The Pragmatics of Current E-Learning Standards

Experience with building distance-learning applications shows that a clear understanding of the big picture of standardization in this area is a necessary prerequisite for successful use of standards in practical developments. This article presents e-learning standards, standardization activities and organizations, standards-based development practices, and driving forces for improving existing standards and developing new ones. With these resources, educators and Web-based education system developers will have the tips necessary to approach, implement, and reuse a standards-based distance-learning application.

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Nowadays, e-learning standards are abundant and cover all aspects of e-learning and distance education, from representation, packaging, and publishing of learning objects (LOs); to metadata that describe LOs, learning design, instruction delivery, assessment procedures, and learners; to architectures of learning management and educational applications. These standards are important because they establish high-level principles for organizing learning resources and developing Web-based education (WBE) applications. They also regulate interoperability between applications and enable interchange and reuse of learning artifacts across different e-learning systems, in spite of the heterogeneity of formats and metadata descriptions (schemas) across domains. (See related work[1] for a comprehensive discussion of other advantages of e-learning standards.)

We're interested in the pragmatics of using standards in developing and deploying WBE and distance-learning applications. Our experience with building such applications shows that a clear understanding of the big picture of standardization in this area is a necessary prerequisite for successful use of standards in practical developments. Therefore, this article's objective is to provide that big picture by presenting the e-learning standards, standardization activities and organizations,

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Standardization Bodies

A number of organizations, institutions, industry representatives, committees, working groups, and other bodies are involved with standardization efforts and initiatives. We've listed some of them in Table A.

Table A. Selected e-learning standardization bodies.

Body	Mission	Standards
IEEE Learning Technology Standardization Committee (LTSC; http://ieeeltsc.org)	Development of accredited technical standards, recommended practices, and guides for learning technology. Cooperation with other organizations that produce specifications and standards (gathering recommendations and proposals from such institutions and organizations)	LOM
ISO/IEC JTC1 (Joint Technical Committee 1, a joint SC36 (http://jtc1sc36.org)	Standardization of information technology and metadata for learning, education, and training committee of ISO and IEC)	
IMS Global Learning Consortium (www.imsproject.org)	Development of open technical specifications for interoperable learning technology. Promotionof adoption of these specifications	IMS Content Packaging, IMS, Learning Design, IMS LIP, and so on
Advanced Distributed Learning (ADL) initiative (www.adlnet.org)	Development of standards, tools, and learning content to be tailored to learners' individual needs and delivered in a cost-effective way, anytime, and anywhere	Scorm
Ariadne Foundation (www.ariadne-eu.org)	Fostering sharing and reuse of electronic pedagogical material (learning objects) among universities and corporations through development of a body of standards	Specifications that later provided important educational ingredients to the IEEE LTSC LOM standard and in some IMS metadata specifications
Open Knowledge Initiative (OKI) Project (www.okiproject.org)	Development of specifications that describe how components of an educational software environment communicate with each other and with other enterprise systems	A set of Open Service Interface Definitions (OSIDs) that create an abstraction layer (service-based API) between programmers and educational software infrastructure

standards-based development practices, and driving forces for improving existing standards and developing new ones.

Basic Concepts

The e-learning community colloquially uses the word *standard* to denote one of the following concepts:[1]

- *official standard*: a set of definitions, requirements, formats, and design guidelines for e-learning systems or their components that a recognized standards organization has documented and approved (see the "Standardization Bodies" sidebar for a detailed list of organizations).
- *de facto standard*: the same as an official standard, but widely accepted only by the community and industry—that is, lacking formal approval from a recognized standardization body.
- *specification*: a document on the same issues as an official standard, but less evolved; usually developed and promoted by organizations or consortia of partners from academia, industry, and educational institutions. It captures a rough consensus in the e-learning community and is used as a de facto standard in system and content development.
- *reference model*: an adapted and reduced version of a combination of standards and specifications focusing on architectural aspects of an e-learning system, definitions of parts of the system, and their interactions.

(See the "Glossary of Relevant Terms" sidebar for informal definitions of LOs and other important concepts we use in this article.)

Standards can be comprehensive, so for practical reasons, developers often customize them into *application profiles* by making some elements mandatory, leaving out or restricting (but not modifying) some others, or adding extensions.[1,2] Developers can also combine elements from more than one specification or standard into a single application profile.

Glossary of Relevant Terms

- *Learning object*: a small, reusable content unit relevant for learning.[1] For example, an online exercise, a coherent small set of introductory readings on a specific topic, or an assessment test.
- *Learning object repository*: an online, organized collection of learning objects supporting their search, discovery, retrieval, browsing, and exchange.
- *Learning management system*: a coherent set of integrated and external tools, Web-based applications, functions, services, and features that support creating, maintaining, and administering courses, course materials, and the learning process online.
- *Web-based education*: the branch of education encompassing all aspects and processes that use the Web as a communication medium and supporting technology.

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1. E. Duval and W. Hodgins, "Standardized Uniqueness: Oxymoron or Vision of the Future?," *Computer*, vol. 39, no. 3, 2006, pp. 96–98.

Table 1. Selected e-learning standards.

Standard	Developer	Description	Level	Type
Learning Object Metadata (LOM; http://ltsc.ieee.org/wg12)	IEEE	A conceptual structure for a metadata instance based on a hierarchy of nine categories of metadata elements.	Official standard	Metadata standard
IMS Content Packaging (www.imsglobal.org/content/packaging/cpv1p1p4/imscp_infov1p1p4.html)	IMS Global Learning Consortium	A set of structures that enable exchanging learning content.	Specification	Packaging standard
IMS Learning Design (LD; www.imsglobal.org/learningdesign/ldv1p0/imsld_infov1p0.html)	IMS Global Learning Consortium	A standardized framework for integrating learning (instructional) design with content packages.	Specification	Packaging standard
IMS Learner Information Package (LIP; www.imsglobal.org/profiles/lipinfo01.html)	IMS Global Learning Consortium	A set of structures that enable recording and managing the learner's characteristics as well as exchanging learner information among applications.	Specification	Learner information standard
Public and Private Information (PAPI) for Learners (PAPI Learner) (www.edutool.com/papi/drafts/08/)	IEEE	Semantics and syntax of learner information; elements for recording and viewing descriptive information about learners from different perspectives.	Specification	Learner information standard
Learning Technology Systems Architecture (LTSA; http://ltsc.ieee.org/wg1/files/IEEE_1484_01_D09_LTSA.pdf)	IEEE	High-level, pedagogically neutral, content-neutral, culturally neutral, and platform/technology-neutral architecture for learning technology systems based on abstract components.	Reference model	Communication standard (reference architecture)
Sharable Courseware Object Reference Model (Scorm; www.adlnet.org/scorm/history/2004/index.cfm)	ADL Initiative	A unified content and communication reference model for consistent implementation of e-learning systems. The latest release (Scorm 2004) is augmented with learning content sequencing capabilities.	Specification and reference model	A combination of multiple other standards

Selected E-Learning Standards

There are several types of e-learning standards frequently used in WBE and distance-learning applications:

- *Metadata standards* specify the metadata used to describe LOs' attributes, such as the authors, title, and languages; such descriptions can be published along with the LOs to facilitate their search and retrieval.
- *Packaging standards* regulate assembly of LOs and complex units of learning (such as online courses) from various texts, media files, and other online learning resources; such an assembly can be stored in a *learning object repository* (LOR) and imported in a *learning management system* (LMS).
- *Learner information standards* support the exchange of learner information among various WBE systems, LMSs, and other systems used in the learning process.
- *Communication standards* specify how the learners access educational content during online learning, assessment, collaboration, and

other Internet-based educational services.

- *Quality standards* are related to the quality of LOs and courseware from the pedagogical, technical, design, and accessibility perspectives.
- *Semantics standards* are emerging and increasingly popular specifications that define how we can organize content and refer to it on the Semantic Web.

Table 1 lists some of the most popular standards underlying current WBE systems, with a clear indication of the standard type.

Current Development Practices

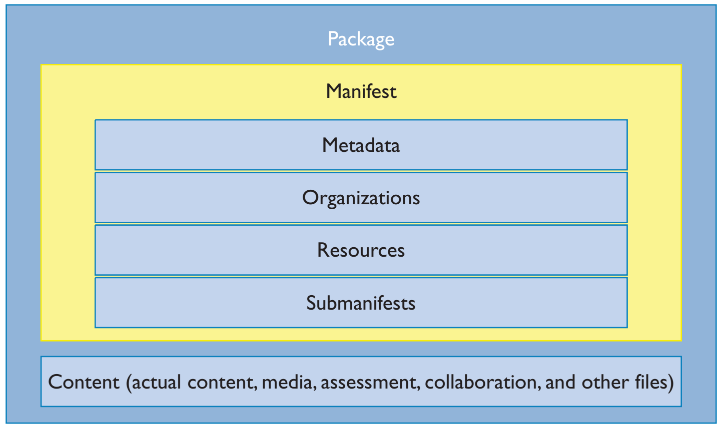
When creating LOs and building applications, developers use current e-learning standards in several ways. We've included two typical ones here.

Creating New LOs

For authors to create new LOs, it's useful to have standards-compliant authoring tools. The tools should be capable of

- generating LO content (resource) files and the related metadata that comply with one or more standards or application profiles,
- storing a newly created LO in an LOR, and
- importing (from various LORs) reusable LOs compliant with the supported standards for integrating them into new LOs.

A standards-based LO typically combines several digital resources into a coherent whole and provides an XML-based description of its structure and content to facilitate its search, discovery, and retrieval. Figure 1 illustrates this idea. According to the IMS Content Packaging specification, an LO is conceptually a package (Figure 1a) that includes various, possibly distributed, content files (resources) and a *manifest file* that describes how to put together the resources. The manifest file is an XML document with several sections (Figure 1b). The required *resources* section includes references to all the resource files that compose the LO. The optional *metadata* section describes the LO as a whole and typically includes LOM-based metadata elements, such as title, description, keywords, and so on. The required *organizations* section declares zero, one, or more different ways of structuring the LO content. Essentially, it defines alternative ways for organizing the resources included in the package (such as course outline or lesson exercises views). The optional *submanifests* section refers to zero or more other LOs (that is, to their manifest files) possibly aggregated in this LO. Altogether, the content package's elements are assembled into a



(a)

```
<?xml version="1.0"?>
<manifest identifier="MANIFEST1"
        xmlns="http://www.imsglobal.org/xsd/ims_cp_rootv1p1"
        xmlns:imsmd = "http://www.imsglobal.org/xsd/imsmd_v1p2">
   <metadata>
        . . .
           <imsmd:title>
        <imdmd:langstring xml:lang="en_US">
               Semantic Web
        </imsmd:langstring>
           </imsmd:title>
        . . .
   </metadata>
   <organizations default="TOC">
      . . .
        <title>The lesson contents</title>
        <item identifier="ITEM1"identifierr ef="RESOURCE1">
           <title>Lesson</title>
           <item identifier="ITEM2"identifier ef="RESOURCE1">
              <title>Introduction</title>
           </item>
      . . .
   </organizations>
   <resources xml:base="http://repository.imsglobal.org/foo/bar/">
      <resource identifier="RESOURCE1" type="webcontent"
        href="lesson.htm"/>
      <resource identifier="RESOURCE2" type="webcontent"
        href="introuction.htm"/>
      . . .
   </resources>
<manifest>
```

(b)

```
manifest
   metadata
   organizations
      learning-design
   resoirces>
      assessmant
content
```

(c)

Figure 1. A standards compliant LO. (a) The structure of a LO according to the IMS Content Packaging specification. (b) The structure of the manifest file. (c) Embedding pedagogical information into a manifest file.

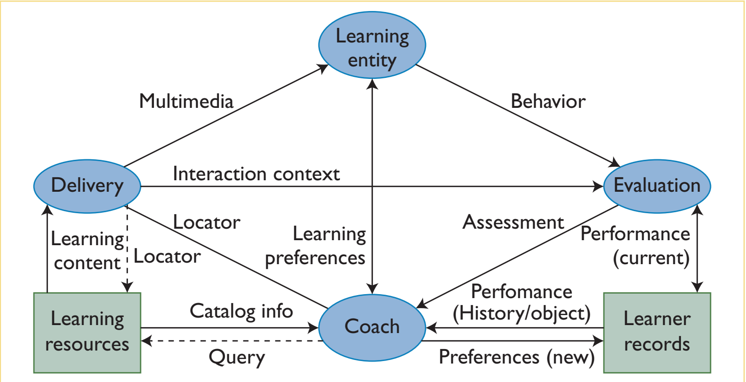


Figure 2. The IEEE Learning Technology Systems Architecture (LTSA) conceptual model (after http://ltsc.ieee.org/wg1/files/IEEE_1484_01_D09_LTSA.pdf). The ovals represent processing elements, boxes represent repositories, solid arrows show data flows, and dashed arrows reflect control flows.

structure resembling a logical directory.

Standards regulate how to meaningfully aggregate LOs and how to disaggregate an LO into a set of reusable parts. Hence, in terms of content packaging, standards-based tools must let authors describe their content in any way they want applications to reuse it. For example, in the case of the IMS Content Packaging specification, the manifest file provides a standardized and structured way to do this. In addition, in terms of pedagogy, the manifest file's structure lets authors express and associate with LO information such as its instructional purpose, preconditions, learning and assessment activities, and so on (see Figure 1c). The manifest file includes this pedagogical information in accordance with the IMS Learning Design specification.

Developing a New Application

After deciding on the target group of users and the purpose of the new system or application, standards-based design can start early in the development by answering questions like,

- What are the system's major processing modules?
- How do you standardize LO access and instruction delivery?
- Where does the information about the learners come from, and what standards does it follow?
- What external applications, LORs, and other systems does this one interact with, and what is the level of interoperability to be supported?

Architectural reference models, combined with other available standards, are good starting points in making these kinds of decisions. For example, the IEEE Learning Technology Systems Architecture (LTSA; see Figure 2 and Table 1) is a suitable high-level framework for an architectural design of a range of learning technology systems, including education and training, computer-based training, computer-assisted instruction, intelligent tutoring, and so on. Most of Figure 2's meaning is intuitively clear; a *learner entity* stands for both individual learners and learning groups, and *locators* are lesson plans, URLs, and the like. *Coach* is responsible for securing the achievement of pedagogical objectives. LTSA can be nicely combined with other standards. For example, there's a clear mapping between LTSA and IEEE Public and Private Information (PAPI) for learners (PAPI Learner, see Table 1).[1]

The decision on how the system's core processing elements should interact with each other and with external repositories and applications when exchanging LOs and other information can be also based on existing specifications. For example, the Massachusetts Institute of Open Knowledge Initiative (OKI) Project (see the "Standardization Bodies" sidebar) developed a set of such specifications. The IEEE LTSA reference architecture specification also provides a detailed description of the process of developing an e-learning application.

Some Drawbacks…

However, using standards in practical developments of WBE applications isn't as straightforward as you might expect. There might be a lack of an appropriate standard or, at best, just an initiative to develop one. Moreover, even official and widely used standards might turn out to be partially inadequate in practical applications. For example, Mimi Recker and David Wiley[4] have noted that the IEEE Learning Object Metadata (LOM) standard's form of prescriptive metadata doesn't provide enough information to adequately support the learning process (for example, to help automate the recommendation of learning content). Some developers find parts of IEEE LOM metadata too restrictive or too vague and imprecise. For instance, the set of prescribed values of the `Context` metadata field are `school`, `higher education`, `training`, and `other`. However, this set of values is neither comprehensive enough to cover all possible learning contexts nor descriptive enough to depict their peculiarities. In addition, content authors are typically reluctant to provide metadata, so the amount of metadata is usually insufficient. Even when authors do provide metadata, these typically express the particularities of the authoring context and the intended use of the learning content, but not a specific learner's context and learning goals. Thus, a metadata-based query to an LOR for certain LOs might not return the most suitable content for the learner, or learners might have to examine several returned LOs manually to select those that suit their needs. Likewise, it's impossible for authors to predict all possible learning situations when annotating LOs with metadata.

There might be more than one standard covering a certain aspect of WBE. In such situations, an application developer should have a good understanding of all the existing relevant standards and specifications to select the most appropriate. For example, IEEE PAPI Learner and IMS Learner Information Package (LIP) both cover the issue of learner modeling. Even though these specifications seem similar, they are largely different and reflect different perspectives on user modeling. Being derived from the best practices in writing curriculum vitaes, the IMS LIP specification consists of rich structures for representing various user aspects (not necessarily learning related). On the other hand, the IEEE PAPI Learner has been developed from the perspective of learners' performance during studies, as its main categories (performance, portfolio, and certificate) indicate. Despite their breadth and complexity, neither of the two specifications is comprehensive enough to fully support personalizing the learning process. Therefore, in practice, the elements of these specifications are typically combined in application profiles.

Many current tools used for LO development and description closely follow standards and require developers to fill electronic forms that are then (internally) converted into parts of the standard's representation format (for example, see the suite of tools available at www-i5.informatik.rwth-aachen.de/lehrstuhl/projects/index.html). It's the same with most current learning design editors (such as the Reload editor, www.reload.ac.uk/), which fully support the IMS Learning Design (LD) specification but are too technical and hence too complex for educators.

…and How to Eliminate Them

E-learning standards and specifications must evolve over time to allow for developing new applications that support

- integrating multiple LORs into larger federated repositories, with internal boundaries fully transparent to learners;
- the learners' needs for simple and intuitive interfaces for querying and accessing federations of LORs;
- the authors' needs for eliminating the extra effort of annotating the LOs they create; and
- personalizing the learning process.

In the meantime, we can use several other approaches to meet these needs.

Advanced Tools

Automating the process of LO and courseware development and standards-based annotation requires advanced tools that make details of built-in standards transparent to developers.[2,3] In addition, because standards can't formalize all details of learning situations and system or courseware developments, tools should also include links to libraries of proven designs. For example, such cookbooks might contain various learning design patterns that cover diverse teaching approaches and learning strategies, multitudes of learning styles, and the heterogeneity of context-specific factors.

The Learning Activity Management System (LAMS; www.lamsinternational.com) to some extent meets the aforementioned requirements. LAMS is a good example of an advanced tool for designing, managing, and delivering online collaborative learning activities. Its primary advantage over conventional learning management systems is its highly intuitive visual environment for learning design authoring that hides the IMS LD specification's complexity — that is, an IMS LD application profile — which lies beneath. In addition, LAMS offers a library of best-practice collaborative learning designs that we can easily adapt to suit the needs of our own particular requirements. These features made it widely adopted by educators.

E-Learning Standardization and the Semantic Web

Semantic Web technologies enable nice features such as semantic annotation of LOs, semantic search, and semantic Web services, all of which ontologies support. An ontology formally and declaratively represents a topic or domain's terminology and essential knowledge. Ontologies can define mappings between unknown and known terms in the data. Hence, ontology-supported semantic search makes it possible to query multiple LORs for LOs with semantically similar, albeit possibly syntactically different, content. (This is impossible with keyword- and metadata-based search grounded in the current standards.) For example, a semantic query for LOs on the topic "musical chord" might also return some LOs about "harmony" that reference the concept of a musical chord because the two concepts are related. An appropriate ontology must explicitly express that fact, and the two LOs must be annotated (either automatically or by a human agent) with the corresponding ontological concepts to support semantic search.

Current standards don't include formally described semantics, so they should evolve to support reasoning and semantic search based on LO metadata. Future standards must also support advanced, ontology-based metadata and automatic annotation of LOs. Technically, much of the practical implementations and use of standards is related to LO annotation, but it must be done manually, using fixed and often not quite appropriate sets of prescribed metadata. In contrast, ontology-based annotation brings more flexibility and dynamics in associating metadata with LOs, provides opportunities to effectively and efficiently mine content for relevant metadata, and enables combining metadata sets and schemes from multiple sources. Finally, ontology-based annotations of LOs serve as points of semantic integration of multiple LORs.

Although advanced standards to support such Semantic Web features in WBE applications are still lacking, initial efforts in this regard are already underway. For example, the RDF binding of the IEEE LOM standard already serves as the starting point of the DCMI/IEEE LTSC Taskforce working on the development of a common abstract model for IEEE LOM and Dublin Core (http://dublincore.org/educationwiki/DCMIIEEELTSCTaskforce). Also, the Semantic Web Interest Group of the World Wide Web Consortium (W3C) has developed the Simple Knowledge Organization Systems (SKOS) specifications to enable representing the content and structure of various concept schemes (such as thesauri, taxonomies, terminologies, and glossaries) in a machine-understandable way, as an RDF graph.

Another challenge is to develop standards to enable development of applications that support automatic, context-based retrieval and presentation of an appropriate learning content when needed, without requiring the learner to know to request it.[2]

Application Profiles

E-learning standards are often open for extensions to the base schema. In addition, two or more standards can target the same issue. Researchers, developers, practitioners, and vendors sometimes creatively use such standards to develop a suitable application profile for the application at hand. They typically do so by proposing extensions of an existing standard or combining elements from different standards. For example, the learner model ontology developed in the context of the Tangram project (http://iis.fon.bg.ac.yu/TANGRAM/) combines elements from the IEEE PAPI Learner and IMS LIP specifications (see Figure 3). This enables Tangram to interoperate and exchange data about learners with other learning applications. Specifically, we picked up the elements aimed at representing learners' performance from the IEEE PAPI Learner, as well as the elements for representing learners' preferences from the IMS LIP. The ontology also introduces additional elements to enable the representation of application-specific learners' characteristics needed in Tangram.

Alternative Approaches

Slight deviations from the rigidity of standards and specifications in practical developments can add value to a system's usability. For example, we've developed a framework for combining IEEE LOM metadata with context-specific information about the actual use of LOs. We've extended the notion of the *learning object context*, introduced in an earlier work,[5] and defined it as a triple of the form `{activity, learner(s), learning object}`. It captures an activity (such as quizzing, discussing, and chatting) that a learner undertook (either alone or in collaboration with other learners) when interacting with an LO. The framework integrates ontologies for representing learning activities and learner models. It also incorporates Semantic Web enabled metadata, such as an RDF representation of a classical metadata schema — possibly IEEE LOM, Dublin Core, or their customization in the form of an application profile — enhanced with the use of domain ontologies to explicitly define the meaning (semantics) of LOs and the activities in

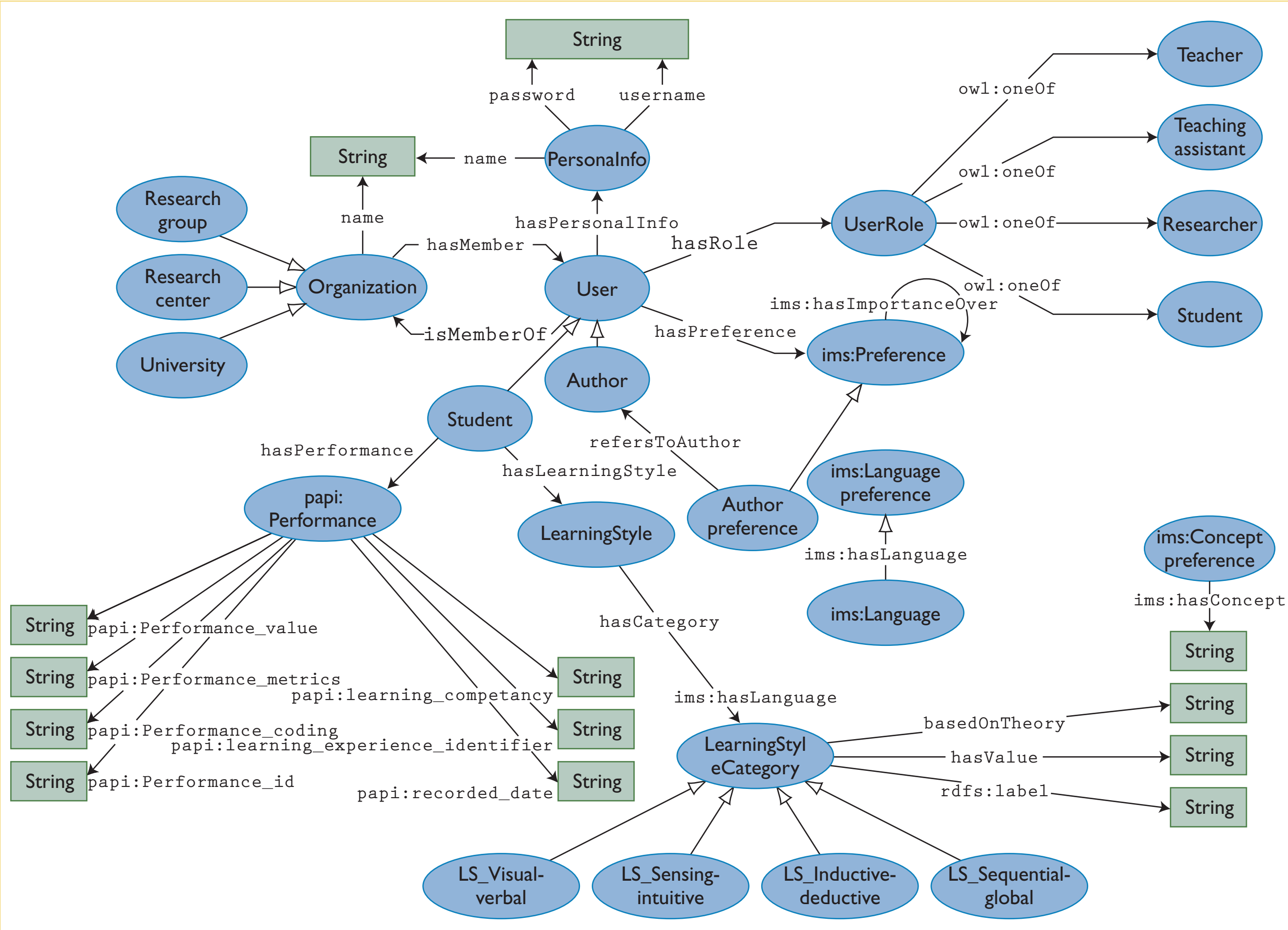


Figure 3. Graphical representation of Tangram's learner model ontology.[3] The ontology combines elements from IEEE PAPI Learner (the element with prefix papi) and IMS LIP (the elements with ims prefix) specifications and introduce new, custom elements (the elements without any prefix) to build an application profile for modeling Tangram's users.

which they were used.

We're using this ontological framework to

- provide feedback to learning content authors about the use of their content during the learning process;
- generate feedback for instructors to inform them about the learners' activities, performance, and collaboration; and
- personalize the learning process.

Having recognized the peculiarities of the current learning situation, the system can search the repository of LO context data to identify similar learning situations and from them infer the most suitable LOs for the present circumstances.

An insight into different standards and specifications in learning technology is useful when developing WBE and distance-learning systems because of the standards' regulatory function and because of the need for systems to interoperate and reuse the learning material. Most current standards cover general-purpose e-learning needs and processes. However, existing development practices and the increasing use of Semantic Web technologies in e-learning incur additional requirements that future standards and specifications must address.

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