ECP 2007 EDU 417008

ASPECT

Final Public Report

September 2008 – April 2011

http://aspect-project.org

Deliverable number/name	*D1.3.2*
Dissemination level	*Public*
Delivery date	*April 2011*
Status	*Final*
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e*Content*plus

This project is funded under the *e*Content*plus* programme[1],
a multiannual Community programme to make digital content in Europe more accessible, usable and exploitable.

[1] OJ L 79, 24.3.2005, p. 1.

Summary

This is the final public report of the ASPECT Best Practice Network, a 32-month project supported by the European Commission's eContent*plus*[2] programme to improve the adoption of learning technology standards and specifications. This report describes the project, its main results and recommendations, and their impact on the discovery and use of content for schools in Europe.

[2] http://ec.europa.eu/information_society/activities/econtentplus/

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1 Project Overview

The ASPECT Best Practice Network (BPN) was supported by the European Commission's eContent*plus*[3] programme. It started in September 2008 and involved twenty-two partners from fifteen countries, including nine Ministries of Education (MoE), four commercial content developers and leading technology providers. For the first time, experts from all international standardisation bodies and consortia active in e-learning (CEN/ISSS, IEEE, ISO, IMS, ADL) worked together in order to improve the adoption of learning technology standards and specifications.

In the course of thirty-two months, the ASPECT consortium implemented and tested two categories of specifications: specifications for content use (e.g., content packaging formats, access control, and licensing); and specifications for content discovery (e.g., metadata, vocabularies, protocols, and registries). Through this work, the project identified best practices for learning content discovery and use and produced recommendations for the education community in Europe.

Work in developing these best practices involved project partners and teachers using a version of the European Schoolnet Learning Resource Exchange[4] (LRE) service that enables schools to find open educational content from many different countries and providers. In ASPECT a customized and password protected version of the LRE was developed for schools in the project that contained resources from commercial providers and some additional search and retrieval features related to the exploration of the standards under investigation in the project.

During ASPECT, content providers from both the public and private sectors applied content standards to their learning resources and made them available via the LRE. This represents a large-scale implementation of standards and specifications for content discovery and use. As a result, the following elements, not directly linked to the quality of the specifications themselves, were identified as necessary for the successful adoption of a standard:

- Availability and quality of tools for producing compliant content and metadata;
- Availability and quality of tools to test for compliance;
- Availability of solutions adapted to the different needs of content providers from both the public and private sectors.

An important focus in the project was the exploration of content standards and specifications for content packaging (SCORM and Common Cartridge) by both Ministries of Education and commercial content developers. ASPECT tested existing tools for creating, validating content packages and using these specifications. Having identified areas in need of improvement, ASPECT also developed new tools to enhance content packages and to validate them more accurately.

[3] http://ec.europa.eu/information_society/activities/econtentplus/
[4] http://lreforschools.eun.org

After the end of the project, ASPECT continues to make publicly available a variety of tools and services to support the best practices that emerged from its work. These can be accessed via the Learning Resource Exchange (LRE) Service Centre[5].

The LRE Service Centre includes:

- A Learning Technology Standards Observatory (LTSO) serving as a focal access point to updated information on projects, results, news, organisations, activities and events that are relevant to the development and adoption of e-learning technology standards and specifications.
- An application profile registry providing information about the data elements and vocabularies used by different application profiles and mappings between different profiles of a given standard.
- A Vocabulary Bank for Education (VBE) providing a browsable and searchable interface to locate, view and download controlled vocabularies.
- Learning Object Repository Registries providing up-to-date information about repositories of learning resources and their collections.
- Validation services for testing conformance of metadata records to different metadata specifications and profiles.
- Metadata transformation services for converting metadata records from one application profile to another.
- An automatic metadata translation service integrated in the Learning Resource Exchange (LRE) enabling the discovery of learning resources in various languages.

An important aim in ASPECT was to help redress a perceived 'disconnect' between standards' organisations and the educational community by working directly with teachers to help them explore and implement standards. From the perspective of Ministries of Education, it is important that teachers' views as well as those of technical experts are fed into the pre-standardisation process. In line with this objective, 46 teachers from Belgium, Lithuania, Portugal and Romania took part in a series of ASPECT workshops to elicit their opinions and observe their use of content packaging, search features and mechanisms developed in the ASPECT project. The tests were carried out between October 2009 and May 2010, and involved three independent workshops:

(1) National workshops on content discovery;

(2) Online workshops on content reuse; and

(3) An international workshop for all participants on content packaging and access control.

Additional information on these activities with teachers can be found in ASPECT public deliverables D6.4, D6.5 and D7.3.2.

The various ASPECT activities were driven by the needs of the different stakeholders as identified at the start of the project. ASPECT conducted several studies on the different stakeholders' adoption and awareness of content discovery/repository standards (e.g., IEEE

[5] http://aspect-project.org/node/52

LOM, IMS LODE, …) and content packaging standards (SCORM & IMS Common Cartridge). This work included interviews with the ASPECT content providers (Ministries of Education and commercial content providers), ascertaining their readiness and willingness to adopt content standards. Insights from these interviews informed the development of the ASPECT recommendations (see section 5).

ASPECT results were disseminated trough over thirty face-to-face events and online webinars that attracted 1479 attendees. ASPECT workshops, plugfests, seminars and newsletters also allowed ASPECT to create an active global community, including nearly 200 ASPECT Associate Partners, interested in the implementation and ongoing development of educational content standards and specifications. Like the LRE Service Centre, this community will exist after the end of the project and be integrated in a new version of the Learning Resource Exchange that was launched by European Schoolnet and its supporting Ministries of Education in February 2011.

2 Consortium

ASPECT involved twenty-two partners from fifteen countries, including nine Ministries of Education (MoE), four commercial content developers and leading technology providers.

The ASPECT partners were representatives of the different categories of stakeholders involved with specifications for learning content discovery and use: learning content providers (both commercial and non-commercial); repository builders and organisations federating repositories and learning resources; learning technology platform and tools' providers; users (i.e., teachers and their pupils); and e-learning standards' specialists.

Participant name	Country	Role in the project[6]
EUN Partnership a.i.s.b.l.	BE	Coordinator / content provider (public sector) / technology provider / dissemination
Katholieke Universiteit Leuven	BE	Technology provider
Siveco Romania SA	RO	Content provider (commercial)/school pilot
Cambridge University Press (Holdings) Ltd.	UK	Content provider (commercial)
Universität Koblenz-Landau	DE	Technology provider
Instituto Nazionale di Documentazione per L'Innovazione e la Ricerca Educativa	IT	Content provider (public sector)
RWCS Limited	UK	Technology provider
Vocabulary Management Group	UK	Technology provider
Association EIfEL, European Institute for E-Learning	FR	Dissemination
Universidad Vigo	ES	Dissemination
Icodeon	UK	Technology provider
Young Digital Planet S.A.	PL	Content provider (commercial)
Svietimo Informaciniu Technologiju Centras Valstybes Biudzetine Istaiga	LT	Content provider (public sector) /school pilot
EduCentrum	BE	Content provider (public sector)/school pilot
UNI•C Danmarks EDB-Center for Uddan	DK	Coordination of content providers (public sector)
FWU Institut für Film und Bild in Wissenschaft und Unterricht GmbH.	DE	Content provider (both public sector and commercial)

[6] The main operational role(s) that the participant plays in the project. For example: content provider, technology provider, pedagogical expert, standardisation body, evaluation, dissemination etc.

DG Innovation and curriculum development (Ministry of Education)	PT	Content provider (public sector) /school pilot
Univerza v Ljubljani	SI	Content provider (public sector)
EDUCATIO Tarsadalmi Szolgaltato Koz	HU	Content provider (public sector)
The Open University	UK	Content provider (public sector)
Jyvaskylan Yliopisto, University of Jyvaskylan	FI	Evaluation
Centre National de Documentation Pédagogique	FR	Content provider (public sector)

3 Main Results and Achievements

ASPECT aimed at taking steps to address the potentially damaging 'disconnect' between standards bodies and experts on the one hand and educational policy makers, ICT advisers and practitioners on the other. It has ensured that best practice with regard to the implementation of standards and specifications for learning technologies (SSLT) are no longer derived primarily via technical experts.

ASPECT actively worked with leading European experts, professionals and policy makers in Ministries of Education who can make a real impact on SSLT take-up. From the perspective of Ministries of Education taking part in the project, a key result was that teachers' views as well as those of technical experts are considered during the standardisation process. In addition, the ASPECT partners have continued to be active contributors to all international standardization bodies and consortia active in e-learning (CEN/ISSS, IEEE, ISO, IMS, ADL).

The project has:

(1) Helped to create the Simple Publishing Interface, a new CEN Workshop Agreement (CWA) to publish metadata in a repository and initiated two others: one on Social Data for learning objects; and the other on interoperability of learning object repository registries (subject to approval by CEN Workshop on Learning Technologies). It has also helped to produce the IMS Learning Object Discovery and Exchange specification (subject to approval by the IMS Global Learning Consortium) and three European norms: The Curriculum Exchange Format, which is now an official European norm and the Simple Query Interface and Simple Publishing Interface, which will be developed within two recently approved New Work Items created in TC353.

(2) Made proposals and recommendations concerning how a number of standards can be combined in order to ensure more transparent forms of interoperability between learning content repositories and the wide variety of learning platforms in schools.

(3) Enabled stakeholders to better understand the merits of a range of different standards and specifications and how these can be applied to both professionally generated content and the growing volume of user-generated content from teachers and pupils.

(4) Provides a new set of support services that facilitate the interoperability of learning content, implemented within an LRE Service Centre.

(5) Consolidates and further extends work that has already commenced related to the building of a pan-European Learning Resource Exchange service for schools.

(6) Produced the following public deliverables:
- D1.1 Charter for ASPECT Associate Partners
- D1.3.1 Intermediate Public Report
- D1.3.2 Final Public Report (this document)
- D2.1 ASPECT Approach to Federated Search and Harvesting of Learning Object Repositories

- D2.2 Design of Data Model and Architecture for a Registry of Learning Object Repositories and Application Profiles
- D2.3 ASPECT Approach To Multilingual Vocabularies, Including Automated Translation Services
- D2.4 Wiki with Material from Repository to Support Training and Dissemination
- D2.5 Infrastructure and services v1.0
- D2.6 Infrastructure and services v2.0
- D2.7 Infrastructure and services v3.0
- D3.1 Best Practice Report for Content Use
- D3.2.1 Conformance Testing Tools version 1
- D3.2.2 Conformance Testing Tools version 2
- D3.3 IMS CC & SCORM Demonstrator v1.0
- D3.4 Intermediate Evaluation Report for Content Use
- D3.5 Best practice report for content use v2.0
- D3.6 IMS Common Cartridge & SCORM Demonstrator v2.0
- D4.1 Dissemination Plan & Communication Handbook
- D4.2 ASPECT web site and community
- D4.3.1 PowerPoint presentations on project (initial)
- D4.3.2 PowerPoint presentation on project (final)
- D4.4.1 Report on ASPECT workshops, plugfests and conferences 1
- D4.4.2 Report on ASPECT workshops, plugfests and conferences No. 2&3
- D4.5 ASPECT Network of Practitioners
- D4.6 LRE Service Centre provided by ASPECT
- D4.7 Strategic Seminar on Educational Publishing Futures
- D5.1 A critical mass of metadata that can be searched for and discovered seamlessly
- D5.2 A critical mass of content to which a set of preferred standards and specifications have been applied
- D5.3 Release 1 of the integrated system
- D5.4 Release 2 of the integrated system (including a Common Cartridge tutorial)
- D5.5 Report on the advantages/issues associated with the large-scale implementation of selected standards
- D6.3 Report on summer school
- D6.4 National Validation reports
- D6.5 Final Report on the Experimentation
- D7.3.1 Evaluation Report v1
- D7.3.2 Final Evaluation Report

All this material can be accessed from http://aspect-project.org/node/28.

4 Examples of ASPECT Results and Achievements

This section describes some examples of results and achievements of the technical work packages (i.e., work packages 2, 3, and 5). A full description of results for each work package can be found in online version of the work package deliverables (cf. http://aspect-project.org/node/28).

4.1 Application Profile Registry (WP2)

The Application Profile Registry (APR) describes the metadata application profiles used to describe learning resources managed in different learning object repositories. The APR allows 'core standards' such as IEEE LOM to be defined in terms of the elements within the standard's published data model. It also provides links to externally-held and authoritative documents such as schemas for technology bindings, specifications and guidance. The APR is available at the following URL: http://apr.vocman.org

When a profile of a core standard is created, the APR automatically populates the profile with details about the core standard; this allows the author to modify these details rather than having to populate the entire profile from scratch. Elements in the APR are defined in terms of their obligation, size, order, vocabulary and data type. Elements can be used in multiple profiles and can be modified for a particular profile (e.g., to use a different controlled vocabulary). References to controlled vocabularies are made by linking to the URIs that are provided for that vocabulary by the Vocabulary Bank for Education developed in the project. The APR provides mappings between profiles, highlighting differences. The APR provides this information via a human readable interface and via a RESTful machine API.

The APR was designed to support the following functional requirements:

- Storage of descriptive information about application profiles conforming to a specified schema (including their location)
- Authentication of users
- Role assignment for users
- Storage of application profile bindings; this is available in case the profiles have no public location.
- Web-based browsing
- Client based browsing
- Web based data management (add, delete, update, register for changes)
- Web based administrative functions (change permissions, add, user, delete user)
- Client-based searching
- Web-based searching
- Change Notification

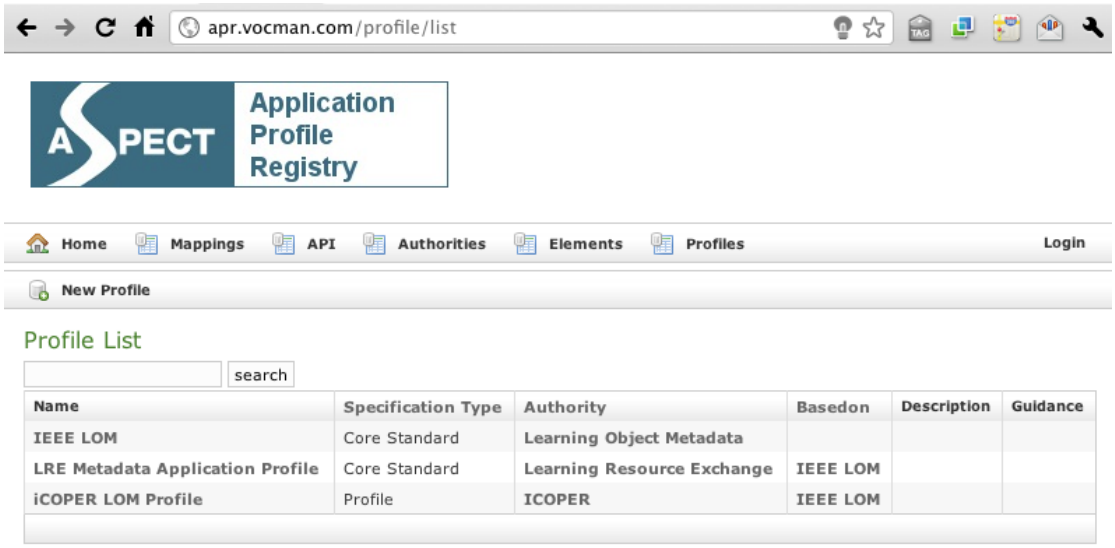

Figure 1: The Application Profile Registry

Figure 1 shows a screenshot of the APR with the application profiles that are currently stored:

The IEEE LOM standard
The LRE metadata application profile
The ICOPER application profile

The rest of this section presents the mappings between application profiles, a key use case of the Application Profile Registry.

Summary:
A person wants to see the mapping between two application profiles that are registered in the APR.

Actors:
Any Person
Trigger:
Triggered by the actor

Description:
The users navigate to the "mappings" page of the APR web application.
The system asks the source and the target application profiles.
The user selects the source and the target application profiles.
The system returns the mapping between the requested profiles.

Result:
An overview is presented to the user that maps each metadata element of the source application profile to the metadata element of the target application profile. This overview is shown in Figure 2.

Home Mappings API Authorities Elements Profiles Login

Aspect APR demonstrator - Mapping Result

This table explains how to map from a document conforming to the IEEE LOM profile to a target document using iCOPER LOM Profile Use this table by sequentially processing the actions. Copy actions appear where there is a 1:1 correspondence between source and target profiles. The action may include additional information about vocabulary or datatype transformations. Withold actions appear where an element is not present in the target profile, and create actions appear where an element is introduced into a target profile.

Source Reference	Action	Target Reference
1 Label (lom:general)	1.1 -> Simple Text Copy ->	1 Label (lom:general)
1.1 Label (lom:identifier)	1.1 -> Simple Text Copy ->	1.1 Label (lom:identifier)
1.1.1 Label (lom:catalog)	1.1 -> Simple Text Copy ->	1.1.1 Label (lom:catalog)
1.1.2 Label (lom:entry)	1.1 -> Simple Text Copy ->	1.1.2 Label (lom:entry)
1.1.3 Label (lom:title)	1.1 -> Simple Text Copy ->	1.1.3 Label (lom:title)
1.1.4 Label (lom:description)	1.1 -> Simple Text Copy ->	1.1.4 Label (lom:description)
1.1.5 Label (lom:keyword)	1.1 -> Simple Text Copy ->	1.1.5 Label (lom:keyword)
5 Label (lom:educational)	1.1 -> Simple Text Copy ->	5 Label (lom:educational)
5.1 Label (lom:interactivityType)	1.4 -> Copy Controlled (LOM:interactivityTypeValues) to Controlled (LOM:interactivityTypeValues) (Same Vocab) ->	5.1 Label (lom:interactivityType)
5.10 Label (lom:descriptionUnbounded)	1.1 -> Simple Text Copy ->	5.10 Label (lom:descriptionUnbounded)
5.11 Label (lom:language)	1.1 -> Simple Text Copy ->	5.11 Label (lom:language)
5.2 Label (lom:learningResourceType)	1.4 -> Copy Controlled (LOM:learningResourceTypeValues) to Controlled (LOM:learningResourceTypeValues) (Same Vocab) ->	5.2 Label (lom:learningResourceType)
5.3 Label (lom:interactivityLevel)	1.4 -> Copy Controlled (LOM:interactivityLevelValues) to Controlled (LOM:interactivityLevelValues) (Same Vocab) ->	5.3 Label (lom:interactivityLevel)
5.4 Label (lom:semanticDensity)	1.4 -> Copy Controlled (LOM:semanticDensityValues) to Controlled (LOM:semanticDensityValues) (Same Vocab) ->	5.4 Label (lom:semanticDensity)
5.5 Label (lom:intendedEndUserRole)	1.4 -> Copy Controlled (LOM:intendedEndUserRoleValues) to Controlled (LOM:intendedEndUserRoleValues) (Same Vocab) ->	5.5 Label (lom:intendedEndUserRole)

Figure 2: Mapping one application profile to another

Other significant results from work package 2 include learning object repository registries, a Vocabulary Bank for Education, metadata validation services, metadata enrichment services, a broken link checker, a social data manager, etc. A complete description of these tools and services can be found in deliverables D2.5 Infrastructure and services v1.0, D2.6 Infrastructure and services v2.0 and D2.7 Infrastructure and services v3.0.

4.2 Vocabulary Manager (WP3)

The Vocabulary Manager is a tool for inserting vocabularies into users' application profiles. It was developed at the University of Koblenz, Knowledge Media Institute (IWM). The Vocabulary Manager allows a user to insert vocabularies that are located on his/her hard disk, available via the ASPECT Vocabulary Bank for Education or available via a web page link. The Vocabulary Manager is published under a Creative Commons License (http://creativecommons.org/licenses/by-nc-sa/2.5/legalcode).

The Vocabulary Manager mainly works in four steps after the user has selected an application profile for inserting vocabularies.

- First, the Vocabulary Manager unzips the profile into a temporary directory.
- It searches for already existing vocabularies in the Vocabularies' folder and parses the vocabularies.xml file.
    - If there are vocabularies that exist in the Vocabularies' directory but not in the vocabularies.xml, the tool parses these vocabularies for their name and identifier and inserts new entries into the vocabularies.xml.
    - If the vocabularies in the Vocabularies' directory are not placed in separate folders as described in the specification, the tool generates new folders for each vocabulary and copies the vocabularies into these.
- Vocabulary Manager provides three different dialogs for inserting vocabularies from the local hard disk, the Vocabulary Bank for Education and from web pages.
    - Inserting vocabularies from the hard disk is done by copying the selected vocabularies into the temporary profile folder. Additional information about the vocabulary (e.g. its name, ID, type, URL etc.) can be stated in appropriate textboxes. It will be inserted into the vocabularies.xml on saving the profile.
    - Downloading vocabularies from the Vocabulary Bank for Education is realized by generating a link out of the vocabulary authority, the vocabulary identifier and an optional vocabulary revision number. The file that is found under the link can be downloaded and saved to the temporary profiles' folder. If it is not a VDEX file, it will be deleted.
    - Downloading vocabularies from web pages works in a similar manner to downloading vocabularies from the Vocabulary Bank for Education. The only difference is that the link will not be generated automatically but has to be stated manually.
- The last step consists of two smaller steps.
    - Firstly the information about all vocabularies is saved to a new vocabularies.xml file.
    - Then the whole profile is zipped and described with the name of the old file plus the suffix "_vocabularies.zip".

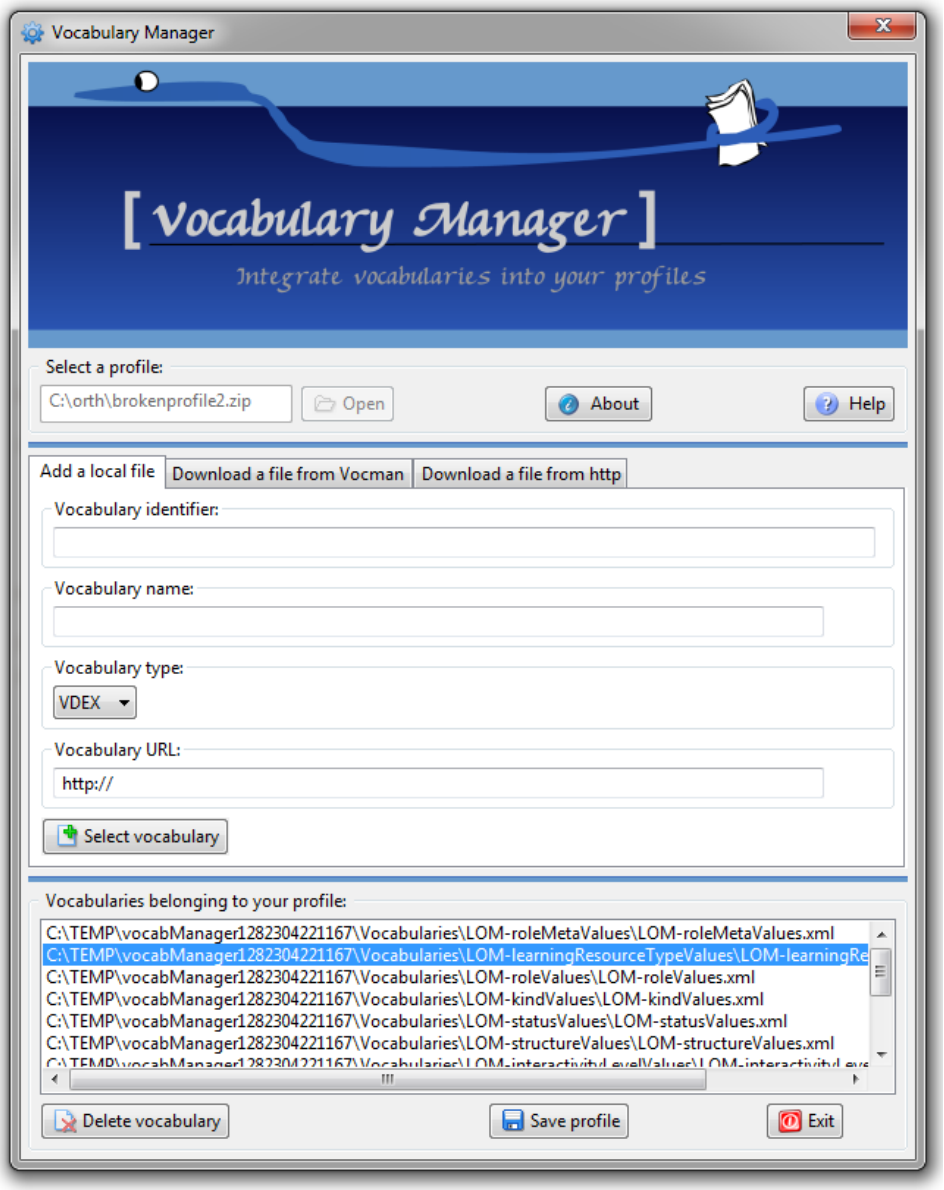

Figure 3: Loading a profile into Vocabulary Manager

Other significant outcomes resulting from work package 3 include conformance testing tools, an IMS Common Cartridge and SCORM demonstrator, and best practices for content use. A complete description of these recommendations and tools can be found in deliverables D3.1 Best Practice Report for Content Use, D3.2.1 Conformance Testing Tools version 1, D3.2.2 Conformance Testing Tools version 2, D3.3 IMS CC & SCORM Demonstrator v1.0, D3.4 Intermediate Evaluation Report for Content Use, D3.5 Best practice report for content use v2.0 and D3.6 IMS Common Cartridge & SCORM Demonstrator v2.0.

4.3 Working with IMS Common Cartridge (WP5)

When the ASPECT project started, many content providers were particularly interested in exploring the possibilities and restrictions of IMS Common Cartridge 1.0 that was a new

specification for most of them at that time. This section summarizes their experience with its implementation.

4.3.1 Understanding and implementation

The vast majority of the ASPECT content providers were involved in some work with the Common Cartridge format. Some have implemented only minor packages as part of their preparation for the teachers' summer school piloting. Others included – or examined – large-scale implementations of the specification as part of their ordinary workflow.

The general view is that the Common Cartridge specification is an interesting specification. There are a number of reasons for this interest. First, there are simple tools available to help developers get started. Second, it is easy to create packages using these tools. Finally, validation tools, such as the IMS Online Validator service, are available.

The ease of implementation is illustrated by Educatio, which is one of the organizations that decided to use the Common Cartridge format as one of the possible formats supported by their Sulinet (SDT) portal:

> As a part of ASPECT project we implemented the Common Cartridge standard that gave us the opportunity to publish our content in a way that we did not offer before to our users. The development of this service ensures that schools will be able to use the SDT content in their own learning content management systems. The implementation of Common Cartridge was an easy process and we did not meet serious problems.

The general impression is that, with the Common Cartridge Builder, a drag and drop tool developed and provided for free by *Learning Components, Inc*[7], and a simple 10-15-page tutorial, anyone can create a Common Cartridge package without any great technical skills. Thanks to the ease of implementation, one can rapidly develop a script-based and automated packaging process for larger numbers of resources.

4.3.2 Views and issues

Tools issues

As the IMS Common Cartridge is a relatively new specification, there are a number of issues. The key issue according to Global Grid for Learning (GGfL) centers on the availability of tools:

> The most significant lesson learned by Global Grid for Learning throughout ASPECT is that there is currently a significant shortage of authoring tools on the market that are standards' compliant.
>
> We have found that there are many tools that claim to be standards' compliant which are not fully compliant, or that are not compliant with the most current version of the standard.

[7] Download address: https://www.learningcomponents.com/download.php

GGfL sees the lack of standards' compliant tools as the most serious issue at the moment. To achieve complete compliance with the specification, GGfL had to carry out a great deal of manual editing of XML files generated by various tools.

Another problem noted by GGfL is that available tools lack required features:

> We have found that many of the authoring tools that have achieved standards' conformance are not yet capable of creating the quality of content that we require as publishers. AContent/ATutor, for example, is one of only two Common Cartridge authoring tools currently listed as conformant by the IMS (the full list is here: http://www.imsglobal.org/cc/statuschart.html). It does not yet have the capacity to incorporate images, which is an intrinsic part of our quiz content.

Restrictions built into the specification

Another issue raised by GGfL is the limitations placed on, for example, LOM and QTI within the Common Cartridge specification:

> We found that the limitations placed on the use of supplementary standards (such as LOM and QTI) within the Common Cartridge specification made the standard more difficult to use. Specifically:
>
> - Only six of the question types specified in QTI 1.2 are available in Common Cartridge
> - Most of the fields specified in LOM are disallowed in Common Cartridge

These restrictions were inexplicable from GGfL's point of view and they:

> Found that the restrictions increased the time and effort required to create fully conformant content as our workflows were originally designed around meeting the full specification requirements, not a subset.

So, although IMS added these restrictions in order to achieve a higher degree of simplicity in the Common Cartridge specification, to some this actually adds to the complexity of the internal workflows.

The same approach to achieve simplicity and thus a higher degree of acceptance and compliance is also an issue for Young Digital Planet (YDP), whose highly interactive learning resources require a tailored player and LMS/backend system. YDP finds it difficult to produce Common Cartridges that match the type and quality of the learning resources they currently produce.

Large-scale implementation

The right balance between simplicity and restrictions was also of concern for those working on large-scale implementations. The Open University has developed a complex workflow that allows them to provide their courses in a number of different output formats such as HTML, PDF, SCORM (IMS Content Packaging), Moodle backup, and Common Cartridge. The costs involved in large-scale production put restrictions on the features that can be used in the learning resources:

> There is no individual work required to generate the export formats and no extra effort in authoring beyond that targeted at the OpenLearn website itself. This is the only way in which it is possible for us to generate the wide range of export formats that we make available across all our existing content and anything we plan to release in future.
>
> Because this workflow matches standard course production, there is no additional cost in supporting OpenLearn content creation. However, the XML and automatic export creation approach lack flexibility to individually tune output either for a specific unit or perhaps within a specific export format.

Although it is a somewhat different issue, because it involves large-scale implementation of a particular specification and not the functionality of the specification as such, the results are the same: learning resources are simplified and standardized to reduce production costs.

Relevance of content packaging

Another key issue for a number of our content providers is that they do not consider content packaging relevant – to their users, to their view of learning, for the resources they provide, and the distribution models they have chosen so far.

Although some content providers recognize that IMS Common Cartridge is an 'improvement' over SCORM, the views relating to SCORM-packaged content continues to color their attitude towards the Common Cartridge format. As expressed by ANSAS:

> Certainly, in our view, the Common Cartridge standard is more adequate to the education world compared to the SCORM one, but it still does not correspond to our socio-constructivist view.

Others share these views. The perception persists that packaged content is somehow more 'closed' and not quite relevant to their model of learning and distribution:

> SCORM is a widely disseminated standard when it comes to packaged content. It is clearly useful for organizations that espouse a structured, behaviorist transmission of knowledge, from teacher or trainer to student or trainee.
>
> Common Cartridge originates from a different approach to learning and teaching and is thus closer to a constructivist view of education as a whole.
>
> These two standards may be useful for enterprises that want their content to be "sealed". However, for a Ministry of Education such as the Portuguese one, what seems to make sense is to open content available on its portal to everyone who may, in one way or another, benefit from its use.[8]

Distribution

Non-adoption of or lack of interest in content packaging is not just a question of learning models. Some see it primarily as a question of the distribution mechanism selected:

[8] DGIDC, from the "Report on content Packaging. The point of view of content providers", https://docs.google.com/Doc?docid=0AYLgVgqFWn46ZGhyYmI4a3JfNGRzbWZkcTVn&hl=en

> Currently, the French ENT's (VLEs) do not deal with packaged content. The content packaging standards are not very well known in the school context. The content provided by public institutions is available on the institutions' websites.

In cases when content providers offer access to their learning resources from a website as web pages, packaging content does not add any value – neither for the content provider nor the user. Value is added only if users want to – and the content providers will allow them to – integrate a copy of that content in lessons delivered by means of a 'local' LMS. If that is the case, i.e., if you are distributing complex learning resources to the local environment of the user, packaged formats provide some 'ease of distribution'. For example, it is much easier and faster to import a Common Cartridge package into one's Moodle system than importing perhaps two hundred individual resources into the LMS or having to import and set up a complex structure of resources on your web-platform.

Supporting systems

Another barrier to Common Cartridge packaged content is the need for a special player or runtime environment if one does not have an LMS/portal that supports the format. The KlasCement portal has an integrated SCORM player, but still needs a Common Cartridge player:

> At the moment we have not yet managed to implement a real Common Cartridge-player on our portal. Since the SCORM-player is already a success, we hope a (free) CC-player will become available soon.[9]

4.3.3 Conclusions

According to the ASPECT content providers, the issues and advantages in relation to Common Cartridge are:

- The specification is relatively easy to understand.
- It is relatively easy to create a script-based packaging process.
- Currently there are too few tools that produce fully compliant Common Cartridge packages.
- There is one simple drag-n-drop tool that is free and easy to use.
- Tools do not support all Common Cartridge functionalities.
- There is a freely available online validator for testing cartridges.
- The Common Cartridge specification imposes restrictions on LOM and QTI used as part of a Common Cartridge package.
- The user needs a Common Cartridge compliant LMS or environment in order to run packages.

[9] Ibid.

Other significant achievements resulting from work package 5 include evaluations of content specifications such as ADL SCORM and IMS QTI, evaluations of other specifications like IMS ILOX and IMS VDEX and an integrated system for the discovery and use of learning objects. A complete description of these achievements can be found in deliverables: D5.3 Release 1 of the integrated system, D5.4 Release 2 of the integrated system (including a Common Cartridge tutorial) and D5.5 Report on the advantages/issues associated with the large-scale implementation of selected standards.

5 Recommendations and Best Practices

The recommendations below reflect the experience of partners in the ASPECT Best Practice Network and are grouped by the different categories of stakeholders involved in the project: content providers and repository owners, tools providers, federation and discovery service builders, and standards organizations. Given that end-users should benefit from standards and specifications rather than be concerned with issues related to their implementation and adoption, they are not addressed as a category of stakeholders.

The general recommendations are those that are applicable to all the categories of stakeholders. Policy making decisions should be informed by recommendations in all the categories.

5.1 General Recommendations

R-G.1: Use standards and specifications.
There are four core reasons to use standards and specifications:

1. They avoid dependency on single vendors (vendor lock-in);
2. Their use facilitates interoperability;
3. Their use lowers costs by making it possible to build higher-level services on top of proven and standard compliant systems;
4. They represent best-practice solutions to known problems even when interoperability is not at issue.

R-G.2: Check conformance.
Standards and specifications are of little value when implemented poorly. Systematic conformance testing permits for verifying that a specification is implemented correctly and ensures (at least) syntactical interoperability.

R-G3: Select appropriate standards.
Given the profusion of standards available, it is critical to identify the existing standards of communities with which you want to interoperate. When a standard exists that addresses a certain requirement, using it, even if it is complex or incomplete – is often better than creating a new specification. Keep in mind that trying to create a new standard, when existing standards are already available, guarantees failure to interoperate with existing practices!
Do not abuse data elements: Using a data element for content for which it has not been foreseen leads to semantic interoperability problems that are particularly hard to detect. Instead, consider inserting additional elements at extension points foreseen in a specification (see also R-G5).

R-G4: Don't profile without consent.
Interoperability is jeopardized when standards and specifications are customized (profiled) without consent of the target community; in particular when data providers and data consumers use incompatible profiles. Therefore, as much as possible, try to use standards and specifications 'as-is'. A profile must always have a clearly defined scope and purpose for the target community whose needs it should meet. If no formal consensus can be reached in this community, it is recommended to meet the needs of its common practice.

Providing tools that help community members in achieving conformance with profiles can greatly ease the establishment of informal consensus.

R-G5: When profiling, preserve interoperability.
When profiling is unavoidable, keep any customization as limited as possible and profile in a way that preserves interoperability with the original specifications. For example, do not make mandatory elements optional or do not remove terms from an existing controlled vocabulary. If new elements must be introduced, do it only at the extension points foreseen in the specification. Several standardization organizations have created guidelines for application profiles. Examples of lists of dos and don'ts can be found at http://www.imsglobal.org/ap/index.html and http://www.cen-ltso.net/main.aspx?put=922.

R-G6: Combine standards and specifications consistently.
Most solutions call for combining several specifications in a domain profile. Ensure that the standards to be combined work together in a precisely defined way. Moreover, ensure that this combination is compatible with the practices of the target communities. The ASPECT Integrated System, described in ASPECT deliverable D5.4, is an example of how to combine specifications, such as OAI-PMH, IMS ILOX, IEEE LOM, IMS VDEX, in a consistent way.

R-G7: Use a progressive strategy.
Adopting a complete solution can be expensive but interoperability can be built gradually. Build interoperability in stages by adopting specifications most pertinent to your immediate requirements and progressively add other complementary specifications. For instance, adopt first the most common protocol specification in a community for exposing metadata and then add other protocols to address other needs. Always be frank: Describe explicitly which specifications or profiles are fully supported in your application.

5.2 Content Providers and Repository Owners

5.2.1 Interoperable Content

R-CP.1: Only use content specifications when required
If content is always to be used only on a single platform, providing it in a format which this particular platform can process most efficiently is usually more efficient than using a standard format. Nevertheless, the correct functioning of the content in all variants of the target platform should be carefully tested.

R-CP.2: For learning assets, stick to web-standards
When the intention is to make simple learning assets (i.e., images, videos, texts, sounds) widely available, employ web-standard formats, i.e., standards that can be directly rendered in a web browser or only require popular plug-ins such as pdf. For example, in the Learning Resource Exchange (LRE), high-quality images in encapsulated postscript (EPS) format and thus could not be rendered in a browser, were not used before they were made available in JPEG format despite their lower quality. Keep in mind that Adobe Flash is not supported by some mobile systems.

R-CP.3: Learning assets (i.e., single file content) should not be packaged

Web standards are sufficient to make learning assets interoperable and they should not be packaged. Collections of content objects should be packaged as zip files, if the structure of the collection is only used to resolve internal references.

R-CP.4: The distribution of complex content requires packaging
The distribution of complex content requires packaging because such content consists of multiple components that should be rendered in specific ways. Packaging specifications determine how complex content can be rendered. It allows the importing system to infer the intended role of each content object. The IMS Content Packaging specification should be the first choice for describing multi-faceted hierarchically structured content collections. The IMS Question and Test Interoperability (QTI) standard was designed to support the distribution of assessments.

R-CP.5: Use content package specifications used by your intended audience
Packaged content can only be rendered on platforms that support it. Use specifications supported by the platforms commonly used by your intended audience. Contact the developers of the target platforms and request precise information on the formats they can process, i.e. about the read profiles of the target platforms. Ask them for tools to test whether your content conforms to their requirements.

5.2.2 Open Content

R-CP.6: "Creative Commons" maximizes reuse
If you plan to use open content to maximize reuse, opt for a Creative Commons license.
For example, the LRE specifically encourages Creative Commons Attribution.

5.2.3 Commercial Content

R-CP.7: Make sure the distribution of interoperable content does not conflict with your business model.
There are two main categories of scenarios for accessing content. Either the content is delivered to the user or a list of links is given to the user and the content remains on the content providers' server. Since Digital Rights Management (DRM) solutions are not supported in the technology-enhanced learning domain, controlling content access requires another combination of licensing regimes and technical solutions.
When content is delivered to an institution and delivered through a learning management system (LMS), an appropriate license agreement can be enforced by the LMS's access control mechanism. When content remains on the content provider's server, that server can control access by requesting credentials or by identifying the calling system through its IP address.
The IMS Common Cartridge and Basic LTI specification define ways to control content access. It should be checked whether these features are supported by the target systems.

5.2.4 Describing Content

R-CP.8: Make metadata creation easy and, where possible, try to generate metadata automatically.

Metadata is necessary for effectively managing, finding, and assessing the usefulness of learning resources. However, creating quality metadata is a challenging activity. Most users don't like to describe learning resources and usually produce poor or incomplete descriptions while professional indexers are expensive and not always consistent over time. Many metadata elements either already exist in one form or another and can be reused or can be produced in an automatic or semi-automatic way from the resource itself or its context. Moreover, tools exist for automatic metadata creation (such as the Simple automatic metadata generation Interface – SamgI). Therefore, each time it is possible and relevant, put in place tools and services to automate the generation of metadata. The LRE Service Centre provided by ASPECT offers examples of such tools and services such as:

- The LRE automatic metadata translator that allows for systematically translating English metadata into 6 additional languages.
- The ASPECT metadata transformer that, in a fully automated way, extract metadata from a common cartridge package, generates the corresponding metadata record in a specified standard, and exposes it using OAI-PMH.

R-CP.9: Combine as many sources of information as possible about the resource.
Descriptive metadata provided by content providers is only one of the possible sources of information about a learning resource. It can be complemented by other valuable information such as:

- Usage data, such as the number of times a resource is retrieved;
- Explicit feedback from users, such as ratings and annotations (Web 2.0 tools and practices);
- Third-party metadata provided by aggregators or reviewers.

This type of information provides feedback to enhance searching by users and ranking and feedback helps providers better understand issues related to the quality and usage of their content.

5.2.5 Exposing Content

R-CP.10: Expose metadata and content in as many ways as possible.
Each specification supports a different way of exposing metadata (e.g., metadata harvesting with OAI-PMH, search with SQI, metadata publication with SPI). These specifications make possible the development of different types of specialized discovery services. Although such services offer high degrees of precision in searches, it is important to recognize that a significant number of users rely on a different set of discovery tools. These include web search engines, social web services, full text indexing, etc. Therefore it is important to expose metadata and content in ways that make them accessible by these tools.

R-CP.11: Register your repository to ensure its discoverability.
Learning object repository registries, such as the ones developed in ASPECT, allow content aggregators to easily discover and access repositories. Properly describing a repository in such a registry ensures that its content will be made available in the federations that use this registry.

R-CP.12: Describe each re-usable part of content

If content can be disaggregated, as in the case of Common Cartridges, describe each re-usable part with appropriate metadata so that it can be easily found. Metadata for parts can be inherited from metadata of the package but their validity needs to be checked.

5.3 Tools providers

R-TP.1: Build tools that support all features and options in a specification.
Some specifications (for example IMS Common Cartridge, IMS LODE, IMS QTI) define core profiles reflecting common practice.
Tools producing data should allow use of all features of these core profiles and they should have a mode disabling all features beyond those defined in the respective core profile. Tools consuming data should be capable of reading all data conforming to the core profile. They should at least tolerate additional data provided at specified extension points.

R-TP.2: Support content specifications best adapted to the type of learning scenarios a platform supports.
ADL SCORM is best suited for self-paced learning, IMS Common Cartridge is best suited for blended learning, IMS Question and Test Interoperability for assessments. Tools' providers might support one or more of these content specifications depending on the type of learning activities provided by their learning platforms.

5.4 Federation and Discovery Service Builders

R-DS.1: Minimize the cost of joining a federation.
If the barriers to joining a federation are too high, the infrastructure will not be used. Means to lower such barriers to entry include:

- Only requiring simple metadata application profile(s);
- Making appropriate tools available for joining (e.g., metadata generator, conformance tests, transformer services, metadata translators, identifier service, metadata enrichment service);
- Supporting multiple ways to join the federation both as content provider and consumer (i.e., supporting as many protocols as possible);
- Providing reference implementations for the main protocols (both server and client side);
- Providing mechanisms for sharing usage data and feedback on content within the federation.

R-DS.2: Offer persistent management of learning resources and metadata.
The following set of services and tools are recommended for this purpose (Note that the order does not impose a priority):

- A *Collection Registry* for learning object repositories is needed for providing up-to-date information on the repositories in their network. It provides interoperability between numerous LORs and other collection registries.
- An *identifier service* should be provided for maintaining persistent unique identifiers for learning objects.

- A *validation service* must be provided that checks both the syntactic and semantic validity of metadata instances against multiple standards, specifications and their application profiles.
- A broken link checker must be provided to ensure the availability of the learning objects referenced in metadata.
- It cannot be expected, nor is it necessary, that all content providers over the world should support one and the same metadata standard or application profiles. Therefore, a *transformation service* should be provided that converts metadata from one format, for instance Dublin Core or IEEE LOM, into another format, for instance IMS ILOX.
- An *enrichment service* must be used to enrich incoming metadata from content providers in order to enable better discovery rates of resources. Examples of enrichments are automatic translations of titles, descriptions, etc.
- An *application profile registry* is recommended for storage of descriptive information about application profiles conforming to a specified schema. It should be connected with links to the formal documentation of the application profile required for validation and with links to the validation tools mentioned above. Moreover the application profile registry should provide information whether a profile in the registry is a restriction of another one.
- A *vocabulary bank* should be used in which controlled vocabularies can be published and disseminated in a range of standardized interchange formats.
- A client tool such as a *harvester* should be used to semi-automate the process from harvesting metadata from content providers to making it available in the broker network.

R-DS.3: Establish good communication channels between the different stakeholders of a federation.
A good communication between the different stakeholders of a federation is key to ensure federation service quality. For example, communication with content providers requires that:

- Clear training documentation for content providers must be provided to successfully publish materials in a federation.
- Content providers must be able to subscribe to news-feeds that inform them whether a harvesting cycle (harvesting, identification, validation, etc.) succeeded or not.
- Request for Change tools such as TRAC are deployed to enable people to report problems with services, tools, etc.

R-DS.4: Use already existing best practices and tools when setting up a federation.
The ASPECT project and others have produced many recommendations, tools, and best practices for efficiently managing federations. All these tools and services are available on the LRE service centre provided by ASPECT.

5.5 Standards Organizations

R-SO.1: Support the development of free and user-friendly tools to edit, deploy, re-arrange, and play educational content.
These tools should have open interfaces following open specifications. Coordinate the development of these tools. Leverage the potential of open source development in Europe.

R-SO.2: Provide community-based conformance competence forums, supporting stakeholders which apply open educational standards. These centers should be freely accessible for all. They should allow for open discussions of practical interoperability issues.
No specification can foresee all potential issues. Authorize a specification management group to rapidly provide preliminary recommendations on how newly emerging issues should be handled until the specification is updated.

R-SO.3: Support the development of application profiles and domain profiles of existing standards reflecting what is used in common practice.
Provide tools helping software developers and content authors to become fully compliant with these profiles. Develop a culture where the end user can rely that *all* features described in these profiles are implemented in any product that claims conformance. Only release standards and profiles that have been fully implemented and tested.

R-SO.4: Maintain backward compatibility
Whenever possible, data conformant to one version of a specification should remain conformant when the specification is updated. This builds trust into the specification, avoids re-engineering costs prevents slow-down of specification take-up.

R-SO.5: Do not encode controlled vocabularies in bindings.
Controlled vocabularies evolve rapidly to meet changing requirements and must often be available in multiple languages. Terms and their definitions must also be documented. The management of controlled vocabularies is optimized when they are encoded using specifications such as VDEX, ZTHES, or SKOS and stored in a bank (such as the ASPECT Vocabulary Bank for Education) independent of a binding. The binding can then refer to these external vocabularies. This comes at the price of an extra look up for resolving an identifier into the corresponding vocabulary term in a given language. However, the benefits (e.g., better management of controlled vocabularies, support for multilingualism – see R-SO.6) are worth this extra cost. Moreover, in order to lower this cost, ASPECT has developed an array of tools to integrate binding and vocabularies. These include the ASPECT transformer service, the ASPECT Application Profile Registry, the ASPECT Vocabulary Management Tool, the ASPECT Validation Services. When using changing vocabularies, make sure content is conformance tested using the latest version of the vocabularies in use.

R-SO.6: Uniquely identify each controlled vocabulary and controlled vocabulary term and only use identifiers in metadata records.
Because identifiers are language neutral tokens, they can be associated with multiple translations of the same term. Using tokens in metadata records makes it possible to display in a given language a metadata record created in another language provided that both languages are available in the vocabulary bank.
Note that this recommendation is applicable to all organizations developing controlled vocabularies, not just standards organizations.

6 Target Users & their Needs

The following stakeholders can benefit directly or indirectly from the ASPECT best practices related to the implementation of standards and specifications for content discovery and use:

- Educators will have an easy way to discover learning content that addresses the needs of their students, making their jobs easier, and maximizing re-use and minimizing costs by repurposing materials.
- Students benefit from having access to high-quality learning resources; these can make a significant impact on the quality of their learning experience and their learning outcomes.
- Content providers will be able to more easily make their products interoperable and to promote/market them by making them globally discoverable.
- System vendors will only need to support a limited set of specifications to make their systems compliant with learning resources from major federations.
- Finally, repository and federation builders will secure and maximize their investment by developing infrastructures based on standard specifications.

Within ASPECT, there was a specific work package (WP7) dedicated to examining stakeholder requirements, including those of: (i) teachers directly involved in the school pilots; (ii) content providers (including both Ministries of Education and commercial providers) that were members of the ASPECT Consortium; and (iii) organisations that declared an interest in ASPECT's work and that registered as ASPECT Associate Partners. The final evaluation report (D7.3.2) from this work package can be accessed on the project web site[10].

Work in ASPECT also leveraged and drew on the user requirements and needs continually identified in the context of European Schoolnet's Learning Resource Exchange (LRE) service[11]. Of particular note here are the activities of the LRE Subcommittee of European Schoolnet (EUN) that includes nine Ministries of Education. This subcommittee was created by the EUN Steering Committee (consisting of thirty-one Ministries) on 26 May 2010 to define the strategy and operational rules of the LRE, to manage its ongoing development and to ensure that it is properly aligned with national content strategies for schools. ASPECT progress and results were presented and discussed with Ministries at each LRE Subcommittee meeting and, at these meetings, Ministries themselves also reported on how the content requirements and needs of their teachers and schools were developing.

[10] http://aspect-project.org.
[11] http://lre.eun.org.

7 Impact & Sustainability

As the ASPECT Best Practice Network (BPN) identified best practices for the use of standards and specifications in the field of content discovery and use, its partners fed the project's experience into standardisation activities and ran an extensive set of dissemination actions. These included over thirty face-to-face international workshops, plugfests, regional events and online webinars and a final dissemination event on educational publishing futures attended by more than 150 participants.

A total of 1479 participants attended the various ASPECT BPN dissemination activities. The project engaged with 197 associated partners and developed a unique co-operation framework for all stakeholders who, after the end of the project, continue to benefit from a set of new support services that include: registries of learning object repositories; a vocabulary bank for education; an application profile registry; an automatic translation service for metadata; compliance testing; transformer services; a social data manager; and access to the knowledge accumulated during the project.

The following outcomes of the project are expected to have a long-term impact on the technology-enhanced learning field:

- Learning Resource Exchange (LRE);
- LRE Service Centre;
- Specifications such as IMS LODE or CEN WSLT SPI.

Most of the tools, services, and recommendations developed by ASPECT have already been integrated with the Learning Resource Exchange (LRE) service for schools, making it a standard-based infrastructure for the delivery of learning content to schools in Europe. As an active federation of learning object repositories, the LRE is a real-life example of the project's impact.

The ASPECT partners use the tools and services of the LRE Service Centre for their own operations and have agreed to support the LRE Service Centre after the end of the project. This guarantees that the tools and services developed during the project, most of them as open source software, will be further developed and remain publicly available.

Finally, ASPECT had a strategic impact on standardisation activities. Thanks to the experience gained during the project, partners were able to submit proposals for new specifications to European and international standardisation bodies and to actively participate in the resulting workgroups:

- IMS Learning Object Discovery and Exchange
- CEN WSLT - Simple Publishing Interface
- CEN WSLT - Interoperability of Learning Object Repository Registries
- CEN WSLT - Social Data
- CEN TC 353 - Simple Query Interface
- CEN TC 353 - Simple Publishing Interface
- CEN TC 353 - Curriculum Exchange Format

In addition, ASPECT actively contributed to the following standardization efforts initiated by others:

- ADL SCORM Harmonization
- IMS Common Cartridge
- IMS Question and Test Interoperability
- US Dept. of Education Learning Registry
- NSDL Paradata

8 ASPECT for Stakeholders

This section presents the main results of the project by categories of stakeholders: Ministries of Education, teachers and students, commercial content developers, owners of learning content repositories, tools providers, and experts in standards. For each category, it presents specific recommendations, tools and services, and deliverables.

8.1 ASPECT for Ministries of Education

8.1.1 Recommendations

R-G.1: Use standards and specifications.

There are four core reasons to use standards and specifications:

1. They avoid dependency on single vendors (vendor lock-in);
2. Their use facilitates interoperability;
3. Their use lowers costs by making it possible to build higher-level services on top of proven and standard compliant systems;
4. They represent best-practice solutions to known problems even when interoperability is not at issue.

R-G.2: Check conformance.

Standards and specifications are of little value when implemented poorly. Systematic conformance testing permits for verifying that a specification is implemented correctly and ensures (at least) syntactical interoperability.

R-G3: Select appropriate standards.

Given the profusion of standards available, it is critical to identify the existing standards of communities with which you want to interoperate. When a standard exists that addresses a certain requirement, using it, even if it is complex or incomplete – is often better than creating a new specification. Keep in mind that trying to create a new standard, when existing standards are already available, guarantees failure to interoperate with existing practices!

Do not abuse data elements: Using a data element for content for which it has not been foreseen leads to semantic interoperability problems that are particularly hard to detect. Instead, consider inserting additional elements at extension points foreseen in a specification (see also R-G5).

R-G4: Don't profile without consent.

Interoperability is jeopardized when standards and specifications are customized (profiled) without consent of the target community; in particular when data providers and data consumers use incompatible profiles. Therefore, as much as possible, try to use standards and specifications 'as-is'. A profile must always have a clearly defined scope and purpose for the target community whose needs it should meet. If no formal consensus can be reached in this community, it is recommended to meet the needs of its common practice.

Providing tools that help community members in achieving conformance with profiles can greatly ease the establishment of informal consensus.

R-G5: When profiling, preserve interoperability.

When profiling is unavoidable, keep any customization as limited as possible and profile in a way that preserves interoperability with the original specifications. For example, do not make mandatory elements optional or do not remove terms from an existing controlled vocabulary. If new elements must be introduced, do it only at the extension points foreseen in the specification. Several standardization organizations have created guidelines for application profiles. Examples of lists of dos and don'ts can be found at http://www.imsglobal.org/ap/index.html and http://www.cen-ltso.net/main.aspx?put=922.

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R-G7: Use a progressive strategy.
Adopting a complete solution can be expensive but interoperability can be built gradually. Build interoperability in stages by adopting specifications most pertinent to your immediate requirements and progressively add other complementary specifications. For instance, adopt first the most common protocol specification in a community for exposing metadata and then add other protocols to address other needs. Always be frank: Describe explicitly which specifications or profiles are fully supported in your application.

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If content is always to be used only on a single platform, providing it in a format which this particular platform can process most efficiently is usually more efficient than using a standard format. Nevertheless, the correct functioning of the content in all variants of the target platform should be carefully tested.

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Web standards are sufficient to make learning assets interoperable and they should not be packaged. Collections of content objects should be packaged as zip files, if the structure of the collection is only used to resolve internal references.

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If the barriers to joining a federation are too high, the infrastructure will not be used. Means to lower such barriers to entry include:

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- A *Collection Registry* for learning object repositories is needed for providing up-to-date information on the repositories in their network. It provides interoperability between numerous LORs and other collection registries.
- An *identifier service* should be provided for maintaining persistent unique identifiers for learning objects.
- A *validation service* must be provided that checks both the syntactic and semantic validity of metadata instances against multiple standards, specifications and their application profiles.
- A broken link checker must be provided to ensure the availability of the learning objects referenced in metadata.
- It cannot be expected, nor is it necessary, that all content providers over the world should support one and the same metadata standard or application profiles. Therefore, a *transformation service* should be provided that converts metadata from one format, for instance Dublin Core or IEEE LOM, into another format, for instance IMS ILOX.
- An *enrichment service* must be used to enrich incoming metadata from content providers in order to enable better discovery rates of resources. Examples of enrichments are automatic translations of titles, descriptions, etc.
- An *application profile registry* is recommended for storage of descriptive information about application profiles conforming to a specified schema. It should be connected with links to the formal documentation of the application profile required for validation and with links to the validation tools mentioned above. Moreover the application profile registry should provide information whether a profile in the registry is a restriction of another one.
- A *vocabulary bank* should be used in which controlled vocabularies can be published and disseminated in a range of standardized interchange formats.
- A client tool such as a *harvester* should be used to semi-automate the process from harvesting metadata from content providers to making it available in the broker network.

R-DS.3: Establish good communication channels between the different stakeholders of a federation.

A good communication between the different stakeholders of a federation is key to ensure federation service quality. For example, communication with content providers requires that:

- Clear training documentation for content providers must be provided to successfully publish materials in a federation.
- Content providers must be able to subscribe to news-feeds that inform them whether a harvesting cycle (harvesting, identification, validation, etc.) succeeded or not.
- Request for Change tools such as TRAC are deployed to enable people to report problems with services, tools, etc.

R-DS.4: Use already existing best practices and tools when setting up a federation.
The ASPECT project and others have produced many recommendations, tools, and best practices for efficiently managing federations. All these tools and services are available on the LRE service centre provided by ASPECT.

R-SO.1: Support the development of free and user-friendly tools to edit, deploy, re-arrange, and play educational content.
These tools should have open interfaces following open specifications. Coordinate the development of these tools. Leverage the potential of open source development in Europe.

R-SO.2: Provide community-based conformance competence forums, supporting stakeholders which apply open educational standards. These centers should be freely accessible for all. They should allow for open discussions of practical interoperability issues. No specification can foresee all potential issues. Authorize a specification management group to rapidly provide preliminary recommendations on how newly emerging issues should be handled until the specification is updated.

R-SO.3: Support the development of application profiles and domain profiles of existing standards reflecting what is used in common practice.
Provide tools helping software developers and content authors to become fully compliant with these profiles. Develop a culture where the end user can rely that *all* features described in these profiles are implemented in any product that claims conformance. Only release standards and profiles that have been fully implemented and tested.

R-SO.4: Maintain backward compatibility
Whenever possible, data conformant to one version of a specification should remain conformant when the specification is updated. This builds trust into the specification, avoids re-engineering costs prevents slow-down of specification take-up.

R-SO.5: Do not encode controlled vocabularies in bindings.
Controlled vocabularies evolve rapidly to meet changing requirements and must often be available in multiple languages. Terms and their definitions must also be documented. The management of controlled vocabularies is optimized when they are encoded using specifications such as VDEX, ZTHES, or SKOS and stored in a bank (such as the ASPECT Vocabulary Bank for Education) independent of a binding. The binding can then refer to these external vocabularies. This comes at the price of an extra look up for resolving an identifier into the corresponding vocabulary term in a given language. However, the benefits (e.g., better management of controlled vocabularies, support for multilingualism – see R-SO.6) are worth this extra cost. Moreover, in order to lower this cost, ASPECT has

developed an array of tools to integrate binding and vocabularies. These include the ASPECT transformer service, the ASPECT Application Profile Registry, the ASPECT Vocabulary Management Tool, the ASPECT Validation Services. When using changing vocabularies, make sure content is conformance tested using the latest version of the vocabularies in use.

R-SO.6: Uniquely identify each controlled vocabulary and controlled vocabulary term and only use identifiers in metadata records.
Because identifiers are language neutral tokens, they can be associated with multiple translations of the same term. Using tokens in metadata records makes it possible to display in a given language a metadata record created in another language provided that both languages are available in the vocabulary bank.
Note that this recommendation is applicable to all organizations developing controlled vocabularies, not just standards organizations.

8.1.2 Tools and Services

Learning Technology Standards Observatory LTSO

- **URL:** http://www.cen-ltso.net
- **End users:** Anyone interested in Learning Technology Standards and Specifications
- **Description:** The Learning Technology Standards Observatory (LTSO) is a focal access point to updated information on projects, results, news, organisations, activities and events that are relevant to the development and adoption of e-learning technology standards and specifications. It offers a newsletter service, access to relevant experts and up-to-date information in this field.

Vocabulary Bank for Education VBE

- **URL:** http://aspect.vocman.com/vbe/
- **End users:** Taggers, taxonomists, developers and curriculum designers.
- **Description:** The ASPECT Vocabulary Bank for Education (VBE) provides a browsable and searchable web application to locate, view and download sets of terms, plus a machine interface (REST API). The vocabularies can be used for metadata, in particular for the Learning Resource Exchange.

LRE Learning Object Repository Registry (LORRy)

- **URL:** http://lreregistry.eun.org:5984/registry/_design/registry/index.html
- **End users:** Content providers, repository owners, learning object federation administrators
- **Description:** The LRE LORRy is a catalog that provides up-to-date information on repositories of learning resources. It facilitates the access to the content of these repositories by describing: Collections of learning content (e.g., languages, formats, topics covered); collections of metadata used to describe this content (e.g., metadata schemas, metadata languages) and protocols used to get access to these collections (e.g., OAI-PMH, SQI, SPI, SRU/SRW)

ARIADNE Collection Registry

- **URL:** http://ariadne.cs.kuleuven.be/ariadne-registry/
- **End users:** System administrators of content providers, developers of registry client tools

- **Description:** The Collection Registry enables the interconnection of learning object repositories, in order to further increase their impact in making relevant content available to teachers, trainers and (life-long) learners, by specifying the locations of those repositories and the description of the protocols they support for exposing their learning resources to the consumers of the registry.

ARIADNE Validation Service

- **URL:** http://ariadne.cs.kuleuven.be/validationService/
- **End users:** System Administrators & developers of Content providers
- **Description:** The validation service is available for providing validation of metadata instances against predefined application profiles, for example based on IEEE LOM such as the LREv4.5 AP. To ensure that only compliant metadata are stored in a LOR, we use the validation service to check both the syntactic and semantic validity of the instances against the used profiles. The validation service has a modular approach, and combines different sorts of validation techniques, etc.

8.1.3 Deliverables

- D1.3.2 Final Public Report
- D3.1 Best Practice Report for Content Use
- D3.2.2 Conformance Testing Tools version 2
- D3.3 IMS CC & SCORM Demonstrator v1.0
- D3.5 Best practice report for content use v2.0
- D3.6 IMS CC & SCORM Demonstrator v2.0
- D4.4.2 Report on ASPECT workshops, plugfests and conferences
- D4.6 LRE Service Center provided by ASPECT
- D5.1 A critical mass of metadata that can be searched for and discovered seamlessly
- D5.2 A critical mass of content to which a set of preferred standards and specifications have been applied
- Part of D5.4: Common Cartridge tutorial
- D5.5 Report on the advantages/issues associated with the large-scale implementation of selected standards
- D6.3 Report on summer school
- D6.4 National Validation reports
- D6.5 Final Report on the Experimentation
- D7.3.2 Final Evaluation Report

All these deliverables can be accessed from http://aspect-project.org/node/28.

8.2 ASPECT for Teachers and Students

Given that teachers and students should benefit from standards and specifications rather than be concerned with issues related to their implementation and adoption, there are a limited number of general-purpose recommendations, tools, and deliverables produced by ASPECT that might be of interest for them. They are listed below. However, all the ASPECT recommendations, tools, services, and deliverables aim at making learning easier to discover

and use by teachers and students as illustrated by the Learning Resource Exchange portal available at http://lreforschools.eun.org. The Learning Resource Exchange (LRE) from European Schoolnet (EUN) is a service that enables schools to find educational content from many different countries and providers. It was developed in order to provide Ministries of Education with access to a network of learning content repositories and associated tools that allow them to more easily exchange high quality learning resources that 'travel well' and can be used by teachers and students in different countries. The LRE uses the ASPECT tools and implements its best practices.

8.2.1 Recommendations

R-G.1: Use standards and specifications.

There are four core reasons to use standards and specifications:

1. They avoid dependency on single vendors (vendor lock-in);
2. Their use facilitates interoperability;
3. Their use lowers costs by making it possible to build higher-level services on top of proven and standard compliant systems;
4. They represent best-practice solutions to known problems even when interoperability is not at issue.

8.2.2 Tools and Services

Learning Technology Standards Observatory LTSO

- URL: http://www.cen-ltso.net
- End users: Anyone interested in Learning Technology Standards and Specifications
- Description: The Learning Technology Standards Observatory (LTSO) is a focal access point to updated information on projects, results, news, organisations, activities and events that are relevant to the development and adoption of e-learning technology standards and specifications. It offers a newsletter service, access to relevant experts and up-to-date information in this field.

8.2.3 Deliverables

- D1.3.2 Final Public Report
- Part of D5.4: Common Cartridge tutorial
- D6.3 Report on summer school
- D6.4 National Validation reports
- D6.5 Final Report on the Experimentation

All these deliverables can be accessed from http://aspect-project.org/node/28.

8.3 ASPECT for Commercial Content Providers

8.3.1 Recommendations

R-G.1: Use standards and specifications.

There are four core reasons to use standards and specifications:

5. They avoid dependency on single vendors (vendor lock-in);
6. Their use facilitates interoperability;
7. Their use lowers costs by making it possible to build higher-level services on top of proven and standard compliant systems;

8. They represent best-practice solutions to known problems even when interoperability is not at issue.

R-G.2: Check conformance.
Standards and specifications are of little value when implemented poorly. Systematic conformance testing permits for verifying that a specification is implemented correctly and ensures (at least) syntactical interoperability.

R-G3: Select appropriate standards.
Given the profusion of standards available, it is critical to identify the existing standards of communities with which you want to interoperate. When a standard exists that addresses a certain requirement, using it, even if it is complex or incomplete – is often better than creating a new specification. Keep in mind that trying to create a new standard, when existing standards are already available, guarantees failure to interoperate with existing practices!
Do not abuse data elements: Using a data element for content for which it has not been foreseen leads to semantic interoperability problems that are particularly hard to detect. Instead, consider inserting additional elements at extension points foreseen in a specification (see also R-G5).

R-G4: Don't profile without consent.
Interoperability is jeopardized when standards and specifications are customized (profiled) without consent of the target community; in particular when data providers and data consumers use incompatible profiles. Therefore, as much as possible, try to use standards and specifications 'as-is'. A profile must always have a clearly defined scope and purpose for the target community whose needs it should meet. If no formal consensus can be reached in this community, it is recommended to meet the needs of its common practice.
Providing tools that help community members in achieving conformance with profiles can greatly ease the establishment of informal consensus.

R-G5: When profiling, preserve interoperability.
When profiling is unavoidable, keep any customization as limited as possible and profile in a way that preserves interoperability with the original specifications. For example, do not make mandatory elements optional or do not remove terms from an existing controlled vocabulary. If new elements must be introduced, do it only at the extension points foreseen in the specification. Several standardization organizations have created guidelines for application profiles. Examples of lists of dos and don'ts can be found at http://www.imsglobal.org/ap/index.html and http://www.cen-ltso.net/main.aspx?put=922.

R-G6: Combine standards and specifications consistently.
Most solutions call for combining several specifications in a domain profile. Ensure that the standards to be combined work together in a precisely defined way. Moreover, ensure that this combination is compatible with the practices of the target communities. The ASPECT Integrated System, described in ASPECT deliverable D5.4, is an example of how to combine specifications, such as OAI-PMH, IMS ILOX, IEEE LOM, IMS VDEX, in a consistent way.

R-G7: Use a progressive strategy.
Adopting a complete solution can be expensive but interoperability can be built gradually. Build interoperability in stages by adopting specifications most pertinent to your immediate

requirements and progressively add other complementary specifications. For instance, adopt first the most common protocol specification in a community for exposing metadata and then add other protocols to address other needs. Always be frank: Describe explicitly which specifications or profiles are fully supported in your application.

R-CP.1: Only use content specifications when required
If content is always to be used only on a single platform, providing it in a format which this particular platform can process most efficiently is usually more efficient than using a standard format. Nevertheless, the correct functioning of the content in all variants of the target platform should be carefully tested.

R-CP.2: For learning assets, stick to web-standards
When the intention is to make simple learning assets (i.e., images, videos, texts, sounds) widely available, employ web-standard formats, i.e., standards that can be directly rendered in a web browser or only require popular plug-ins such as pdf. For example, in the Learning Resource Exchange (LRE), high-quality images in encapsulated postscript (EPS) format and thus could not be rendered in a browser, were not used before they were made available in JPEG format despite their lower quality. Keep in mind that Adobe Flash is not supported by some mobile systems.

R-CP.3: Learning assets (i.e., single file content) should not be packaged
Web standards are sufficient to make learning assets interoperable and they should not be packaged. Collections of content objects should be packaged as zip files, if the structure of the collection is only used to resolve internal references.

R-CP.4: The distribution of complex content requires packaging
The distribution of complex content requires packaging because such content consists of multiple components that should be rendered in specific ways. Packaging specifications determine how complex content can be rendered. It allows the importing system to infer the intended role of each content object. The IMS Content Packaging specification should be the first choice for describing multi-faceted hierarchically structured content collections. The IMS Question and Test Interoperability (QTI) standard was designed to support the distribution of assessments.

R-CP.5: Use content package specifications used by your intended audience
Packaged content can only be rendered on platforms that support it. Use specifications supported by the platforms commonly used by your intended audience. Contact the developers of the target platforms and request precise information on the formats they can process, i.e. about the read profiles of the target platforms. Ask them for tools to test whether your content conforms to their requirements.

R-CP.6: "Creative Commons" maximizes reuse
If you plan to use open content to maximize reuse, opt for a Creative Commons license.
For example, the LRE specifically encourages Creative Commons Attribution.

R-CP.7: Make sure the distribution of interoperable content does not conflict with your business model.

There are two main categories of scenarios for accessing content. Either the content is delivered to the user or a list of links is given to the user and the content remains on the content providers' server. Since Digital Rights Management (DRM) solutions are not supported in the technology-enhanced learning domain, controlling content access requires another combination of licensing regimes and technical solutions.
When content is delivered to an institution and delivered through a learning management system (LMS), an appropriate license agreement can be enforced by the LMS's access control mechanism. When content remains on the content provider's server, that server can control access by requesting credentials or by identifying the calling system through its IP address.
The IMS Common Cartridge and Basic LTI specification define ways to control content access. It should be checked whether these features are supported by the target systems.

R-CP.8: Make metadata creation easy and, where possible, try to generate metadata automatically.
Metadata is necessary for effectively managing, finding, and assessing the usefulness of learning resources. However, creating quality metadata is a challenging activity. Most users don't like to describe learning resources and usually produce poor or incomplete descriptions while professional indexers are expensive and not always consistent over time. Many metadata elements either already exist in one form or another and can be reused or can be produced in an automatic or semi-automatic way from the resource itself or its context. Moreover, tools exist for automatic metadata creation (such as the Simple automatic metadata generation Interface – SamgI). Therefore, each time it is possible and relevant, put in place tools and services to automate the generation of metadata. The LRE Service Centre provided by ASPECT offers examples of such tools and services such as:

- The LRE automatic metadata translator that allows for systematically translating English metadata into 6 additional languages.
- The ASPECT metadata transformer that, in a fully automated way, extract metadata from a common cartridge package, generates the corresponding metadata record in a specified standard, and exposes it using OAI-PMH.

R-CP.9: Combine as many sources of information as possible about the resource.
Descriptive metadata provided by content providers is only one of the possible sources of information about a learning resource. It can be complemented by other valuable information such as:

- Usage data, such as the number of times a resource is retrieved;
- Explicit feedback from users, such as ratings and annotations (Web 2.0 tools and practices);
- Third-party metadata provided by aggregators or reviewers.

This type of information provides feedback to enhance searching by users and ranking and feedback helps providers better understand issues related to the quality and usage of their content.

R-CP.10: Expose metadata and content in as many ways as possible.
Each specification supports a different way of exposing metadata (e.g., metadata harvesting with OAI-PMH, search with SQI, metadata publication with SPI). These specifications make possible the development of different types of specialized discovery services. Although such services offer high degrees of precision in searches, it is important to recognize that a significant number of users rely on a different set of discovery tools. These include web

search engines, social web services, full text indexing, etc. Therefore it is important to expose metadata and content in ways that make them accessible by these tools.

R-CP.11: Register your repository to ensure its discoverability.
Learning object repository registries, such as the ones developed in ASPECT, allow content aggregators to easily discover and access repositories. Properly describing a repository in such a registry ensures that its content will be made available in the federations that use this registry.

R-CP.12: Describe each re-usable part of content
If content can be disaggregated, as in the case of Common Cartridges, describe each re-usable part with appropriate metadata so that it can be easily found. Metadata for parts can be inherited from metadata of the package but their validity needs to be checked.

8.3.2 Tools and Services

Learning Technology Standards Observatory LTSO

- **URL:** http://www.cen-ltso.net
- **End users:** Anyone interested in Learning Technology Standards and Specifications
- **Description:** The Learning Technology Standards Observatory (LTSO) is a focal access point to updated information on projects, results, news, organisations, activities and events that are relevant to the development and adoption of e-learning technology standards and specifications. It offers a newsletter service, access to relevant experts and up-to-date information in this field.

Application Profile Registry

- **URL:** http://apr.vocman.com
- **End Users:** Systems needing information about application profiles. Owners of application profiles and specialists developing new application profiles
- **Description:** The ASPECT Application Profile Registry (APR) provides a browsable interface, which allows specialists to find information about the data elements and vocabularies used by different application profiles and to view mappings between different profiles of the same base standard. The interface allows authorised users to add details of new application profiles. The machine interface (REST API) provides this information in XML and JSON formats to consuming systems.

Vocabulary Bank for Education VBE

- **URL:** http://aspect.vocman.com/vbe/
- **End users:** Taggers, taxonomists, developers and curriculum designers.
- **Description:** The ASPECT Vocabulary Bank for Education (VBE) provides a browsable and searchable web application to locate, view and download sets of terms, plus a machine interface (REST API). The vocabularies can be used for metadata, in particular for the Learning Resource Exchange.

ARIADNE Validation Service

- **URL:** http://ariadne.cs.kuleuven.be/validationService/
- **End users:** System Administrators & developers of Content providers
- **Description:** The validation service is available for providing validation of metadata instances against predefined application profiles, for example based on IEEE LOM

such as the LREv4.5 AP. To ensure that only compliant metadata are stored in a LOR, we use the validation service to check both the syntactic and semantic validity of the instances against the used profiles. The validation service has a modular approach, and combines different sorts of validation techniques, etc.

Transformer Service, transforming metadata and vocabularies into another format

- **URL:** http://lrecoreprod.eun.org:6080/mtdTransformer/
- **Source code:** https://lretools.svn.sourceforge.net/svnroot/lretools/trunk/transformation-service
- **End users:** Metadata creators, Metadata developers
- **Description:** The purpose of the Metadata transformation service is to allow users transform metadata from one format (one application profile) such as LOM Strict to another format (another application profile) such as LREv4.0 application profile. The service does not only support structural transformation using Extensible Stylesheet Language (XSL) transformation or Java-based transformation but also support for the vocabulary crosswalks from the vocabulary bank. From a software standpoint, it is based on a plugin architecture where new transformations can be added as plugins, provided as jar files, with no needs for modifying the transformer core. The transformation service is available online at http://lrecoreprod.eun.org:6080/mtdTransformer/. However, this version only permits users to transform one metadata instance at a time, which is convenient for demonstration or to see how the transformation service works. In case the user wants to transform a large number of metadata instances, it is recommended that the user checks out the transformation library at source forge and develops an upper "layout" which connects to his/her repository.

Automatic Translation Service for Learning Object Metadata

- **URL:** http://lreforschools.eun.org, http://lrecoreprod.eun.org:6080/oaitarget/OAIHandler?verb=Identify
- **End users:** Metadata editors, LRE end users
- **Description:** Automatic Translation Service, which is integrated in the Learning Resource Exchange (LRE), enables better discovery rate of resources. All the metadata collected by the LRE are machine translated from English into German, Greek, Spanish, French, Italian and Portuguese using SYSTRAN. Due to license costs, these services are currently limited to the LRE Associate Partners and ASPECT Associate Partners. Partners' metadata collections that contribute to the LRE are enriched with translations and identifiers and can be harvested back using the LRE OAI-PMH target (http://lrecoreprod.eun.org:6080/oaitarget/OAIHandler?verb=Identify).

8.3.3 Deliverables

- D1.3.2 Final Public Report
- D2.1 ASPECT Approach to Federated Search and Harvesting of Learning Object Repositories
- D2.3 ASPECT Approach To Multilingual Vocabularies, Including Automated Translation Services
- D3.1 Best Practice Report for Content Use
- D3.2.2 Conformance Testing Tools version 2

- D3.5 Best practice report for content use v2.0
- D3.6 IMS CC & SCORM Demonstrator v2.0
- D4.6 LRE Service Center provided by ASPECT
- D5.5 Report on the advantages/issues associated with the large-scale implementation of selected standards
- D6.5 Final Report on the Experimentation

All these deliverables can be accessed from http://aspect-project.org/node/28.

8.4 ASPECT for Owners of Learning Content Repositories

8.4.1 Recommendations

R-G.1: Use standards and specifications.
There are four core reasons to use standards and specifications:

5. They avoid dependency on single vendors (vendor lock-in);
6. Their use facilitates interoperability;
7. Their use lowers costs by making it possible to build higher-level services on top of proven and standard compliant systems;
8. They represent best-practice solutions to known problems even when interoperability is not at issue.

R-G.2: Check conformance.
Standards and specifications are of little value when implemented poorly. Systematic conformance testing permits for verifying that a specification is implemented correctly and ensures (at least) syntactical interoperability.

R-G3: Select appropriate standards.
Given the profusion of standards available, it is critical to identify the existing standards of communities with which you want to interoperate. When a standard exists that addresses a certain requirement, using it, even if it is complex or incomplete – is often better than creating a new specification. Keep in mind that trying to create a new standard, when existing standards are already available, guarantees failure to interoperate with existing practices!
Do not abuse data elements: Using a data element for content for which it has not been foreseen leads to semantic interoperability problems that are particularly hard to detect. Instead, consider inserting additional elements at extension points foreseen in a specification (see also R-G5).

R-G4: Don't profile without consent.
Interoperability is jeopardized when standards and specifications are customized (profiled) without consent of the target community; in particular when data providers and data consumers use incompatible profiles. Therefore, as much as possible, try to use standards and specifications 'as-is'. A profile must always have a clearly defined scope and purpose for the target community whose needs it should meet. If no formal consensus can be reached in this community, it is recommended to meet the needs of its common practice.
Providing tools that help community members in achieving conformance with profiles can greatly ease the establishment of informal consensus.

R-G5: When profiling, preserve interoperability.

When profiling is unavoidable, keep any customization as limited as possible and profile in a way that preserves interoperability with the original specifications. For example, do not make mandatory elements optional or do not remove terms from an existing controlled vocabulary. If new elements must be introduced, do it only at the extension points foreseen in the specification. Several standardization organizations have created guidelines for application profiles. Examples of lists of dos and don'ts can be found at http://www.imsglobal.org/ap/index.html and http://www.cen-ltso.net/main.aspx?put=922.

R-G6: Combine standards and specifications consistently.
Most solutions call for combining several specifications in a domain profile. Ensure that the standards to be combined work together in a precisely defined way. Moreover, ensure that this combination is compatible with the practices of the target communities. The ASPECT Integrated System, described in ASPECT deliverable D5.4, is an example of how to combine specifications, such as OAI-PMH, IMS ILOX, IEEE LOM, IMS VDEX, in a consistent way.

R-G7: Use a progressive strategy.
Adopting a complete solution can be expensive but interoperability can be built gradually. Build interoperability in stages by adopting specifications most pertinent to your immediate requirements and progressively add other complementary specifications. For instance, adopt first the most common protocol specification in a community for exposing metadata and then add other protocols to address other needs. Always be frank: Describe explicitly which specifications or profiles are fully supported in your application.

R-CP.1: Only use content specifications when required
If content is always to be used only on a single platform, providing it in a format which this particular platform can process most efficiently is usually more efficient than using a standard format. Nevertheless, the correct functioning of the content in all variants of the target platform should be carefully tested.

R-CP.2: For learning assets, stick to web-standards
When the intention is to make simple learning assets (i.e., images, videos, texts, sounds) widely available, employ web-standard formats, i.e., standards that can be directly rendered in a web browser or only require popular plug-ins such as pdf. For example, in the Learning Resource Exchange (LRE), high-quality images in encapsulated postscript (EPS) format and thus could not be rendered in a browser, were not used before they were made available in JPEG format despite their lower quality. Keep in mind that Adobe Flash is not supported by some mobile systems.

R-CP.3: Learning assets (i.e., single file content) should not be packaged
Web standards are sufficient to make learning assets interoperable and they should not be packaged. Collections of content objects should be packaged as zip files, if the structure of the collection is only used to resolve internal references.

R-CP.4: The distribution of complex content requires packaging
The distribution of complex content requires packaging because such content consists of multiple components that should be rendered in specific ways. Packaging specifications determine how complex content can be rendered. It allows the importing system to infer the intended role of each content object. The IMS Content Packaging specification should be the

first choice for describing multi-faceted hierarchically structured content collections. The IMS Question and Test Interoperability (QTI) standard was designed to support the distribution of assessments.

R-CP.5: Use content package specifications used by your intended audience
Packaged content can only be rendered on platforms that support it. Use specifications supported by the platforms commonly used by your intended audience. Contact the developers of the target platforms and request precise information on the formats they can process, i.e. about the read profiles of the target platforms. Ask them for tools to test whether your content conforms to their requirements.

R-CP.6: "Creative Commons" maximizes reuse
If you plan to use open content to maximize reuse, opt for a Creative Commons license.
For example, the LRE specifically encourages Creative Commons Attribution.

R-CP.7: Make sure the distribution of interoperable content does not conflict with your business model.
There are two main categories of scenarios for accessing content. Either the content is delivered to the user or a list of links is given to the user and the content remains on the content providers' server. Since Digital Rights Management (DRM) solutions are not supported in the technology-enhanced learning domain, controlling content access requires another combination of licensing regimes and technical solutions.
When content is delivered to an institution and delivered through a learning management system (LMS), an appropriate license agreement can be enforced by the LMS's access control mechanism. When content remains on the content provider's server, that server can control access by requesting credentials or by identifying the calling system through its IP address.
The IMS Common Cartridge and Basic LTI specification define ways to control content access. It should be checked whether these features are supported by the target systems.

R-CP.8: Make metadata creation easy and, where possible, try to generate metadata automatically.
Metadata is necessary for effectively managing, finding, and assessing the usefulness of learning resources. However, creating quality metadata is a challenging activity. Most users don't like to describe learning resources and usually produce poor or incomplete descriptions while professional indexers are expensive and not always consistent over time. Many metadata elements either already exist in one form or another and can be reused or can be produced in an automatic or semi-automatic way from the resource itself or its context. Moreover, tools exist for automatic metadata creation (such as the Simple automatic metadata generation Interface – SamgI). Therefore, each time it is possible and relevant, put in place tools and services to automate the generation of metadata. The LRE Service Centre provided by ASPECT offers examples of such tools and services such as:

- The LRE automatic metadata translator that allows for systematically translating English metadata into 6 additional languages.
- The ASPECT metadata transformer that, in a fully automated way, extract metadata from a common cartridge package, generates the corresponding metadata record in a specified standard, and exposes it using OAI-PMH.

R-CP.9: Combine as many sources of information as possible about the resource.

Descriptive metadata provided by content providers is only one of the possible sources of information about a learning resource. It can be complemented by other valuable information such as:

- Usage data, such as the number of times a resource is retrieved;
- Explicit feedback from users, such as ratings and annotations (Web 2.0 tools and practices);
- Third-party metadata provided by aggregators or reviewers.

This type of information provides feedback to enhance searching by users and ranking and feedback helps providers better understand issues related to the quality and usage of their content.

R-CP.10: Expose metadata and content in as many ways as possible.
Each specification supports a different way of exposing metadata (e.g., metadata harvesting with OAI-PMH, search with SQI, metadata publication with SPI). These specifications make possible the development of different types of specialized discovery services. Although such services offer high degrees of precision in searches, it is important to recognize that a significant number of users rely on a different set of discovery tools. These include web search engines, social web services, full text indexing, etc. Therefore it is important to expose metadata and content in ways that make them accessible by these tools.

R-CP.11: Register your repository to ensure its discoverability.
Learning object repository registries, such as the ones developed in ASPECT, allow content aggregators to easily discover and access repositories. Properly describing a repository in such a registry ensures that its content will be made available in the federations that use this registry.

R-CP.12: Describe each re-usable part of content
If content can be disaggregated, as in the case of Common Cartridges, describe each re-usable part with appropriate metadata so that it can be easily found. Metadata for parts can be inherited from metadata of the package but their validity needs to be checked.

8.4.2 Tools and Services

Learning Technology Standards Observatory LTSO

- **URL:** http://www.cen-ltso.net
- **End users:** Anyone interested in Learning Technology Standards and Specifications
- **Description:** The Learning Technology Standards Observatory (LTSO) is a focal access point to updated information on projects, results, news, organisations, activities and events that are relevant to the development and adoption of e-learning technology standards and specifications. It offers a newsletter service, access to relevant experts and up-to-date information in this field.

Application Profile Registry

- **URL:** http://apr.vocman.com
- **End Users:** Systems needing information about application profiles. Owners of application profiles and specialists developing new application profiles
- **Description:** The ASPECT Application Profile Registry (APR) provides a browsable interface which allows specialists to find information about the data elements and vocabularies used by different application profiles and to view mappings between

different profiles of the same base standard. The interface allows authorised users to add details of new application profiles. The machine interface (REST API) provides this information in XML and JSON formats to consuming systems.

Vocabulary Bank for Education VBE

- **URL:** http://aspect.vocman.com/vbe/
- **End users:** Taggers, taxonomists, developers and curriculum designers.
- **Description:** The ASPECT Vocabulary Bank for Education (VBE) provides a browsable and searchable web application to locate, view and download sets of terms, plus a machine interface (REST API). The vocabularies can be used for metadata, in particular for the Learning Resource Exchange.

LRE Learning Object Repository Registry (LORRy)

- **URL:** http://lreregistry.eun.org:5984/registry/_design/registry/index.html
- **End users:** Content providers, repository owners, learning object federation administrators
- **Description:** The LRE LORRy is a catalog that provides up-to-date information on repositories of learning resources. It facilitates the access to the content of these repositories by describing: Collections of learning content (e.g., languages, formats, topics covered); collections of metadata used to describe this content (e.g., metadata schemas, metadata languages) and protocols used to get access to these collections (e.g., OAI-PMH, SQI, SPI, SRU/SRW)

ARIADNE Validation Service

- **URL:** http://ariadne.cs.kuleuven.be/validationService/
- **End users:** System Administrators & developers of Content providers
- **Description:** The validation service is available for providing validation of metadata instances against predefined application profiles, for example based on IEEE LOM such as the LREv4.5 AP. To ensure that only compliant metadata are stored in a LOR, we use the validation service to check both the syntactic and semantic validity of the instances against the used profiles. The validation service has a modular approach, and combines different sorts of validation techniques, etc.

ARIADNE Collection Registry

- **URL:** **http://ariadne.cs.kuleuven.be/ariadne-registry/**
- **End users:** System administrators of content providers, developers of registry client tools
- **Description:** The Collection Registry enables the interconnection of learning object repositories, in order to further increase their impact in making relevant content available to teachers, trainers and (life-long) learners, by specifying the locations of those repositories and the description of the protocols they support for exposing their learning resources to the consumers of the registry.

Transformer Service, transforming metadata and vocabularies into another format

- **URL:** http://lrecoreprod.eun.org:6080/mtdTransformer/
- **Source code:** https://lretools.svn.sourceforge.net/svnroot/lretools/trunk/transformation-service
- **End users:** Metadata creators, Metadata developers

- **Description:** The purpose of the Metadata transformation service is to allow users transform metadata from one format (one application profile) such as LOM Strict to another format (another application profile) such as LREv4.0 application profile. The service does not only support structural transformation using Extensible Stylesheet Language (XSL) transformation or Java-based transformation but also support for the vocabulary crosswalks from the vocabulary bank. From a software standpoint, it is based on a plugin architecture where new transformations can be added as plugins, provided as jar files, with no needs for modifying the transformer core. The transformation service is available online at http://lrecoreprod.eun.org:6080/mtdTransformer/. However, this version only permits users to transform one metadata instance at a time, which is convenient for demonstration or to see how the transformation service works. In case the user wants to transform a large number of metadata instances, it is recommended that the user checks out the transformation library at source forge and develops an upper "layout" which connects to his/her repository.

Automatic Translation Service for Learning Object Metadata

- **URL:** http://lreforschools.eun.org, http://lrecoreprod.eun.org:6080/oaitarget/OAIHandler?verb=Identify
- **End users:** Metadata editors, LRE end users
- **Description:** Automatic Translation Service, which is integrated in the Learning Resource Exchange (LRE), enables better discovery rate of resources. All the metadata collected by the LRE are machine translated from English into German, Greek, Spanish, French, Italian and Portuguese using SYSTRAN. Due to license costs, these services are currently limited to the LRE Associate Partners and ASPECT Associate Partners. Partners' metadata collections that contribute to the LRE are enriched with translations and identifiers and can be harvested back using the LRE OAI-PMH target (http://lrecoreprod.eun.org:6080/oaitarget/OAIHandler?verb=Identify).

8.4.3 Deliverables

- D1.3.2 Final Public Report
- D2.1 ASPECT Approach to Federated Search and Harvesting of Learning Object Repositories
- D2.2 Design of Data Model and Architecture for a Registry of Learning Object Repositories and Application Profiles
- D2.3 ASPECT Approach To Multilingual Vocabularies, Including Automated Translation Services
- D2.7 Infrastructure and services v3.0
- D3.1 Best Practice Report for Content Use
- D3.2.2 Conformance Testing Tools version 2
- D3.3 IMS CC & SCORM Demonstrator v1.0
- D3.5 Best practice report for content use v2.0
- D3.6 IMS CC & SCORM Demonstrator v2.0
- D4.6 LRE Service Center provided by ASPECT

- D5.5 Report on the advantages/issues associated with the large-scale implementation of selected standards

All these deliverables can be accessed from http://aspect-project.org/node/28.

8.5 ASPECT for Tools Providers

8.5.1 Recommendations

R-G.1: Use standards and specifications.
There are four core reasons to use standards and specifications:

9. They avoid dependency on single vendors (vendor lock-in);
10. Their use facilitates interoperability;
11. Their use lowers costs by making it possible to build higher-level services on top of proven and standard compliant systems;
12. They represent best-practice solutions to known problems even when interoperability is not at issue.

R-G.2: Check conformance.
Standards and specifications are of little value when implemented poorly. Systematic conformance testing permits for verifying that a specification is implemented correctly and ensures (at least) syntactical interoperability.

R-G3: Select appropriate standards.
Given the profusion of standards available, it is critical to identify the existing standards of communities with which you want to interoperate. When a standard exists that addresses a certain requirement, using it, even if it is complex or incomplete – is often better than creating a new specification. Keep in mind that trying to create a new standard, when existing standards are already available, guarantees failure to interoperate with existing practices!
Do not abuse data elements: Using a data element for content for which it has not been foreseen leads to semantic interoperability problems that are particularly hard to detect. Instead, consider inserting additional elements at extension points foreseen in a specification (see also R-G5).

R-G4: Don't profile without consent.
Interoperability is jeopardized when standards and specifications are customized (profiled) without consent of the target community; in particular when data providers and data consumers use incompatible profiles. Therefore, as much as possible, try to use standards and specifications 'as-is'. A profile must always have a clearly defined scope and purpose for the target community whose needs it should meet. If no formal consensus can be reached in this community, it is recommended to meet the needs of its common practice.
Providing tools that help community members in achieving conformance with profiles can greatly ease the establishment of informal consensus.

R-G5: When profiling, preserve interoperability.
When profiling is unavoidable, keep any customization as limited as possible and profile in a way that preserves interoperability with the original specifications. For example, do not make mandatory elements optional or do not remove terms from an existing controlled vocabulary. If new elements must be introduced, do it only at the extension points foreseen in the

specification. Several standardization organizations have created guidelines for application profiles. Examples of lists of dos and don'ts can be found at http://www.imsglobal.org/ap/index.html and http://www.cen-ltso.net/main.aspx?put=922.

R-G6: Combine standards and specifications consistently.
Most solutions call for combining several specifications in a domain profile. Ensure that the standards to be combined work together in a precisely defined way. Moreover, ensure that this combination is compatible with the practices of the target communities. The ASPECT Integrated System, described in ASPECT deliverable D5.4, is an example of how to combine specifications, such as OAI-PMH, IMS ILOX, IEEE LOM, IMS VDEX, in a consistent way.

R-G7: Use a progressive strategy.
Adopting a complete solution can be expensive but interoperability can be built gradually. Build interoperability in stages by adopting specifications most pertinent to your immediate requirements and progressively add other complementary specifications. For instance, adopt first the most common protocol specification in a community for exposing metadata and then add other protocols to address other needs. Always be frank: Describe explicitly which specifications or profiles are fully supported in your application.

R-TP.1: Build tools that support all features and options in a specification.
Some specifications (for example IMS Common Cartridge, IMS LODE, IMS QTI) define core profiles reflecting common practice.
Tools producing data should allow use of all features of these core profiles and they should have a mode disabling all features beyond those defined in the respective core profile. Tools consuming data should be capable of reading all data conforming to the core profile. They should at least tolerate additional data provided at specified extension points.

R-TP.2: Support content specifications best adapted to the type of learning scenarios a platform supports.
ADL SCORM is best suited for self-paced learning, IMS Common Cartridge is best suited for blended learning, IMS Question and Test Interoperability for assessments. Tools' providers might support one or more of these content specifications depending on the type of learning activities provided by their learning platforms.

8.5.2 Tools and Services

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- D3.2.2 Conformance Testing Tools version 2

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All these deliverables can be accessed from http://aspect-project.org/node/28.

8.6 ASPECT for Experts in Standards

8.6.1 Recommendations

R-SO.1: Support the development of free and user-friendly tools to edit, deploy, re-arrange, and play educational content.
These tools should have open interfaces following open specifications. Coordinate the development of these tools. Leverage the potential of open source development in Europe.

R-SO.2: Provide community-based conformance competence forums, supporting stakeholders which apply open educational standards. These centers should be freely accessible for all. They should allow for open discussions of practical interoperability issues.
No specification can foresee all potential issues. Authorize a specification management group to rapidly provide preliminary recommendations on how newly emerging issues should be handled until the specification is updated.

R-SO.3: Support the development of application profiles and domain profiles of existing standards reflecting what is used in common practice.
Provide tools helping software developers and content authors to become fully compliant with these profiles. Develop a culture where the end user can rely that *all* features described in these profiles are implemented in any product that claims conformance. Only release standards and profiles that have been fully implemented and tested.

R-SO.4: Maintain backward compatibility
Whenever possible, data conformant to one version of a specification should remain conformant when the specification is updated. This builds trust into the specification, avoids re-engineering costs prevents slow-down of specification take-up.

R-SO.5: Do not encode controlled vocabularies in bindings.
Controlled vocabularies evolve rapidly to meet changing requirements and must often be available in multiple languages. Terms and their definitions must also be documented. The management of controlled vocabularies is optimized when they are encoded using specifications such as VDEX, ZTHES, or SKOS and stored in a bank (such as the ASPECT Vocabulary Bank for Education) independent of a binding. The binding can then refer to these external vocabularies. This comes at the price of an extra look up for resolving an identifier into the corresponding vocabulary term in a given language. However, the benefits (e.g., better management of controlled vocabularies, support for multilingualism – see R-SO.6) are worth this extra cost. Moreover, in order to lower this cost, ASPECT has developed an array of tools to integrate binding and vocabularies. These include the ASPECT transformer service, the ASPECT Application Profile Registry, the ASPECT Vocabulary Management Tool, the ASPECT Validation Services. When using changing vocabularies, make sure content is conformance tested using the latest version of the vocabularies in use.

R-SO.6: Uniquely identify each controlled vocabulary and controlled vocabulary term and only use identifiers in metadata records.
Because identifiers are language neutral tokens, they can be associated with multiple translations of the same term. Using tokens in metadata records makes it possible to display in a given language a metadata record created in another language provided that both languages are available in the vocabulary bank.
Note that this recommendation is applicable to all organizations developing controlled vocabularies, not just standards organizations.

8.6.2 Tools and Services

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- D3.1 Best Practice Report for Content Use
- D3.2.2 Conformance Testing Tools version 2
- D3.5 Best practice report for content use v2.0
- D5.1 A critical mass of metadata that can be searched for and discovered seamlessly
- D5.2 A critical mass of content to which a set of preferred standards and specifications have been applied
- D5.5 Report on the advantages/issues associated with the large-scale implementation of selected standards

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