Framework (RDF) is a family of World Wide Web Consortium (W3C) specifications originally designed as a metadata data model. It has come to be used as a general method for conceptual description or modeling of information that is implemented in web resources, using a variety of syntax formats. The RDF data model is based upon the idea of making statements about resources (in particular Web resources) in the form of subject-predicate-object expressions. These expressions are known as triples in RDF terminology. For example, one way to represent the notion "The sky has the color blue" in RDF is as the triple: a subject denoting "the sky", a predicate denoting "has the color", and an object denoting "blue".
RDFa	Resource Description Framework – in – attributes (RDFa) is a W3C HTML 5 Recommendation that adds a set of attribute-level extensions to HTML, XHTML and various XML-based document types for embedding rich metadata within Web documents (Learning Object metadata can be embedded in Learning Objects using this data structure syntax/encoding). The RDF data-model mapping enables its use for embedding RDF subject-predicate-object expressions within XHTML documents, it also enables the extraction of RDF model triples by compliant user agents.
Restful Web Service	Representational State Transfer (REST) is a style of software architecture for distributed systems such as the World Wide Web. REST has emerged as a predominant Web service design model. REST-style architectures consist of clients and servers using HTTP or similar protocols by constraining the interface to a set of well-known, standard operations (like GET, POST, PUT, DELETE). Clients initiate requests to servers; servers process requests and return appropriate responses. Requests and responses are built around the transfer of representations of resources. A resource can be essentially any coherent and meaningful concept that may be addressed. A representation of a resource is typically a document that captures the current or intended state of a resource (such as a Learning Object Description in JSON or XML). The client begins sending requests when it is ready to make the transition to a new state. While one or more requests are outstanding, the client is considered in transition. The representation of each application state contains links that may be used the next time the client chooses to initiate a new state-transition.

RTTT	Race to the Top, abbreviated R2T, RTTT or RTT, is a $4.35 billion United States Department of Education contest/grant created to spur innovation and reforms in state and local district K-12 education. It is funded by the ED Recovery Act as part of the American Recovery and Reinvestment Act of 2009 and was announced by President Barack Obama and Secretary of Education Arne Duncan on July 24, 2009. States were awarded points for satisfying certain educational policies, such as performance-based standards (often referred to as an Annual professional performance review) for teachers and principals, complying with nationwide standards, promoting charter schools and privatization of education, and computerization. State applications for funding were scored on various selection criteria including components addressing: Standards and Assessments, Turning Around the Lowest-Achieving Schools and Data Systems to Support Instruction. RTTT prompted 48 states to adopt common core standards for K-12 as a response to a deadline for adopting common core standards, after which states would not receive points toward round 2 RTTT applications. In addition, the White House announced a $350 million federal grant funding the development of assessments aligned to the common core standards.
SBAC	The Smarter Balanced Assessment Consortium (SBAC) is a state-led consortium working to develop next-generation assessments that accurately measure student progress toward college- and career-readiness. Smarter Balanced is one of two multistate consortia (PARCC being the other) awarded funding from the U.S. Department of Education in 2010 to develop an assessment system aligned to the Common Core State Standards (CCSS) by the 2014-15 school year.
Schema.org	The Schema.org site provides a collection of schemas that webmasters can use to markup their pages to expose machine-readable structured data in ways recognized by major search providers. Many Web sites are generated from structured data (including Educational Tool Provider Web sites), which is often stored in databases. Those databases and their metadata are now primarily queried using OAI/Restful Web Services for discovery of their learning objects and resources; however, when Web page markup includes embedded LRMI/Schema.org metadata understood by search engine the result is richer search results making it easier for users to find relevant information on the web. Many applications, especially search engines, can benefit greatly from direct access to this structured data. The search engines (Bing, Google, Yahoo!) created Schema.org and have agreed to support it. Schema.org is an attempt to define a broad vocabulary focusing on popular concepts, to simplify things for mass adoption and to cover the most common use cases. This generalized approach to the embedded structured/metadata is a significant limitation of Schema.org when teachers are attempting granular searches for CCSS learning objects as is the fact that commercial tool providers will not likely expose their web pages/learning objects to public search.

Self Actualization	Assistance to student's with the process of self actualization (reaching their full potential) through continuous opportunities to deconstruct and construct knowledge through direct problem solving experiences within an authentic/project based learning environment (which produces changes in self concept regarding their abilities to understand and solve problems) is a major advantage of the constructivist approach to learning implicit within the CCSS.
Semantic Web	The Semantic Web is driving the evolution of the current Web by enabling users to find, share, and combine information more easily. Humans are capable of using the Web to carry out tasks; however, machines cannot accomplish all of these tasks without human direction. Web pages are designed to be read by people, not machines. The semantic web is a vision of information that can be readily interpreted by machines, so machines can perform more of the tedious work involved in finding, combining, and acting upon information on the web. The Semantic Web, as originally envisioned, is a system that enables machines to "understand" and respond to complex human requests based on their meaning. Such an "understanding" requires that the relevant information sources be semantically structured. The capabilities of an increasingly semantic Web and a standard Learning Object metadata vocabulary relate directly to this paper's proposed automation of the more labor intensive and repetitive CCSS learning environment design and delivery tasks (particularly Learning Object location and assignment as well as differentiation of instruction and delivery and analysis of formative assessment).
Serialize	In computer science, in the context of data storage and transmission, serialization is the process of translating data structure or object state into a format that can be stored in a file or memory buffer, or transmitted across a network connection link and "resurrected" later in the same or another computer environment. When the resulting series of bits is reread according to the serialization format, it can be used to create a semantically identical clone of the original object. For many complex objects, such as those that make extensive use of references (such as Learning Object Metadata), this process is not straightforward. Serialization of object-oriented objects does not include any of their associated methods with which they were previously inextricably linked. This process of serializing an object is also called deflating or marshalling an object. The opposite operation, extracting a data structure from a series of bytes, is deserialization (which is also called inflating or unmarshalling).
SIF	The Schools Interoperability Framework, Systems Interoperability Framework (UK), or SIF, is a data sharing open specification for academic institutions from kindergarten through twelfth grade (K-12). Until recently, it has been used primarily in the United States alone; however, it is increasingly being implemented in Australia, the UK, India and elsewhere. The specification is composed of two parts: an XML specification for modeling educational data, and a Service-Oriented Architecture (SOA) specification for sharing that data between

	institutions. SIF is not a product, but an industry initiative that enables diverse applications to interact and share data. The specification is maintained by the Schools Interoperability Framework Association
SLC	The Shared Learning Infrastructure (SLI) is being developed through funding from the Carnegie Foundation and the Gates Foundation, working in partnership with the states of New York, Illinois, Massachusetts, North Carolina, and Colorado. The work is being coordinated through the Council of Chief State School Officers (CCSSO) and hosted by a separate entity called the Shared Learning Collaborative (SLC, See http://www.slcedu.org/) The SLI is designed to help educators address the Common Core standards through access to resources, data, and tools. The key attributes of the SLI are: • A cloud-based data integration and aggregation service that provides a layer of interoperability to capture, warehouse, aggregate, and report data to educators and vendors about student progress. The service will provide data loading tools so that districts can integrate their existing systems into a single, secure SLI data store. • A content services layer that links to courseware, content repositories, and assessment tools from many providers enabled through both the Learning Registry and the Learning Resource Metadata Initiative. • Learning maps that will allow teachers to track individual student learning and connect to relevant content and tools. An open source-authoring tool will allow third party developers to create learning maps as well.
W3C	The World Wide Web Consortium (W3C) is an international community where Member organizations, a full-time staff, and the public work together to develop Web standards. Led by Web inventor Tim Berners-Lee and CEO Jeffrey Jaffe, W3C's mission is to lead the Web to its full potential.
XML	Extensible Markup Language (XML) is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable. It is defined in the XML Specification produced by the W3C, and several other related gratis open specifications/standards. The design goals of XML emphasize simplicity, generality, and usability over the Internet. It is a textual data format with strong support for the languages of the world. Although the design of XML focuses on documents, it is widely used for the representation of arbitrary data structures (Learning Object metadata instances), for use in web services.

