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D1.2 Open ICOPER Content Space
Implementation of 2nd Generation of
Open ICOPER Content Space
including Integration Mini Case Studies

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</tr>
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</tr>
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</tbody>
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Executive summary

In the context of the ICOPER project, the Open ICOPER Content Space (OICS) has been defined as the umbrella combining a set of specialised interconnected repositories, content and tools, as a test bed for the specifications and standards that are part of the ICOPER Reference Model (IRM). The OICS has been conceived as an infrastructure for sharing educational resources, with sophisticated services for publication, enrichment, search and retrieval. Additionally the OICS provides the services for the management of learning outcome profiles.

This deliverable documents the final status of the OICS as with end of January 2011. For the 1st generation of the OICS, described in D1.1, we had concentrated on building an infrastructure for harvesting and aggregating content provided by members of the consortium. We are now able to use this infrastructure as the underlying framework for implementing prototypical interfaces that allow learners and learning facilitators to engage in processes of outcome based learning.

This deliverable starts with describing the types of shareable educational resources that the OICS deals with and documents the data models implemented by the OICS: for users and groups, for repositories and collections, for learning content and instructional models, for learning outcomes, for achievement profiles and for learning opportunities. These data models have been defined in cooperation with other ICOPER work packages, mainly 2 and 3. For learning content and instructional models, we chose the LOM standard as base, since it provides the most complete set of attributes for describing educational properties of an object. The main challenge consisted in defining, implementing and validating an application profile (AP), which would allow us to capture information about learning content and instructional models needed in the context of processes of outcome-oriented education: The main features of the ICOPER LOM AP that extend the base LOM standard allow

- to capture the relationships between instructional models;
- to distinguish between different types of comments;
- to link instructional models to learning outcome definitions;
- to define the type of shareable educational resource according to the ICOPER terminology;
- and to provide the packaging format of a learning design.

Several technical challenges were met during the implementation of the ICOPER LOM AP, e.g. with respect to validating constraints for vocabularies, implementing persistent, stable and resolvable identifiers, and transforming custom formats used by content providers.

In order to make the OICS content accessible from those environments where learning processes are implemented (learning management systems, personal learning environments and social networks), we have defined a Middle Layer API following the design principles of a Service Oriented Architecture. We argue how following these principles allowed us to achieve important quality attributes like interoperability, scalability, reliability, configurability and testability. We present a comprehensive, documentation for the Middle Layer API and three alternative bindings that are optimized for specific client requirements.

Section 5 is dedicated to a series of Integration Mini Case Studies which together present the main achievements of WP1:
inclusion of six different sources for learning outcome definitions totalling 3,781 distinct resources;

integration of 19 content providers totalling around 80,000 resources, providing more than 17,500 documented hours of instructional content;

experimental implementation of the Metadata for Learning Opportunities (MLO) specification and import of course catalogues from two universities;

implementation of OICS related functionality into 14 different client environments jointly covering a complex workflow of outcome-oriented education including the definition of learning outcomes, the authoring of instructional models, the delivery of learning designs through a learning management system and learners’ management of learning needs, achievements and assessment records.

OICS search functionality has been integrated into the ICOPER project website. It allows searching and retrieving of all types of shareable educational resources and display of a user’s achieved learning outcomes.

The problems solved during the development of the OICS infrastructure, and some results of the end user evaluation of the OICS client applications lead us to formulate a set of recommendations (Section 7) that are grouped with respect to the development life cycle phase they address.

We have learnt that the following key factors need to be taken into account during the design of a brokerage infrastructure for educational resources:

- maintenance of consistent technical information through a registry service;
- development of an interface specification through a managed community process that takes into account the requirements of different client contexts;
- definition of an application profile and validation of all ingested resources;
- user perception of relevancy, copyright and privacy;
- integration of repository services with social networks which increasingly become part of educational processes.

For the setup of the infrastructure, end-user evaluation showed that quantity and quality of content are most relevant for users.

For a successful deployment of the infrastructure, we recommend the use of testing environments and monitoring services and of a service capable of managing persistent and unique identifiers for resources.

The complete OICS infrastructure is made available as Open Source software. Installation instructions are provided on the ICOPER web site. The OICS infrastructure has been successfully transferred into a different context within the German SpITKom project as described in Section 6.2.
# TABLE OF CONTENTS

## 1 INTRODUCTION .................................................................................................................. 12  
1.1 MOTIVATION ....................................................................................................................... 12  
1.2 DESIGN GUIDELINES .......................................................................................................... 13  
1.3 CONCEPTUAL FOUNDATIONS ............................................................................................ 14  
1.4 RELATED WORK .................................................................................................................. 17  
1.5 DOCUMENT OUTLINE ........................................................................................................ 19  

## 2 DATA MODELS ................................................................................................................... 20  
2.1 ICOPER USER AND GROUP DATA MODEL ........................................................................ 20  
2.2 IMS LODE COLLECTION DATA MODEL ........................................................................... 21  
2.3 ICOPER LEARNING OBJECT METADATA (LOM) APPLICATION PROFILE ....................... 21  
2.4 LEARNING OUTCOME DEFINITION DATA MODEL .......................................................... 26  
2.5 PERSONAL ACHIEVED LEARNING OUTCOME DATA MODEL ......................................... 26  
2.6 METADATA FOR LEARNING OPPORTUNITIES ................................................................ 28  

## 3 SERVICES ............................................................................................................................ 29  
3.1 DESIGN PRINCIPLES FOR SERVICE DESCRIPTIONS ....................................................... 29  
3.2 QUALITY ATTRIBUTES ....................................................................................................... 30  
3.3 SEARCH AND RETRIEVAL SERVICE ................................................................................ 31  
3.4 PUBLICATION SERVICE .................................................................................................... 32  
3.5 USER MANAGEMENT SERVICE .......................................................................................... 32  
3.6 RECOMMENDATION SERVICE .......................................................................................... 32  
3.7 HARVESTING SERVICE ...................................................................................................... 32  
3.8 REGISTRY SERVICE .......................................................................................................... 32  
3.9 VALIDATION SERVICE ....................................................................................................... 33  
3.10 IDENTIFICATION SERVICE ............................................................................................... 33  

## 4 MIDDLE LAYER API ............................................................................................................. 33  
4.1 USER MANAGEMENT AND LEARNING OUTCOME PROFILE SERVICE ............................... 34  
4.1.1 listUsers ......................................................................................................................... 34  
4.1.2 createUser .................................................................................................................... 34  
4.1.3 getUser ......................................................................................................................... 35  
4.1.4 modifyUser ................................................................................................................... 35  
4.1.5 createGroup ................................................................................................................. 35  
4.1.6 addUserToGroup ......................................................................................................... 35  
4.1.7 getGroup ....................................................................................................................... 35  
4.1.8 addAchievement ......................................................................................................... 35  
4.1.9 addAssessmentRecord ............................................................................................... 36  
4.1.10 getLearningOutcomeProfile .................................................................................... 36  
4.2 RECOMMENDATION SERVICE ......................................................................................... 36  
4.2.1 recommendUsers ........................................................................................................... 36  

5/128
4.3 SEARCH AND RETRIEVAL SERVICE
4.3.1 getLearningOpportunities
4.3.2 getLearningOutcomes
4.3.3 getTeachingMethods
4.3.4 getLearningDesigns
4.3.5 getLearningContent
4.3.6 getAssessmentMethods
4.3.7 getAssessmentDesigns
4.3.8 getAssessmentResources
4.3.9 getObject
4.3.10 getMetadata
4.3.11 resolveIdentifier
4.4 PUBLICATION SERVICE
4.4.1 submitObject
4.4.2 submitMetadata
4.4.3 submitEnrichment
4.4.4 submitComment
4.4.5 submitRelation
4.4.6 deleteObject
4.5 BINDING AND IMPLEMENTATION
4.5.1 ATOM implementation
4.5.2 JSON implementation
4.5.3 PLQL - SQI Wrapper
5 SYSTEM ARCHITECTURE AND INTEGRATION MINI CASE STUDIES
5.1 OICS TECHNICAL INFRASTRUCTURE
5.2 INTEGRATION MINI CASE STUDIES: PROVIDERS OF SHAREABLE EDUCATIONAL RESOURCES
5.2.1 Learning Outcome Definitions
5.2.2 Harvesting educational content: Problems and solutions
5.2.3 Providers of educational content and instructional models
5.2.4 Learning opportunities
5.3 INTEGRATION MINI CASE STUDIES: END USER TOOLS
5.3.1 OpenGL -- Open Graphical Learning Modeller
5.3.2 Recommendation widgets in Moodle
5.3.3 .LRN prototype for managing assessment resources
5.3.4 OICS Learning Design Search and Import, Learning Outcome export
5.3.5 OICS Recommendation Viewer
5.3.6 OICS Achievement (Learning Outcome) Viewer
5.3.7 iPolio - ICOPER Elgg based e-portfolio
5.3.8 Facebook Learning Outcomes Profile Application - FLOP. My skills
5.3.9 ULA4eXact LCMS – UoLs, LOPs and Assessments management into eXact LCMS
D1.2 Open ICOPER Content Space
Implementation of 2nd Generation of Open ICOPER Content Space including Integration Mini Case Studies

LIST OF FIGURES

Figure 1: IRM concepts integrated and implemented in the OICS. ........................................ 14
Figure 2: Searchable collection maintenance SUM from E-Framework ................................ 18
Figure 3: Repository registry information model developed in IMS LODE................................. 21
Figure 4: Instructional model conceptual model ........................................................................... 22
Figure 5: ICOPER LOM AP ........................................................................................................ 25
Figure 6: LOD data model ........................................................................................................... 26
Figure 7: PALO data model ......................................................................................................... 27
Figure 8: MLO data model .......................................................................................................... 28
Figure 9: OICS as OpenSearch provider ...................................................................................... 47
Figure 10: Integration between WU and ARIADNE repositories .................................................. 48
Figure 11: Data captured about context in Personal Achieved Learning Outcomes (PALO) data model (D2.2) ........................................................................................................ 54
Figure 12: Dialog for selecting field of education from the CSO taxonomy in the OICS metadata editor .................................................................................................................. 55
Figure 13: List of learning outcomes in OpenGLM retrieved from OICS .................................... 64
Figure 14: Recommendation widgets in Moodle ........................................................................... 66
Figure 15: Publication of assessment designs from .LRN ............................................................... 68
Figure 16: Learning Design search interface in Moodle. ............................................................... 70
Figure 17: Publish achieved and taught learning outcomes from Moodle ................................... 71
Figure 18: Teacher recommendations in Moodle ......................................................................... 72
Figure 19: List of achievements in Moodle .................................................................................. 74
Figure 20: Course overview in Elgg ............................................................................................... 75
Figure 21: PALO profile displayed in Facebook ......................................................................... 77
Figure 22: List of learning designs in eXact .................................................................................. 78
Figure 23: author42.ICOPER search integration with OICS and re-use of content retrieved... 80
Figure 24: CLIX ICOPER: Add Learning Outcome to IMS-LD Learning Design ....................... 81
Figure 25: Display of learning outcomes in Learn@WU ............................................................... 82
Figure 26: Learning opportunity in 2know2 .................................................................................. 84
Figure 27: Context filters for searching OICS content ................................................................. 86
Figure 28: Search interface for learning outcomes ....................................................................... 86
Figure 29: Preview of learning needs ............................................................................................ 86
Figure 30: SpITKom Browser-Game (Draft Version) ................................................................. 90
Figure 31: IT-Café (Draft Version) .............................................................................................. 91
Figure 32: OICS infrastructure as applied to SpITKom ............................................................. 92
Figure 34. GUI at the LMS showing SPI-replicated learning content .................................. 93
LIST OF TABLES

Table 1: Mapping between Instructional Model and ICOPER LOM AP ........................................... 23
Table 2: ATOM binding of user management service ...................................................................... 40
Table 3: ATOM binding of search and retrieval services ................................................................. 42
Table 4: URIs for OICS repositories ................................................................................................. 43
Table 5: ATOM binding for publication service ............................................................................... 43
Table 6: JSON binding for search and retrieval service ................................................................. 45
Table 7: Integration between OpenGLM and OICS ......................................................................... 64
Table 8: Integration between Recommendation widgets in Moodle and OICS .............................. 66
Table 9: Integration between LRN prototype for managing assessment resources and OICS ............ 68
Table 10: Integration between OICS Learning Design Search and Import, Learning Outcome export and OICS ....................................................................................................................... 71
Table 11: Integration between OICS Recommendation Viewer and OICS ..................................... 73
Table 12: Integration between OICS Achievement (Learning Outcome) Viewer and OICS .......... 74
Table 13: Integration between iPolio - ICOPER Elgg based e-portfolio and OICS ......................... 75
Table 14: Integration between Facebook Learning Outcomes Profile Application - FLOP, My skills and OICS .......................................................................................................................... 77
Table 15: Integration between ULA4eXact LCMS – UoLs, LOPs and Assessments management into eXact LCMS and OICS .................................................................................................................. 78
Table 16: Integration between OICS roundtrip authoring use case and OICS ............................... 80
Table 17: Integration between CLIX ICOPER: A Learning Outcome-Based IMS-LD Learning Delivery Solution and OICS .............................................................................................................. 81
Table 18: Integration between 2know2 and OICS ............................................................................. 84
Table 19: Integration between ICOPER web site and OICS .............................................................. 87
LIST OF ACRONYMS

AP  Application Profile
API  Application Programming Interface.
AtomPub  ATOM Publishing Protocol
CEN  Comité Européen de Normalisation
CMIS  Content Management Interoperability Service
DC  Dublin Core
DCMI  Dublin Core Metadata Initiative
EQF  European qualification framework
HTTP  Hypertext Transfer Protocol
IEEE  Institute of Electrical and Electronics Engineers
ILOX  Information for Learning Object eXchange
IMS LD  IMS Learning Design
IMS QTI  IMS Question and Test Interoperability
IPR  Intellectual property rights
IRM  ICOPER Reference Model
ISO  International Organization for Standardization
JCP  Java Community Process
JSON  JavaScript Object Notation
JSR  Java Specification Request
LA  Learner Assessment
LCMS  Learning content management system
LD  Learning Design
LMS  Learning management system
LOD  Learning Outcome Definition
LOM  Learning Object Metadata
LOR  Learning Object Repository
LRE  Learning Resource Exchange
MLO  Metadata for Learning Opportunities
OAI-PMH  Open Archives Initiative – Protocol for Metadata Harvesting
OASIS  Organization for the Advancement of Structured Information Standards
OER  Open Educational Resource
OICS  Open ICOPER Content Space
OKI  Open Knowledge Initiative
OSID  Open Service Interface Definition
PALO  Personal Achieved Learning Outcome
PLE  Personal learning environment
PLQL  Prolearn Query Language
REST  Representational State Transfer
SER  Shareable educational resource
SOA  Service Oriented Architecture
SPI  Simple Publishing Interface
SQI  Simple Query Interface
SQL  Structured Query Language
SRU/SRW  Search/Retrieval via URL/Web Service
SUM  Service Usage Model
TM  Teaching Method
D1.2 Open ICOPER Content Space
Implementation of 2nd Generation of Open ICOPER Content Space including Integration Mini Case Studies

UML  Unified Modeling Language
URI  Uniform Resource Identifier
URL  Uniform Resource Locator
VLE  Virtual Learning Environment
XML  Extensible Markup Language
1 Introduction

1.1 Motivation

The ICOPER Reference Model (IRM) aims at defining a framework through which technology-enhanced best practices for outcome-oriented educational processes such as

- learning needs analyses,
- content development,
- instructional modelling,
- assessment design and delivery, and
- learning process evaluation

are proposed. Driven by the need for supporting the IRM with an adequate electronic infrastructure the Open ICOPER Content Space (OICS) has been set up. The OICS constitutes a combination of specialised interconnected repositories, content and tools. It acts as a test bed for the specifications and standards that are part of the IRM.

The initial requirement for the OICS is to make a critical mass of high-quality, re-usable content available for all processes related to outcome-oriented teaching and learning. We investigated issues with respect to what are best practices for an infrastructure that brings together content producers and content consumers. As our first conclusion we presented in D1.1 the technological foundations for harvesting content and demonstrated a simple web-based search interface on top of this content.

Based on this infrastructure we focus in this deliverable on the design of a service-oriented architecture where Shareable Educational Resources of various kinds – ranging from learning outcome definitions to assessment resources – can be shared and re-used across organizational and technological boundaries.

From a data model perspective this version of the OICS puts a particular emphasis on investigating rich linkages between teaching methods, learning designs, learner assessments, learning content, learning outcome definitions, achievement profiles, learning opportunities, assessment and evaluation resources. From a process perspective this deliverable solves issues with respect to storing, sharing, annotating, and delivering such educational resources.

The OICS architecture has been conceived with the objective of supporting outcome-oriented higher education. This deliverable documents the requirements, the design, the implementation and the deployment of the OICS architecture in such a context. We specifically provide a series of “integration mini case studies” on how this architecture solved problems of integration between content providers and content consumers.

From a pedagogical perspective, the alignment of learning outcomes with assessment methods and teaching methods is one of the core foundations of the Bologna Process (European Commission 1999). Implementing this foundation, the IRM as a reference model and the OICS as its reference implementation represent a visionary yet realistic approach to fully (i.e. conceptually and technically) supporting key pedagogical processes. These include

- the sharing of learning outcome definitions and achievement records;
- the reuse and creation of teaching methods and learning designs;
The OICS supports those processes of outcome-oriented education through the provisioning of services that can be integrated into a variety of platforms: authoring environments, learning management systems and personal learning environments. As a consequence, D1.2 targets all stakeholders in higher education who are interested in the management of repositories of shareable educational resources and plan to integrate innovative services for outcome-based learning and teaching.

1.2 Design Guidelines

Based on the process definitions addressed above (please refer to the final version of the IRM, D7.3b, for detailed descriptions), the following design guidelines have been identified:

- A repository should be able to handle digital resources of various kinds, and should provide customized interfaces for managing and accessing them. Besides interface definitions for learning content, the OICS should provide specialized functionality for learning outcome definitions, assessment resources, personal achievement profiles, teaching methods, learning designs, learning opportunities, and learner assessments.

- Each resource in a repository should have a stable permanent identifier, through which it can be resolved and linked to.

- It should be easy to manage links between resources. In order to deliver services that make learning resources useful for outcome-based learning, for example, learning designs have to be related both to learning outcomes and to learning opportunities.

- Metadata describing learning resources can be quite heterogeneous with respect to ownership, quality and target audience. A repository must be capable of managing multiple metadata records for any resource, creating merged views for specific use cases.

- A repository should provide a customizable search interface optimized for query types that arise in the most common use cases. In the context of outcome-oriented teaching, this design principle can for example be translated into the requirement of making specifying resources searchable via specific learning outcomes they have been linked to.

- The tools connected to the OICS have different requirements in terms of result formats and packaging formats. Resource lists should be delivered in the formats respecting those requirements, and resources should possibly be made available in multiple packaging formats.

- The perceived added value of a repository depends on the quality and quantity of the resources it stores and of the metadata that has been provided for managing those

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1 [Downes 2010], for example, distinguishes between first party, second party and third party metadata: While first party metadata is “related to the creation and nature of the resource itself”, second party metadata concerns the use of the resource. Third party metadata is related to the “evaluation, description or classification of resources”.

13/128
resources. In order to encourage the publication of resources and the enrichment of metadata, the publication interface must be easy to use and well documented.

1.3 Conceptual Foundations

Figure 1 shows a graphical representation of the Conceptual Model of the IRM. All resources stored in the OICS are treated as Shareable Educational Resources (SER). A SER is an addressable object in a repository that is relevant in the context of learning and teaching. It is described via metadata and identifiable through an identifier. SERs are either harvested from content providers through the harvesting interface or published from client applications through the OICS Middle Layer API.

The IRM differentiates two types of SERs:

- Educational Activity Descriptions, and
- Educational Content.

An Educational Activity Description is understood as a machine-readable documentation of a sequence of measures users can get involved in order to achieve an educational objective.
Educational Activity Descriptions represent the dynamic part of the domain model. OICS-relevant Educational Activity Descriptions include process types such as:

- Instructional Models, as well as
- Learning Opportunities.

An *Instructional Model* is an Educational Activity Description, which represents the design of teaching or learning situations. Learning designs and teaching methods are two specific forms of an instructional model. An IMS LD unit-of-learning is an IMS LD compliant description of an instructional model. In this report Instructional Model is used as an umbrella term for teaching methods and learning designs.

A *Teaching Method* is an outcome-oriented set of activities to be performed by Learners and Learning Facilitators (Supporters). Examples for teaching methods are the Jigsaw Method, Problem-based Learning, and Think-Pair-Share. Typically, teaching methods are generic descriptions of activities, independent of specific content or an application context, hence independent from specific Learning Opportunities or Learning Designs. Typically, Teaching Methods are generic descriptions of activities, independent of specific content or an application context. Teaching Methods are realized in Learning Designs within a specific context, with intended learning outcomes and with associated content. An *Assessment Method* is a Teaching Method oriented towards the assessment of Learning Outcomes. The OICS stores Teaching and Assessment Methods in special collections where an authoring environment can retrieve them and allow instructional designers to use them as templates for new Learning Designs.

A *Learning Design* is a reusable representation of a concrete Learning Opportunity. A Learning Design arranges Teaching and Assessment Methods, Learning Content and Assessment Resources towards Learning Outcome attainment. A sketch of a Learning Design can for example be described as follows: "After taking this course a student is able to list a number of learning technologies and their properties. In order to achieve this learning outcome we will ask the students to attend a presentation on learning technologies that will also include some demos. After the presentation the student will be confronted with a short test". In the context of such a scenario ICOPER aims at facilitating collaboration around Learning Designs starting with the creation of Learning Designs out of respective Learning Opportunities, the sharing of Learning Designs as well as finding peers based on Learning Designs. The OICS makes learning designs available through dedicated methods and allows storage of both the actual design resources and metadata about them. An *Assessment Design* is a reusable representation of a concrete Assessment Opportunity. An Assessment Design arranges Assessment Methods and Assessment Resources for the purpose of measuring or informing learning outcome attainment. It can be, but does not have to be, part of a Learning Design.

A *Learning Opportunity* is a chance to participate in education or training. Metadata about learning opportunities provide information to an interested learner about the offered (advertised) learning opportunities at an institution. This information enables the learner to find out whether the offered opportunity is of her interest by providing information about the location, cost, places, engagement, duration, language of instruction and intended learning outcomes (objectives), to name a few. Learners who want to obtain a specific skill or competence search for learning opportunities with intended learning outcomes similar to the ones they plan to obtain. It is important to track and link learning outcomes to learning
opportunities to help learners follow the learning opportunities that really match and help them achieve their desired learning outcomes and goals.

*Educational Content* addresses the static part of the domain model and subsumes all educational resources that can be used or are produced as a result of an engagement in educational process. OICS-relevant Educational Content includes content types such as:

- Learning Outcomes,
- Learning Content,
- Assessment Resources, and
- Personal Achievement Profiles.

*Learning Outcomes* refer to statements of what a learner knows, understands and is able to do on completion of a Learning Opportunity (European Commission 2008). "The student is able to list a number of learning technologies and their properties." is an example of a Learning Outcome. ICOPER is concerned with the interoperability of Learning Outcome definitions, for example, when Learning Outcomes are provided for re-use in the design phase of a course or when students – after having successfully completed a course – want to include a course’s Learning Outcomes in Personal Achievement Profiles. The OICS has a dedicated repository for definitions of Learning Outcomes and specialized services for publishing and retrieving them.

*Learning Content* refers to any digital and non-digital material that can be used in a Learning Opportunity such as a course. Examples of Learning Content are simple web pages, lecture slides, a textbook, SCORM-compliant web-based training modules. ICOPER aims at facilitating the sharing and re-use of Learning Content. The OICS stores metadata about thousands of instances of learning content available for re-use, and allows accessing these resources from authoring environments. An *Assessment Resource* is a special type of Learning Content that can be used in an Assessment Design. An Assessment Resources stimulates some kind of interaction with or reaction by a Learner. A test contain multiple assessment items (i.e. questions) constitutes a typical example of an Assessment Resource. An example of an Assessment Resource is a test question such as the following: "What is typically used for training high-level skills such as flying an airplane? ( ) Simulations ( ) Talent Management Systems ( ) Assessment Tools ( ) Authoring Tools". Assessment Resources are authored by using all kinds of authoring tools and deployed by learning management systems or other Learning Tools.

In the context of outcome-oriented higher education the *Personal Achievement Profile* concept plays a central role. A Personal Achievement Profile is a collection of Learner’s achievements. Achievement refers to a potentially individualized description of an attained Learning Outcome. In order to provide evidence an achievement record can for example refer to an assessment record documenting a Learner’s knowledge, skill, or competency as assessed in an Assessment Opportunity. The OICS allows users to manage their Personal Achievement Profile through a web GUI, but also provides access services that can be integrated into LMSs, PLEs and social networks.
1.4 Related Work

There exist several proposals on how to define the interfaces for a repository service. In the following we review four of them, and explain in what respect they have inspired the design of OICS’ service-oriented architecture.

Repository Open Service Interface Definition

The repository OSID (OKI 2004) defines a repository as a service for the management of assets of various types and information about the assets. Repositories are provisioned through a repository manager interface. The originality of the Repository OSID resides in the generic support for the definition of complex content structures: Asset types can be defined by the structures of mandatory or optional records of information an asset is built up from. Repositories have a set of types associated with them, and manage ingestion, validation and retrieval of assets of these types. While originally expressed as Java interface definitions, OSID V3 strives for platform independence and is expressed in a language-neutral format.

OSIDs define interfaces for establishing interoperability between service providers and consumers. The main concept underlying OSIDs is the OSIDManager that provides access to OSIDSessions through which OSIDObjects are accessed. While OSIDs are conceived to provide interoperability between implementation classes integrated into one single running application environment, the OICS architecture is concerned with interoperability between a system providing repository services and client applications accessing these services. OICS services do not provide the session concept, and each service provides the concept of a manager implicitly giving access to collections of objects.

E-Framework “Searchable collection maintenance” Service usage model

The E-Framework, a joint initiative by the UK's Joint Information Systems Committee (JISC), Australia's Department of Education, Employment and Workplace Relations (DEEWR), the New Zealand Ministry of Education (NZ MoE) and The Netherlands SURF Foundation (SURF), strives at defining best practices for the application of the design patterns for service-oriented architecture to the domain of higher education. Its goal is technical interoperability in education and research by improving strategic planning and the implementation process. It “provides a series of mechanisms by which services may be modelled in an implementation- or domain-neutral manner, and provides a consistent vocabulary by which services may be described. The individual components of the e-Framework describe the behaviours of the different services, as well as showing the precise interfaces to them. The e-Framework also demonstrates how different services may be combined to support a business process within education and research.” (e-Framework 2009).

The E-Framework technical model suggests the standardized description of services according to detailed templates and a specific technique of composing high level “service usage models” out of basic service genres. This model also provides a concise terminology for different levels of generalization and realization: service genres are specialized in a service expression by specifying the exact interfaces and standards used. A service expression can be encoded into a machine-processable service expression definition. Service implementations are led by service implementation designs and result in an executable code or toolkit that is made available at a service instance (endpoint).
The actual collection of service descriptions in the E-Framework has remained unfinished, and the documented service usage models seem to be limited to case studies that arose from different projects. For the OICS, we have studied the “Searchable collection maintenance” SUM (Figure 2). It defines basic capabilities and services for the management of business objects in a collection (e-Framework, 2009, http://www.e-framework.org/Default.aspx?tabid=1001).

- Storing, accessing and maintaining the business objects in the collection
- Discovery of business objects in the collection
- Recording and reporting the operations applied to the business objects in the collection
- Provisioning and managing the collection as a whole

Contrary to the OSID, here the internal structure of business objects is not taken into account, but more care is taken in defining the repository as a composition of a set of basic services.

The OICS repository service provides the same capabilities as this SUM with the exception of recording and reporting which have not been explicitly defined, and composes these capabilities from the same basic services (Add, Read, Replace, Remove, Search). But more than the concrete definition of the repository service, it is the overall model of a service oriented approach and how to translate it into technical concepts that we have tried to follow. We hence refer to the E-Framework terminology while defining the Middle Layer API for the OICS.

![Figure 2: Searchable collection maintenance SUM from E-Framework](image-url)
JSR 283
The “Content Repository for Java Technology API Specification”—originally described in JSR 170, now superseded by JSR 283 (JCP 2009) — aims at providing a common data-centric API for accessing content repositories from JAVA that is independent both from application logic and from storage implementation. It adopts the “design principles of the Web and its focus on uniform identifiers, standard methods, and extensible representation types” (Fielding 2005). Accordingly, JSR 283 does not directly support requirements specific to learning, but due to its focus on extensibility of node types and properties (that can store metadata), it could provide an architectural base for implementing learning object repositories.

For the OICS architecture, we have equally embraced the design principles of the Web, for example through the adoption of a RESTful service binding. Thus the OICS API could be easily mapped to the service descriptions provided by JSR 283.

CMIS
“Content Management Interoperability Services” is a standard defined by OASIS that is “intended to define a generic/universal set of capabilities provided by a content management system and a set of services for working with those capabilities” (OASIS 2010). As JSR-283, it defines a hierarchical model for a repository structure, but is more useful for document centric than data centric applications. It supports object types, management of renditions, relationships, versioning and queries based on an SQL grammar. CMIS can be bound to SOAP, but also to the Atom Publishing Protocol by means of the ATOM and AtomPub extension mechanism. CMIS also leverages link tags to specify additional resources related to the requested resource. The OICS API uses the same binding as CMIS, and providing full compatibility with a client tool implementing CMIS could be easily achieved through an adaptor enriching the OICS services with CMIS properties.

1.5 Document Outline
The following section presents the data models of the IRM that constitute the conceptual foundation of the OICS architecture. It is the quality of this foundation that makes sure that the tools consuming OICS services can work together seamlessly.

Section 3 explains to what extent in the definition and design of OICS’ services, we followed the established approach for service-oriented architectures, its design principles, and what quality attributes it helps to achieve.

The OICS Middle Layer API, presented in Section 4, bundles the IRM interface definitions into a set of service expressions that facilitate implementation, both for service providers and consumers. This API follows best practices for service design explained in Section 3, thus ensuring that bindings can be defined consistently, implementations can be tested for compliance, and applications can consume these services reliably.

Three bindings for this API are described in Section 4.5. While the ATOM implementation described in Section 4.5.1 provides a complete RESTful interface to OICS resources, i.e. it allows creation, retrieval, update and deletion, the implementations described in Sections 4.5.2 (JSON implementation) and 4.5.3 (PLQL – SQI Wrapper) provide optimized access to search functionality for specific client contexts.
Section 6 documents in detail experiences made during implementation and deployment of the OICS architecture. First, we describe the configuration of the backend systems, and external technological components used for the implementation and maintenance of the OICS. We document some of the problems solved while integrating them into a common architecture. We then (Section 6.2) describe the participating content providers and explain the strategies employed for validating, enriching and transforming this content, in order to make it comply with the ICOPER data model for instructional models and learning content. Finally, we present a hypothetical scenario how OICS services could be deployed in the context of a higher education institution and use this scenario as a background for the documentation of the OICS client tools. For each of them, we explain how the integration of OICS services into the client environment helped realizing the constituent steps of this scenario (Section 5.3).

Section 7 presents our strategy for future development of OICS content and services and presents as an example the case of the SpITKom project, where the OICS architecture has been used in a context outside higher education.

Section 8 condenses all the experiences made during design, setup and deployment of the OICS into a set of recommendations.

2 Data models

The OICS manages Shareable Educational Resources by making use of the following data models (please refer to Section 1.3 for the resp. concept definitions):

- the ICOPER User and Group Data Model for managing Users and Groups (Section 2.1),
- the IMS LODE Collection Data Model for managing Repositories (Section 2.2),
- the ICOPER Learning Object Metadata (LOM) Application Profile for managing Instructional Models (including Teaching Methods, Assessment Methods, and Learning Designs) and Learning Content (including Assessment Resources) (Section 2.3),
- the Learning Outcome Definition Data Model for representing Learning Outcomes (Section 2.4),
- the Personal Achieved Learning Outcome Data Model for managing Personal Achievement Profiles (Section 2.5), and
- the Metadata for Learning Opportunities for managing Learning Opportunities (Section 2.6).

2.1 ICOPER User and Group Data Model

The OICS provides simple services for the management of user data, implementing the following concepts as defined in the IRM:

- Learner: A Learner is a person that performs learning activities in the context of a Learning Activity to attain intended Learning Outcomes. A Learner is also a high-level role that can be specified by a specific Teaching Method with various concrete roles.
Open ICOPER Content Space
Implementation of 2nd Generation of Open
ICOPER Content Space including Integration
Mini Case Studies

(e.g. in the Jigsaw Teaching Method learners assume the role of experts, presenters, and so forth).

- **Learning Facilitator**: A Learning Facilitator is a person that supports the Learner during the activities as carried out in a Learning Opportunity. Learning Supporter is also a high-level role that can be specified by a specific Teaching Method with various concrete roles. Typical learning support roles are teacher, instructor, facilitator, external expert, moderator, etc.

The OICS also has support for defining *groups*. A group has a number of participants that pursue a set of educational processes.

### 2.2 IMS LODE Collection Data Model

The data model used by the ARIADNE registry is described in Massart et al. (2009) and illustrated in Figure 3. It models collections, the targets through which they can be accessed and the parties that relate to collections and targets in different ways. Collections store content or metadata describing this content. A collection can be part of another collection (is-part-of/has-part) or can be derived from another collection (is-version-of/has-version). Collections can be accessed using one or more targets. Targets implement protocols and follow a certain access policy. Parties assume roles like those of owners, collectors, providers, contact etc.

![Repository registry information model developed in IMS LODE](image)

The OICS makes use of this model in the administration of the harvester component.

### 2.3 ICOPER Learning Object Metadata (LOM) Application profile

LOM (Learning Object Metadata) specifies a conceptual data schema that defines the structure of a metadata instance for a learning object. For this standard, a learning object is defined as any entity - digital or non-digital - that may be used for learning, education or training. For ICOPER, LOM has been chosen as the data schema for describing *instructional models*.
(teaching methods, learning designs, assessment designs and assessment methods) and learning content\(^1\). As summarized by Barker and Campbell (2010), LOM has been criticised lately for its lack of an underlying abstract model - as is the case with Dublin Core (DCMI 2007) -, and its concept of a “coherent record describing all aspects of a ‘learning object’ and its use” which does not fully endorse the semantic web’s potential of linking heterogeneous sources of information. Alternative approaches that promise to overcome these shortcomings are currently developed in the context of DCMI\(^2\) and ISO\(^3\), but have not yet delivered practical results.

A metadata instance for a learning object describes relevant characteristics of the learning object to which it applies. In the LOM (v1.0) base schema, these characteristics are grouped into nine categories: general, life cycle, meta-metadata, technical, educational, rights, relation, annotation, and classification.

The definition of the set of elements that ICOPER recommends to use to describe a teaching method and a learning design are covered in D3.1. They are represented in the following UML conceptual model.

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1 In the following, we use the terms “learning object” to refer to this union of instructional model and learning content.

2 The DC-Education Application Profile describes usage of DCMI properties specifically relevant to education (DCMI 2010)

An application profile is an assemblage of metadata elements selected from one or more metadata schemas and combined into a compound schema. The purpose of an application profile is to adapt or combine existing schemas into a package that is tailored to the functional requirements of a particular application, while retaining interoperability with the original base schemas (Duval, et al., 2002). The above data model has been subsequently developed into the ICOPER LOM Application Profile (AP) by integrating concepts and data models of work packages 2-6. The AP is used to describe instructional models, but care was taken to make the same profile also applicable to learning content. In defining the ICOPER LOM AP, the following transformations and adaptations were made to the IEEE LOM standard, based on the data model in Figure 4:

- The ICOPER LOM AP primarily captures data about instructional models (i.e. learning designs, teaching methods, assessment methods and assessment designs). Any valid LOM instance describing learning content is also a valid instance of the ICOPER LOM profile—that is, the profile can be used for other types of learning resources and objects.

- The relationships between the sub-concepts of “instructional model” are captured in the 7:Relation category of LOM; to support the description of the “implements” and “uses” relationships, the Relation.Kind vocabulary was extended with values referring to these relationships (in both directions), i.e. “uses”, “is used by”, “implements”, and “is implemented by”. In addition the “is variation of” vocabulary item allows capturing variations of instructional models.

- The Comment class is captured in the LOM category 8:Annotation. To enable distinction of different types of comments, the Annotation category is extended with the 8.4:Annotation.Type element, which uses the following vocabulary: “teacher reflection”, “student feedback”, “peer review”, and “other”.

- LOM category 5:Educational is extended with 5.12:Educational.LearningOutcome, which is a reference to a learning outcome definition (see Section 2.4). The learning outcome may be qualified using a Level specification (5.12.2:Level) that assigns a value defined in a particular scheme to the learning outcome (e.g. level 5 in the EQF1 scheme).

- Several descriptive elements of the Instructional Model class are mapped to the LOM base schema as follows:

<table>
<thead>
<tr>
<th>Instructional Model descriptive element</th>
<th>ICOPER LOM AP element</th>
</tr>
</thead>
<tbody>
<tr>
<td>title</td>
<td>1.2: General.Title</td>
</tr>
<tr>
<td>authors</td>
<td>2.3: LifeCycle.Contribute</td>
</tr>
<tr>
<td>licensingModel</td>
<td>6: Rights</td>
</tr>
</tbody>
</table>

1 EQF is explained in European Commission (2008).
<table>
<thead>
<tr>
<th>summary</th>
<th>1.4: General.Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>duration</td>
<td>5.9: Educational.TypicalLearningTime</td>
</tr>
<tr>
<td>subject</td>
<td>9: Classification with 9.1:Purpose = “discipline” and the subject either captured as a 9.2:TaxonPath or 9.4:Keyword</td>
</tr>
<tr>
<td>learningOutcomes</td>
<td>5.12: Educational.LearningOutcome (extension of LOM), which references a learning outcome definition, and optionally qualifies the intended learning outcome using instances of 5.12.2:Level</td>
</tr>
<tr>
<td>groupSize</td>
<td>9: Classification with 9.1:Purpose = “group size” (extension of LOM)</td>
</tr>
<tr>
<td>learnerCharacteristics</td>
<td>Includes a description of the “target group” of this resource, i.e. the learners’ prerequisite knowledge, skills, competences, age, level within the curriculum, special attributes, and/or qualities: Age is mapped to 5.7: Educational.TypicalAgeRange Prerequisites are mapped to 9: Classification with 9.1: Purpose = “prerequisite”</td>
</tr>
<tr>
<td>setting</td>
<td>9: Classification with 9.1: Classification.Purpose = &quot;educational setting&quot; and vocabulary values: face-to-face, online, distant, or blended.</td>
</tr>
<tr>
<td>sequenceOfActivities</td>
<td>5.10: Educational.Description</td>
</tr>
</tbody>
</table>

- Those descriptive elements that are part of the representation of the instructional model are not captured in the LOM metadata. These include: rationale, graphicalRepresentation, roles, resources, and literatureReferences.
- Several additional relevant LOM elements are used in the ICOPER LOM AP. Important ones among those are:
  - 1.1: General.Identifier, which identifies an entry in a particular catalog;
  - 2.1: LifeCycle.Version to enable provision of a versioning history for a resource;
  - 4.1: Technical.Format to identify the file format of the object;
  - 4.2: Technical.Size to define the file size;
  - 4.3: Technical.Location to point to the object’s download and/or viewing location(s);
  - 4.4: Technical.OtherPlatformRequirements, which can be used to provide one of the PackageFormat vocabulary values, e.g. indicating whether the object is IMS LD or IMS QTI compliant. The language identifier of the Langstring should be set to "x-t-icoper-packageformat";
  - 5.2: Educational.LearningResourceType; the vocabulary was extended with values referring to the particular type of instructional model, i.e. teaching method, learner assessment, and assessment method, assessment design, and assessment resource.
  - 5.6: Educational.Context, identifying whether the resource is suitable for higher education, training, school, or other contexts.
All other LOM elements may still be used, but they are optional (see the full tabular representation of the ICOPER LOM AP in Appendix A: Tabular Representation of the ICOPER LOM Application Profile.

The UML representation of the LOM profile is displayed in the following figure.
The full tabular representation for the ICOPER LOM AP can be found in Appendix A.

### 2.4 Learning Outcome Definition Data Model

The OICS implements the schema for definitions of *learning outcomes* presented in D2.2, LOD base schema v1.0. Learning outcomes are stored in a specialized repository instance at [http://oics.icoper.org/LOD/](http://oics.icoper.org/LOD/).

Learning outcomes are statements of what a learner knows, understands and is able to do on completion of a learning process. Learning outcomes cover knowledge, skills and personal, social and/or methodological abilities (competence) that a learner should acquire after successfully having participated in a learning opportunity.

The data elements of the Learning Outcome Definitions (LOD) data model are presented in Figure 6. This LOD schema provides a unique way of identifying and referencing learning outcome definitions.

#### Figure 6: LOD data model

<table>
<thead>
<tr>
<th>Learning Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>- identifier : CharString[1]</td>
</tr>
<tr>
<td>- title : LangString[1]</td>
</tr>
<tr>
<td>- description : LangString[0..1]</td>
</tr>
<tr>
<td>- type : Vocab[0..1]</td>
</tr>
</tbody>
</table>

### 2.5 Personal Achieved Learning Outcome Data Model

The OICS implements the schema for managing *Personal Achievement Profiles*. A profile stores *Achievements* (what a learner has learnt, and what a learning supporter has taught), *Assessment Records* and information about *Learning Needs*.

Figure 7 presents a graphical representation of the Personal Achieved Learning Outcomes (PALO) data model, for a detailed description see [http://www.icoper.org/schema/palov1.1](http://www.icoper.org/schema/palov1.1). There are 6 main elements in the model:

- **Personal Achievement Profile** – This element represents a collection of a learner’s achievements. Additional information about the profile is given by a title and optionally a human readable description of the profile. Both title and description can be repeated in multiple languages.

- **Achievement** – This element represents an achievement record, normally, of an attained learning outcome. Information about the achievement may be taken directly from a related learning outcome, rather than being given particularly. Personalised versions of a title and description may be used to supplement learning outcome. The element is also related to the contexts where the achievement is claimed to be attained, and to assessment records that stand as evidence of the achievement.

- **Learning Outcome** – This element represents the learning outcome that is attained by the learner. Its type defines whether the learning outcome is knowledge, skill or competence. Further information about the element is provided by human-readable
title and description of the learning outcome. The outcome can be related to other learning outcomes, e.g., with a relation narrower or broader, or can be related to a specific context and level.

- **Level** – This element captures ranking information about the learning outcomes and/or assessment records of learners. This includes proficiency level, interest level, weight, ageing. The element also defines a schema used to describe the level values. Textual description about the level is useful to be provided when a level value provided is not part of a common ontology or taxonomy.

- **Context** – This element is a set of factors that are external to and give meaning to a learning outcome and/or achievement. For instance subject domain and location (e.g., lab, classroom) are textual information that gives meaning to the learning outcomes. The element also defines a schema used to describe the context values. A textual description about the context domain is useful to be provided when a context value/term provided is not part of a common ontology or taxonomy.

- **Assessment Record** – This element captures information of evidence that a learner has obtained a learning outcome. The record constitutes of evidence of the verification of the attainment of a certain achieved learning outcome by a certain learner. Thus, assessment records allow to associate learners and learning outcomes, in a formalised way, e.g. as a certificate, license or official record. Apart from the learner data and learning outcome data, an assessment record provides information about the type of test performed for verifying the achieved learning outcome, the responsible expert or institution who endorses it, and the date the record was created. The record is qualified by a level.

All six elements are uniquely identified; the context and the level by a combination of a scheme and its value, and the other four elements by means of URIs.

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**Figure 7: PALO data model**

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27/128
2.6 Metadata for Learning Opportunities

The conceptual model of MLO is depicted in Figure 8. The key concepts are defined as follows (cf. MLO, 2008, p. 9):

- **Learning Opportunity Provider**: An agent (person or organization) that provides learning opportunities.
- **Learning Opportunity Specification**: An abstract description of a learning opportunity, consisting of information that will be consistent across multiple instances of the learning opportunity.
- **Learning Opportunity Instance**: A single occurrence of a learning opportunity.

Nevertheless, MLO records information about intended learning outcomes of an opportunity in free text format, this limits the interoperability and reuse of common learning outcome definitions across learning opportunities and curricula. We consider that learning outcomes maybe shared between several learning opportunities of same program or across universities and hence should be managed independently of learning opportunity metadata and be linked using a semantic web services; e.g., using a URI.

For this purpose, in ICOPER, we have extended the content model for the MLO Learning Opportunity Instance “objectives” (see Figure 4). It can enclose an "identifier" element, defined, as in LOM, through "catalog" and "entry". In this way, the MLO "objectives" element can capture multiple learning outcomes for each learning opportunity instance. Hence, reusability of learning outcomes across learning opportunities is increased. As far as the required learning outcomes of a learning opportunity are concerned, the "prerequisite" element...
of MLO was used to capture and provide reference to the required learning outcomes, using the same content model.

Additionally, we added to MLO the possibility to provide to links to assessment resources, teaching methods and learning designs, that are made use of in the context of a learning opportunity. We added an "identifier" element to the content model of MLO's "assessment" element, and defined the two new elements "teachingMethod" and "learningDesign" (in the namespace "http://icoper.org/MLO").

3 Services

In this section, we describe the services the OICS offers, the design principles we tried to follow while designing and implementing them, and the quality attributes which we prioritized during evaluation.

3.1 Design Principles for Service Descriptions

In order to fulfil the goal of making a critical mass of high-quality, reusable content available for all processes related to learning outcome based teaching and learning, the OICS has been designed following a Service Oriented Architecture (SOA).

According to “SOA principles” (SOA Systems Inc, 2009b), one of the key goals of service-oriented computing is increased intrinsic interoperability, i.e. “to establish native interoperability with services in order to reduce the need for integration”. “This establishes an environment wherein services produced by different projects at different times can be repeatedly assembled together into a variety of composition configurations to help automate a range of business tasks” (SOA Systems Inc., 2009a). For the second generation of the OICS architecture we adopted this paradigm of service orientation in order to give users access to high quality learning resources in the context of the environments where outcome oriented learning and teaching takes place: learning management systems, personal learning environments, desktop authoring environments. SOA promises to reduce the effort needed for integrating OICS related functionality into these environments by standardizing services needed for innovative use cases.

According to “SOA principles” (SOA Systems Inc, 2009b), the following design principles guide the service-orientation paradigm and need to be honoured in order to realize SOA’s benefits.

Note that the order in which these principles are listed does not indicate the level of importance.

- **Standardized Service Contracts**: While designing a service’s public interface, a contract guarantees that endpoints are consistent, reliable and governable. For the OICS, we specified these contracts in the form of the Middle Layer API described below.

- **Service Loose Coupling**: A service contract should not be coupled to a single implementation and to specific types of service consumers. For the OICS, we have set up two alternative implementations, each bound to different data formats, ATOM and JSON. While JSON’s simplicity (e.g. native evaluation of results in JavaScript)
Implementation of 2nd Generation of Open ICOPER Content Space including Integration Mini Case Studies

compared to the traditional XML data format approaches, which often require cumbersome DOM-based processing, makes it attractive for inclusion into browser-based functionality. ATOM proved to be easy to implement from the server’s point of view, since it is natively provided by many content-centric web frameworks.

- **Service Abstraction**: Emphasizes the need to hide as much of the underlying details of a service as possible. Whereas in the Middle layer API, we honoured this principle by defining functions that return only the required attributes, in the implementation, to speed up and ease prototype development, the services were bound to existing technological artefacts (ATOM feeds) that provide more information than strictly needed by the service consumers.

- **Service Reusability**: Services have to be defined independently from specific concerns in order to be useful to multiple service consumers. In the process of alignment of the Middle layer with the IRM we tried to achieve reusability by taking into account all aspects in the domain of outcome based learning.

- **Service Autonomy**: Services should have control over the logic they encapsulate in order to control their reliability. Since currently the OICS operates on data that is harvested from content providers, it achieves quite a high degree of service autonomy. The replication between two instances providing different implementations of the same service contributes to its realization.

- **Service Statelessness**: A stateless service does not retain state between consecutive invocations. It is therefore able to scale better. The OICS repository service is truly stateless, since (a) it does not store any data on the service side between consecutive invocations by the same client application; and (b) it exposes collections and learning resources independent from the context of the client application.

- **Service Discoverability**: Services are meant to be described and published in a way that multiple implementations can compete and that service consumers can discover them and bind to them dynamically. During the current phase of prototypical development, we have not yet implemented a service registry. Instead of that, ICOPER uses the registry service that has been developed in the eContentplus ASPECT project. ICOPER is also involved in the CEN WS-LT project team on interoperability of registries. The AtomPub protocol that the OICS Middle Layer is bound to provides the concept of a service document that describes available collections, and their configurations, and allows client applications to adapt to the capabilities of the service.

- **Service Composability**: Services should be easily combined into more complex services. We explore this principle through the prototypes described below.

### 3.2 Quality Attributes

Software Quality Attributes are benchmarks that describe the intended behaviour of a system within the environment for which it was built (Bass, et al, 2006). In the following paragraph, we describe which quality attributes are considered important for ICOPER and which tactics have been followed for optimizing these attributes. Note that these attributes are again listed in a non-importance-indicating way.

- **Interoperability** is defined as the ability of two or more systems to cooperate at runtime. The OICS’ service-oriented architecture is built on the principle that
interoperability and extensibility is best achieved by the integration of different interfaces as clearly defined modules. These interfaces interoperate by using open and interoperable standards and specifications such as IEEE LOM (IEEE 2002), SQI (CEN 2005), SPI (CEN 2010), OAI-PMH (OAI 2008), LOD and PALO (D2.2). For example, SQI serves as a gateway to existing search protocols such as SRU/SRW, O.K.I OSIDs, etc. Another example is the ARIADNE registry that currently contains around 50 repositories with different access protocols and metadata schemas. The OICS connects to that registry for gathering content that can be used by the different prototypes.

- **Scalability** refers to the ability to support large numbers of components, or interactions among components, within an active configuration. Scalability in ICOPER is achieved by distributing services across many components with each of them serving one specific focus such as the identifier, the user management or the validation service. Besides that, the ARIADNE validation service ensures that our approach is scalable by avoiding the publishing of erroneous metadata into the repository. The validation service contains support for the validation of the ICOPER LOM AP.

- **Reliability** relates to the amount of time for the system being up and running correctly. To ensure the reliability of the OICS, we have integrated CruiseControl\(^1\), an extensible framework for creating a custom continuous build process to monitor the uptime and responsiveness of all services. As a result, we are able to minimize the amount of time between failures. Furthermore, the OICS services are connected with a bug tracking system\(^2\) that allows users to notify the technical support team when something is failing.

- **Configurability** refers to post-deployment modification of components, or configurations of components, such that they are capable of using a new service. For example, both the harvesting component and the repository backend of the OICS are easily configurable to handle metadata instances in different metadata standards and specifications.

- **Testability** refers to the ease with which software can be made to demonstrate its faults. Within CruiseControl, we have added a number of junit tests that check the various workflows that we use in ICOPER. For example, one test is to create automatically a test metadata instance of the ICOPER LOM AP. Afterwards, it is published in the OICS using the SPI protocol in the WUW deployment of the OICS. This one is synchronized with the KUL instances of the OICS, so the junit issues a test query to the KUL instance to test if the metadata instance can be found correctly in the OICS.

### 3.3 Search and Retrieval Service

This service provides access to lists of Shareable Educational Resources of specific types (getLearningOutcomes, getTeachingMethods, getLearningDesigns, getLearningContent, getAssessmentDesigns, getAssessmentResources), and supports filtering based on simple

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query expressions. Returned list items provide at least title and identifier. The getMetadata method returns the “objective” metadata record for an object.

3.4 Publication Service

This service permits publication of new resources into a collection stored in a Repository. The service publishes a service document that describes for each collection the types of objects it accepts. The submitObject method ingests a new resource into the system, submitMetadata ingests a metadata record that might be associated with an existing resource, submitEnrichment provides additional information to an existing metadata record, submitComment submits a textual annotation, submitRelation defines a relation of a certain type between two objects, deleteObject removes an object from the OICS.

3.5 User Management Service

This service gives access to a user store implemented on the OICS that permits grouping of users into groups and manipulating a learner’s learning outcome profile.

3.6 Recommendation Service

This service lists users whose learning outcome profiles contain a certain learning outcome. More sophisticated algorithms based on additional information can be exposed by this service.

3.7 Harvesting Service

The OICS is a consumer of the harvesting service as defined in OAI (2008). This service allows content providers to selectively export metadata records, and allows consumers of the service to build value-added services. The OICS harvests these metadata descriptions, and makes them available for outcome-centric learning services. The harvester application used in the OICS makes use of the registry service in order to find repositories eligible for inclusion into the OICS, and of the validation service in order to make sure that metadata of ingested resources comply with the ICOPER LOM AP.

3.8 Registry Service

The OICS reuses the ARIADNE registry service that is currently being developed in the context of the ASPECT project. As explained in (Massart et al., 2008) this service provides a catalogue of up-to-date information about learning object repositories (LORs). It provides the information necessary for systems to be able to select the appropriate protocols such as OAI-PMH, SQI, SPI, SRU/SRW supported by a given learning object repository.

The OICS makes use of this registry of learning object repositories to find information about:

- the metadata schemes they use to describe their contents,
- the OAI-PMH endpoint and the content collections (sets) exposed through it.
ICOPER is currently also involved in the CEN WS-LT project team on the interoperability of registries for LORs. Therefore, ICOPER’s experience and lessons learned will be integrated in the final outcome of this project team.

### 3.9 Validation Service

To ensure that only compliant metadata records are stored in the OICS, we use the ARIADNE validation service to check both the syntactic and semantic validity of the instances against the used profiles. The validation service is available as an online service where one single metadata record can be validated against the appropriate scheme. It is also integrated in the ARIADNE harvester for validating large sets of records. Reports are automatically generated which give an overview of all validation errors. In ICOPER, we have created a validation scheme for the ICOPER LOM Application profile that is added in Appendix A. This scheme consists of an XSD schema, mainly used for structural validation of xml metadata, and Schematron rules, which are used to verify the compliance with constraints defined in the AP, e.g. mandatory elements. The OICS calls this service upon each ingestion of a new shareable educational resource. More information about the validation service can be found in (Ternier, S., et al. 2009).

### 3.10 Identification Service

All resources managed by the OICS are assigned a unique, persistent identifier. The ARIADNE identifier service creates an identifier that contains any information necessary for resolving the identifier to an OICS resource. The identifiers created by the service are compliant with the Universally Unique Identifier standard (UUID 2005). For this purpose the Java Uuid Generator (JUG) is used. The lower level API of the identifier service provides basic functionality for persistent storage: Create, Resolve, Update and Delete (CRUD) identifiers.

### 4 Middle Layer API

The OICS Middle Layer tries to bundle the functionality needed for implementation of the ICOPER user cases into a coherent API that is accessible from all systems and tools inside and outside the consortium, and to comply with the design guidelines outlined in Section 1.2. Its key focus is the integration of concepts and data related to key processes in outcome-based education. The OICS provides a backbone for enabling the testing of feasibility and utility of these processes for different stakeholders. The OICS Middle Layer defines the interface between OICS and parties interested in accessing OICS content, while the harvesting infrastructure based on OAI-PMH constitutes the interface to content providers.

The Middle Layer provides method definitions that are easier to adopt than the interfaces defined by the SQI and SPI protocols implemented in the OICS backend. Middle layer implementations can call upon these backend protocols and give clients access to their functionality through simpler wrapper methods.
This document serves as reference for the version 1.0 of the OICS Middle layer. It is also hosted at the ICOPER web site\(^1\).

This API defines abstract services that can be bound to standards for data formats and protocols.

Authentication and authorization is out of scope for the Middle layer API and needs to be defined on the level of the binding. But it is assumed that services are consumed by authenticated users and that policies define access rights and deal with privacy protection and security concerns.

According to the e-Framework Technical Model, this API defines a Service Usage Model (SUM) “Outcome-oriented learning”. The business requirements it aggregates and the business processes it coordinates are described in the IRM. It includes the following services:

- User management and learning outcome profile service
- Recommendation service
- Search and retrieval service
- Publication service

Following the e-Framework, we provide for each service a service description, enumerate the functionalities it provides, and state the business objects it is operating on.

### 4.1 User Management and Learning Outcome Profile Service

**Description:** This service defines methods for creating users and groups, getting information about them, adding users to groups with a certain role, adding achievements or assessment records to profiles, and retrieving profiles.

**Business objects:** user, group, achievement, assessment record, profile

**Notes:** The API does not define specific properties of a user, beyond name, email and learning outcome profile. Implementations can and should make additional information available that is needed for making the service useful for learning communities in a specific application context.

#### 4.1.1 listUsers

**Description:** lists all users registered at the OICS - might be restricted to system administrators for privacy protection.

**Input parameters:** Void.

**Output:** list of users with names and pointers to detailed information.

#### 4.1.2 createUser

**Description:** creates a new OICS user. OICS users can publish annotations to OICS objects and store learning outcome profiles.

**Input parameters:** email; first names; last name; password.

\(^1\) [http://www.icoper.org/open-content-space/middle-layer](http://www.icoper.org/open-content-space/middle-layer)
Output: userId.

4.1.3 getUser
Description: returns all information about the user that is available for the authenticated user.
Input parameters: user identifier.
Output: list of property/value pairs; values can be pointers to a representation of the property (for example profile).

4.1.4 modifyUser
Description: modifies a property of the user.
Input parameters: property name; value.
Output: Void.
Notes: The following properties should be supported: email, first_names, last_name, email_privacy_level (if set to 1, user's email is shown to other users).

4.1.5 createGroup
Description: creates a group representing a learning context (e.g. a class instance) with users assigned roles (teacher and learner).
Input parameters: group name.
Output: groupId.

4.1.6 addUserToGroup
Description: add a user to a group with a given role (teacher or learner).
Input parameters: user identifier; group identifier; role.
Output: Void.

4.1.7 getGroup
Description: lists all members of a group with their respective role.
Input parameters: group identifier.
Output: List of tuples (userId,role).

4.1.8 addAchievement
Description: adds an achievement to a user's learning outcome profile (the achievement is linked to a learning outcome, assessment record and context). Through the type parameter, this method can be used to add attained learning outcomes, taught learning outcomes and learning needs.
Input parameters: user identifier; identifier (optional); title (optional); description (recommended); related learning outcome (recommended); context (recommended); assessment record (recommended); type: attainment (default), teaching, learningNeed (optional).
Output: identifier.
Note: If no identifier is submitted it will be generated. The title and description of an achievement may be similar to title and description of the attained learning outcome of the achievement.
4.1.9 addAssessmentRecord

Description: adds an assessment record that is an evidence of an achievement (the assessment record is linked to an achievement).

Input parameters: user identifier; identifier (optional); type (mandatory); title (mandatory); score (optional); date (mandatory); assessing body (mandatory); description (recommended); attached reference (optional); level of Assessment Result (scheme, value) (optional).

Output: identifier.

Note: If no identifier is submitted it will be generated.

4.1.10 getLearningOutcomeProfile

Description: retrieves the learning outcome profile for a user.

Input parameters: user identifier.

Output: list of achievements.

4.2 Recommendation Service

Description: This service allows retrieving users based on the achievements stored in their profile.

Business objects: user, achievement, profile.

Notes: Recommendation of learning resources is currently not part of this service.

4.2.1 recommendUsers

Description: looks for users whose learning outcome profiles contain all or any (at least one) of the provided learning outcomes using a matching criteria.

Input parameters: list of object identifiers for Learning Outcome Definitions; logical connector: AND (default) or OR (optional).

Output: list of userIds.

4.3 Search and Retrieval Service

Description: This service gives access to the OICS resources by providing specific access methods for the different types of objects (learning outcome definitions, teaching methods, learning designs, assessment designs, assessment resources and learning opportunities). It also allows to retrieve metadata for objects and to resolve identifiers.

Business objects: collection, learning resource.

Notes: Filter expressions allow restricting the resource lists based on search criteria. Their syntax is dependent on the binding.

For the methods that return lists of objects, what information is returned is also implementation specific. One binding might return a complete metadata record for each object, another one may return only minimal information. The complete description should always be retrievable by calling getMetadata.

4.3.1 getLearningOpportunities

Description: This method returns a list of learning opportunities stored in the OICS.

Input parameters: filter_expression (optional); page number (optional).
Output: list of tuples (title and identifier).

4.3.2 getLearningOutcomes
Description: This method returns a list of definitions for learning outcomes stored in the OICS.
Input parameters: filter_expression (optional); page number (optional).
Output: list of tuples (title and identifier).

4.3.3 getTeachingMethods
Description: This method returns a complete list of all teaching methods and assessment methods stored in the OICS.
Input parameters: filter_expression (optional); page number (optional).
Output: list of tuples (title and identifier).

4.3.4 getLearningDesigns
Description: This method returns a complete list of all learning designs stored in the OICS.
Input parameters: filter_expression (optional); page number (optional).
Output: list of tuples (title and identifier).

4.3.5 getLearningContent
Description: This method returns a complete list of all learning content stored in the OICS.
Input parameters: filter_expression (optional); page number (optional).
Output: list of tuples (title and identifier).

4.3.6 getAssessmentMethods
Description: This method returns a complete list of all assessment methods stored in the OICS.
Input parameters: filter_expression (optional); page number (optional).
Output: list of tuples (title and identifier).

4.3.7 getAssessmentDesigns
Description: This method returns a complete list of all assessment designs stored in the OICS.
Input parameters: filter_expression (optional); page number (optional).
Output: list of tuples (title and identifier).

4.3.8 getAssessmentResources
Description: This method returns a complete list of all assessment resources stored in the OICS.
Input parameters: filter_expression (optional); page number (optional).
Output: list of tuples (title and identifier).

4.3.9 getobject
Description: This method returns the binary stream for the object. If the object is not stored on the OICS, but only a metadata record is available, the behaviour of this method is currently undefined.
Input parameters: object identifier
Output: binary stream

4.3.10 getMetadata
Description: This method returns the metadata record for an object stored in the OICS. This method returns the "default", "objective" metadata record for an object. If multiple metadata records for an object are stored in the OICS, an optional metadata identifier can be provided as input argument.
Input parameters: object identifier; metadata identifier (optional).
Output: string.

4.3.11 resolverentifier
Description: This method gives access to different representations of an object, based on the ICOPER identifier.
Input parameters: identifier: from the ICOPER catalog; type: allows to define the type of representation the client is interested in (implementation specific); query: for some types of resolution a query can qualify the information the client is interested in for example define a subset of metadata for "atom" or the packaging format for "download".
Output: Normally redirects the client to the URI for retrieving the requested representation of the object. If type equals "uri" the services returns the string value of the object's URI.

4.4 Publication Service
Description: This service allows publishing learning objects and metadata records. It also provides methods for replacing the objects, updating and enriching the metadata (e.g. by adding annotations), creating relations between objects and deleting them.
Business objects: collection, learning resource.
Notes: This service follows the model defined in the SPI protocol, i.e. it distinguishes between learning resource and metadata record.

4.4.1 submitObject
Description: adds a new object to the OICS (learning design, teaching method, learning resource, learning outcome definition, assessment design, assessment resource), or updates an existing one.
Input parameters: resource: a binary representation of the object; collection: identifier of the collection where the object should be added (optional); object identifier: if no object identifier is provided, this service generates one (or extracts one from the binary representation of the object) and returns it. If an object identifier is provided and it already exists in the system, the object will be updated (optional).
Output: object identifier.

4.4.2 submitMetadata
Description: submits a metadata record. The status of the record depends on the configuration of the service, and of the collection, and on the privileges of the user, i.e. in some context the
record might be the "objective" metadata record, provided by an accredited source, in some context it might be contributed by a user or by a community.

**Input parameters:** object identifier: if no object identifier is provided, this service generates one (or extracts one from the metadata record). If an object identifier is provided and it already exists in the system, the metadata record will be associated with this object. If this object already has metadata associated, it will be replaced (optional); metadata record.

**Output:** object identifier.

### 4.4.3 submitEnrichment

**Description:** Enrichment here refers to providing additional information to an existing metadata record. If no record exists for the given object, a new empty one, can be instantiated by the service. The metadata fragment should be wrapped into a LOM container, but special input formats for specific fields (for example annotations or relations) can be supported by implementations.

**Input parameters:** object identifier; metadata fragment.

**Output:** metadata identifier.

### 4.4.4 submitComment

**Description:** submits a textual comment.

**Input parameters:** object identifier; comment.

**Output:** object identifier (of the created comment).

### 4.4.5 submitRelation

**Description:** Via this method, two objects can be linked, and if possible, the metadata record for both of them will be updated to reflect their relation.

**Input parameters:** object identifier (of the source of the link); object identifier (of the target of the link); link type (must be value from relation.kind vocabulary of ICOPER LOM AP).

**Output:** void.

### 4.4.6 deleteObject

**Description:** removes an object from the OICS. Associated metadata records are removed as well. Currently, there is no support for removing only the metadata record.

**Input parameters:** object identifier.

**Output:** void.

### 4.5 Binding and Implementation

Currently three partial implementations of the OICS Middle layer API have been developed. The rationale for this strategy is to prove the concept of an abstract service definition that can be bound to specific result formats and communication protocols, and to evaluate their respective usability from the perspective of an application developer.

#### 4.5.1 ATOM implementation

This implementation binds the methods defined in the Middle layer API to a REST interface as defined by the ATOM syndication format and the SPI standard in its AtomPub binding: A collection of resources is mapped to an ATOM feed, a resource corresponds to an entry, and metadata is described in an entry document. Feeds, entries and entry documents are retrieved
and manipulated through the basic commands of the HTTP protocol. Authentication is handled through HTTP Basic Authentication.

We explain the design of this binding for each part of the Middle layer. The base URI for the implementation is http://oics.icoper.org. All URIs mentioned below are relative to this base URI.

Detailed examples of how to call the services provided by this implementation can be found as part of the ICOPER online training as well as in the online version of the Middle layer documentation.

4.5.1.1 User management, learning outcome profile and recommendation services

The service URI is mapped to /icoper-user-service. Users are represented by XML documents listing available properties.

<table>
<thead>
<tr>
<th>Method</th>
<th>Method, URI and parameters</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>listUsers</td>
<td>GET [service URI]/users/</td>
<td>Returns a list of users with full names and links to user URIs.</td>
</tr>
<tr>
<td>createUser</td>
<td>POST [service URI]/users/</td>
<td>Expects as input XML with elements for email, first names, last name and password. Returns the URI for the new user.</td>
</tr>
<tr>
<td>getUser</td>
<td>GET [user URI]</td>
<td>Returns name and link to profile URI</td>
</tr>
<tr>
<td>modifyUser</td>
<td>POST [user URI]</td>
<td>Same input as createUser</td>
</tr>
<tr>
<td>listGroups</td>
<td>GET [service URI]/groups/</td>
<td>Returns a list of available groups.</td>
</tr>
<tr>
<td>createGroup</td>
<td>POST [service URI]/groups/</td>
<td>Expects as input XML with group name (used in URI) and pretty name.</td>
</tr>
<tr>
<td>addUserToGroup</td>
<td>POST [group URI]</td>
<td>Expects as input XML listing users (defined by their ID) and their respective role.</td>
</tr>
<tr>
<td>getGroup</td>
<td>GET [group URI]</td>
<td>Returns list of users and their respective role.</td>
</tr>
<tr>
<td>addAchievement</td>
<td>POST [profile URI]</td>
<td>Expects a PALO achievement instance bound to an ATOM entry (see Appendix D). Can represent an attained or taught learning outcome, or a learning need.</td>
</tr>
<tr>
<td>addAssessmentRecord</td>
<td>POST [profile URI]</td>
<td>Expects a PALO assessment record instance bound to the XML representation found in Appendix D.</td>
</tr>
<tr>
<td>getLearningOutcomeProfile</td>
<td>GET [profile URI]</td>
<td>Returns the personal achieved learning outcomes as an ATOM feed</td>
</tr>
<tr>
<td>recommendUsers</td>
<td>GET [service URI] ? query</td>
<td>The query is matched against entries in the learning outcome profiles.</td>
</tr>
</tbody>
</table>

4.5.1.2 Search and retrieval service

In the current version of the OICS, there are three repositories:

- learning outcome definitions,
- learning resources (instructional designs and learning content),
learning opportunities.

For each of these, an ATOM feed lists the content. Filter expressions can be used to list only resources of a certain learning resource type (teaching method, learning design, assessment resources). ATOM URIs for these types are also defined as aliases for the specific filter expressions.

For each repository, there is a service document that lists the available collections. See below the description of the publication service for these. Each collection has its own ATOM feed, to which the same filter expressions can be applied.

The following GET parameters are interpreted:

- query: if no filter is defined, a full text query is performed
- filter: the filter can be used to restrict the query to particular fields in the LOM structure, referenced in the following syntax: "\{category\}.\{name\}". For categories whose size is greater than 1, you can filter the whole category with a filter called "\{category\}". For example, valid values for filter are
  - general.title
  - lifeCycle.contribute
  - technical.format
  - educational.learningOutcome
  - rights.cost
  - relation
  - annotation
  - classification

Those filters query the information explicitly stored in the respective fields, i.e. for example for learning outcomes and relations, the identifier of the linked resource. Additionally, there exist specialized filters that cache textual information about the linked resource, or provide more efficient access to frequently needed information:

- IcoperLearningOutcome: filter based on title and description of linked learning outcome
- IcoperRelationUses: filter based on full text index of used resource
- IcoperRelationImplements: filters based on full text index of implemented teaching methods
- IcoperClassificationCSO-FoE: filters based on values from the CSO-FoE taxonomy

- page_size
- page_number
- filter_expression: by providing this parameter multiple times, filter expressions can be combined. Each expression has the following syntax {filter=query}, e.g.: ?filter_expression=general.description=film&filter_expression=general.title=literature

Following the Atom publishing protocol (AtomPub 2007) there are three links in each ATOM entry:
- Without rel attribute: This link points at the location of the object in the OICS.
- Rel=edit: This link points at an ATOM representation of the object; it can be used to change the metadata for the object, or to submit annotations.
- Rel=edit-media: Through this link (whose URI is identical with the first link in the current implementation) the object itself can be edited.

### Table 3: ATOM binding of search and retrieval services

<table>
<thead>
<tr>
<th>Method</th>
<th>Method, URI and parameters</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>getLearningOutcomes</td>
<td>GET /LOD.atom</td>
<td></td>
</tr>
<tr>
<td>getTeachingMethods</td>
<td>GET /TM.atom</td>
<td></td>
</tr>
<tr>
<td>getLearningDesigns</td>
<td>GET /LD.atom</td>
<td></td>
</tr>
<tr>
<td>getLearningContent</td>
<td>GET /oics.atom</td>
<td>Currently there is no feed returning exclusively learning content. This gives access to all learning resources, including teaching methods, learning designs and assessment resources.</td>
</tr>
<tr>
<td>getAssessmentsResources</td>
<td>GET /LA.atom</td>
<td></td>
</tr>
<tr>
<td>getLearningOpportunities</td>
<td>GET /MLO.atom</td>
<td></td>
</tr>
<tr>
<td>getMetadata</td>
<td>GET [link rel=edit]</td>
<td>The entries in the ATOM feed also contain the serialized metadata record, as defined in the SPI Sword binding (Ternier 2009).</td>
</tr>
<tr>
<td></td>
<td>GET [link rel=edit]/[category]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GET [link rel=edit]/[category]/[name]</td>
<td></td>
</tr>
</tbody>
</table>
| resolveIdentifier             | GET /resolve/{identifier}/[type]/[query] | /resolve/{identifier} redirects to the default view of the object on the OICS. By providing an optional type  /resolve/{identifier}/[type] a different representation of the object can be retrieved. Type can be  
|                               | /resolve/{identifier}/atom/[lom_path] where lom_path can be specified as with getMetadata. |                                                                                                                                               |
|                               | /resolve/{identifier}/download/[packaging_format] This service redirects to a packaged representation of the object if it is available from the content |
provider. For example for OpenLearn:
- ouxml
- imscp
- imscm
- corm
- plain
- moodle

4.5.1.3 Publication service

Publication service is provided through an implementation of the SWORD/AtomPub binding of SPI (Ternier 2009). The Simple Webservice Offering Repository Deposit (SWORD) (SWORD 2010) is a profile of the Atom Publishing Protocol (AtomPub) (AtomPub 2007) that provides a REST style API for creating web resources. This binding introduces a metadata element in the namespace “http://www.cenorm.be/xsd/SPI” that wraps a resource’s metadata record.

The repositories for learning resources (instructional models and learning content), and for learning outcome definitions have each a service document that lists the available collections (for each content provider). Each repository has a global ATOM feed for retrieving and searching objects across the whole repository.

Table 4: URIs for OICS repositories

<table>
<thead>
<tr>
<th>Repository</th>
<th>Web UI</th>
<th>ATOM feed</th>
<th>AtomPub service document</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning resources</td>
<td>/oics</td>
<td>/oics.atom</td>
<td>/oics/?m=atomsvc</td>
</tr>
<tr>
<td>Learning outcomes</td>
<td>/LOD</td>
<td>/LOD.atom</td>
<td>/LOD/?m=atomsvc</td>
</tr>
</tbody>
</table>

The "accept" element inside each collection element lists the content types that can be posted to it. If it is empty, the user retrieving the service document is not allowed to submit content of any type.

Table 5: ATOM binding for publication service

<table>
<thead>
<tr>
<th>Method</th>
<th>Method, URI and parameters</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>submitObject</td>
<td>POST {collection URI}</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>submitMetadata</td>
<td>PUT [link rel=edit]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

includes a metadata instance

<table>
<thead>
<tr>
<th>Method</th>
<th>Request URI</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>POST {link rel=edit}</td>
<td>By POSTing an ATOM entry including a metadata record to an object’s edit link, a new metadata record will be created that is handled as a metadata record specific to the user submitting the record. (this mechanism is not part of the SPI specification, but constitutes an ICOPER extension.)</td>
<td></td>
</tr>
<tr>
<td>POST {link rel=edit}/{category}</td>
<td>This implementation supports enriching metadata by addressing sections or fields as explained above.</td>
<td></td>
</tr>
<tr>
<td>POST {link rel=edit}/{category}/{name}</td>
<td>* /{category}</td>
<td></td>
</tr>
<tr>
<td>PUT {link rel=edit}/{category}</td>
<td>* /{category}/{name} only works for categories where size is not greater than 1 (not for relation, annotation, classification).</td>
<td></td>
</tr>
<tr>
<td>PUT {link rel=edit}/{category}/{name}</td>
<td>PUTing to this resource replaces the existing value, POSTing to it, adds a new value, if its size allows it.</td>
<td></td>
</tr>
<tr>
<td>POST {link rel=edit}</td>
<td>Posting an ATOM entry with a content element of type text, HTML or XHTML creates a comment to a resource.</td>
<td></td>
</tr>
<tr>
<td>POST {link rel=edit}/relation</td>
<td>Currently no specialized service is available in this implementation. Relations have to be added through the submitEnrichment method, addressing the relation category.</td>
<td></td>
</tr>
<tr>
<td>DELETE {link rel=edit}</td>
<td>This removes the object from the OICS.</td>
<td></td>
</tr>
</tbody>
</table>

Publishing learning opportunities

The XML binding of the MLO specification groups three different types of objects (providers, specifications and instances) into one XML document. In order to support this binding, the SPI target for the MLO repository, is invoked in a slightly different way: There is no service document, new providers (together with embedded specifications and instances are directly POSTed to the repository’s ATOM URI). Updating of a provider (adding new specifications and instances) can be achieved either by PUTting a new document to the provider’s edit link, or by rePOSTing the document to the repository’s ATOM URI.

4.5.2 JSON implementation

This implementation has been built on top of the ARIADNE Repository services, which provides us with (i) an SQI interface for searching the OICS which enables us to work with different kinds of query languages and different types of result sets, and (ii) with an SPI interface for publishing new or changed material into the OICS. Complete details about the ARIADNE repository infrastructure can be found in (Ternier et.al, 2009).
The search and retrieval services of the OICS middle layer API have been deployed on top of the ARIADNE infrastructure. These services use a REST interface and provide the results to the client tools in the JavaScript Object Notation (JSON, 2006) data format. JSON is a lightweight data format heavily used by web developers due to its simplicity compared to the traditional XML data format approaches.

ICOPERs’ JSON implementation of the OICS middle layer currently contains the following methods:

- getLearningOutcomes
- getTeachingMethods
- getLearningDesigns
- getLearningContent
- getAssessmentDesigns
- getAssessmentResources
- getAssessmentMethods
- getMetadata

These methods receive a (i) query, (ii) page number and (iii) page size parameters. For example, we can issue a query with the following GET request:

```
getLearningOutcomes?q=genes&pn=1&ps=1
```

The result will only be the identifier of the first result on the first page from the LOD instances that fulfills the query.

```
{ "results" : [ 
  { "id" : "01914f8eac35d7e14afa065217edd8c0", "title":"genes"} ]
}
```

The implemented method for retrieval of a metadata record is called getMetadata. This method receives the object identifier as a parameter. It returns the full metadata instance if the given identifier is valid. For example, we can retrieve an object by this request:

```
getMetadata?objId= oai:test1.km.co.at:skolverket_8863
```

The result will return the metadata instance of the requested identifier, for example:

```
{ "results" : [ 
  { "id" : "oai:test1.km.co.at:skolverket_8863", "md":"<lom> .... </lom>"} ]
}
```

The methods offered by the implementations are summarized in the following table.

<p>| Table 6: JSON binding for search and retrieval service | 45/128 |</p>
<table>
<thead>
<tr>
<th>Method</th>
<th>Input parameter(s)</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>getLearningOutcomes</td>
<td>• PLQL Level 1 query (q)</td>
<td>JSON (identifier and title)</td>
</tr>
<tr>
<td></td>
<td>• Page number (pn)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Page size (ps)</td>
<td></td>
</tr>
<tr>
<td>getTeachingMethods</td>
<td>• PLQL Level 1 query (q)</td>
<td>JSON (identifier and title)</td>
</tr>
<tr>
<td></td>
<td>• Page number (pn)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Page size (ps)</td>
<td></td>
</tr>
<tr>
<td>getLearningDesigns</td>
<td>• PLQL Level 1 query (q)</td>
<td>JSON (identifier and title)</td>
</tr>
<tr>
<td></td>
<td>• Page number (pn)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Page size (ps)</td>
<td></td>
</tr>
<tr>
<td>getLearningContent</td>
<td>• PLQL Level 1 query (q)</td>
<td>JSON (identifier and title)</td>
</tr>
<tr>
<td></td>
<td>• Page number (pn)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Page size (ps)</td>
<td></td>
</tr>
<tr>
<td>getAssessmentDesigns</td>
<td>• PLQL Level 1 query (q)</td>
<td>JSON (identifier and title)</td>
</tr>
<tr>
<td></td>
<td>• Page number (pn)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Page size (ps)</td>
<td></td>
</tr>
<tr>
<td>getAssessmentResources</td>
<td>• PLQL Level 1 query (q)</td>
<td>JSON (identifier and title)</td>
</tr>
<tr>
<td></td>
<td>• Page number (pn)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Page size (ps)</td>
<td></td>
</tr>
<tr>
<td>getAssessmentMethods</td>
<td>• PLQL Level 1 query (q)</td>
<td>JSON (identifier and title)</td>
</tr>
<tr>
<td></td>
<td>• Page number (pn)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Page size (ps)</td>
<td></td>
</tr>
<tr>
<td>getMetadata</td>
<td>identifier (objId)</td>
<td>JSON (identifier and metadata)</td>
</tr>
</tbody>
</table>

### 4.5.3 PLQL - SQI Wrapper

This implementation is a wrapper around the underlying SQI implementation of the ARIADNE repository.

Its URI is http://oics.icoper.org/client/api/search.php

It interprets the following GET parameters:

- q: can be a PLQL expression, or a list of keywords from which a PLQL expression is constructed
- lang (can also be provided through the HTTP_ACCEPT_LANGUAGE request header): selects the language of the returned data for those resource attributes that are available in multiple languages. If no lang is provided, the first string in the resource LOM will be selected
- format: if set to extended, information about the resource’s identifiers are included

The result format is a simple XML document:

- The root element is result with attributes cardinality, page and rpp (configurable results set size)
Information about each resource that matches the query is expressed in an “lo” element with the attributes: title, description, location, oicsdata (the location of the metadata view page on the OICS repository).

This implementation is used by the OICS search interface hosted at http://oics.icoper.org/client/index.php. This interface makes use of the OpenSearch standard and hence provides easy integration of OICS search functionality into common browsers’ search engine list.

Figure 9: OICS as OpenSearch provider

5 System Architecture and Integration Mini Case Studies

5.1 OICS Technical Infrastructure

As a backbone for the services described above, we have built the OICS infrastructure as a composition of services developed and maintained at Vienna University of Economics and Business (WUW) and Katholieke Universiteit Leuven (KULeuven). At both sides, a learning object repository is used for storing metadata harvested from the ICOPER content providers. Figure 10 illustrates the integration between the repository instances, content providers and client interfaces. ICOPER Content providers are registered in the LOR registry (1). They provide an implementation of the OAI-PMH protocol.

OAI-PMH (Open Archives Initiative Protocol for Metadata Harvesting) (OAI 2008) is a protocol developed by the Open Archives Initiative. The current version is 2.0, updated in 2002. It is used to harvest (or collect) the metadata descriptions of the records in an archive, repository, digital library, or other asset management system, so that services can be built using metadata from many archives.

The ARIADNE harvester retrieves information about the OAI-PMH targets from there and harvests the metadata (2) which is stored in the file system and ingested from there into the WUW repository (3). Metadata is both exposed through OAI-PMH for batch synchronizations and published through the SPI protocol for updates of individual objects to the KULeuven repository (4). Client interfaces access the resources through the services of the OICS Middle layer (6) implemented on both sides (5).
OpenACS at WUW

OpenACS has been successfully used by WUW and its partner KnowledgeMarkets as the basis of two repositories of learning content—Bildungspool (Bildungspool 2009), the federation of learning content for Austrian schools, and Educanext (Educaneext 2009), the brokerage platform for educational content.

OpenACS “is a toolkit for building scalable, community-oriented web applications.” (OpenACS 2009). It relies on AOLserver, an open-source, multithreaded, scalable, Tcl-enabled, web/application server and the Relational Database Management System (RDBMS) PostgreSQL. On top of OpenACS, KnowledgeMarkets has developed a learning object repository service, capable of storing learning objects and metadata in configurable schemas. This package makes use of many of the services provided by the OpenACS platform, most prominently the content repository and XoTcl, an object oriented extension to the Tcl programming language (Neumann and Sobernig 2009). The complete source code of the system has been made available, and installation instructions are provided.

1 http://www.icoper.org/open-content-space/install
ARIADNE at KU Leuven

ARIADNE is a European foundation that aims to foster “Share and Reuse” of learning resources. In order to reach this, KU Leuven has created a standards-based infrastructure for managing learning objects in an open and scalable way. The overall goal of this infrastructure is to provide flexible, effective and efficient access to large-scale collections in a way that goes beyond what typical search engines provide. Therefore, it provides

1. a set of services which allows the integration and management of learning objects, described in various metadata schemas in numerous repositories across the globe,
2. a toolset which allows end users to access the learning material in various ways through information visualization, mobile information devices, multi-touch displays and mash-up applications.

5.2 Integration Mini Case Studies: Providers of Shareable Educational Resources

There are three instances of the OICS repository service storing shareable educational resources, configured to use different metadata schemas: LOD for learning outcome definitions, ICOPER LOM AP for learning resources, MLO for learning opportunities. In the following, we describe how shareable educational resources were acquired for each of them.

5.2.1 Learning Outcome Definitions

Data sources for learning outcome definitions have been identified by WP2 and partners as part of curricula defined by higher education institutions and other organizations. Since these sources are not available in the LOD schema, they had to be transformed algorithmically or, occasionally if an automatic transformation was not feasible, were added manually through the OICS UI for metadata editing. OpenGLM (see Section 5.3.1) also allows the publication of learning outcome definitions.

ECDL Certification: The ECDL Certification is based on the ECDL-Syllabus. It states learning outcomes (objectives) that define the skills and competencies necessary to be a proficient user of a computer and common computer applications. http://www.ecdl.org/programmes/media/ECDL_ICDL_Syllabus_Version_51.pdf.

Learning outcomes of this syllabus were transformed into ICOPER valid LOD XML instances. The LODs were tagged with unique identifiers and stored into the OICS learning outcome repository.

IEEE/ACM Computer Science Curricula: The ACM/IEEE Computer Science Curricula review task force has defined the list of learning outcomes (objectives), as part of course descriptions, for all computer science courses published in 2008 in a PDF file at http://www.acm.org/education/curricula/ComputerScience2008.pdf. Learning outcomes of those courses were extracted into HTML format that was afterwards transformed into ICOPER valid LOD XML instances stored, with unique identifiers, into the OICS learning outcome repository.

OpenLearn: All learning designs offered by OpenLearn have learning outcomes associated to their metadata records, represented in a local XML format and recently as part of IEEE LOM metadata exposed through OAI-PMH. After harvesting and upon ingestion into the OICS these learning outcomes are extracted as explained in Section 5.2.3.5.
WU Wirtschaftspädagogik: For the study programme Business Education at the Vienna University of Economics and Business 52 learning outcomes were defined at the level of the curriculum. These learning outcomes should describe the competences a student should have achieved after successfully completing the whole programme. The learning outcomes were exported from Learn@WU and stored in ICOPER valid LOD XML instances. Afterwards, the LODs were tagged with unique identifiers and stored into the OICS learning outcome repository.

MACE: OUNL created IMS LDs about Modern Architecture that integrate the MACE portal and selected MACE content (MACE 2011). The learning objectives are based on standardised architecture-competence definition\(^1\). The learning outcomes are derived from these learning objectives. Tagged with the unique identifiers and categorized according to EQF (knowledge, skill or competence), the LODs were stored in the OICS repository.

OpenER: Open University of the Netherland’s institutional repository, member of the Open Courseware Consortium, covers high quality materials for High School to MBA level. OUNL follows an open educational resources strategy; the OpenER portal provides access to these resources. The learning outcomes for the Computer Science section of OER were defined according to the ACM Computer Science Curriculum 2008. These learning outcomes were tagged with unique identifiers and stored in the OICS repository. For the course “Communicatietechnologie – Een inleiding” an online test that is based on the existing assessment for this course was created and exported to the IMS QTI format.

5.2.2 Harvesting Educational Content: Problems and Solutions

In the following section, we describe the content that has been included into the OICS by means of the OAI-PMH protocol. Here we summarize the issues that arose and how they were solved.

As explained in Section 3.7, for the OICS, we use the ARIADNE harvester connected to a registry service, where information about content providers are maintained, a validation service, which validates metadata records with respect to the ICOPER LOM AP, and a transformation service that modifies metadata records according to defined rules in order to make it compliant. The latter service was needed, because some content providers were not able to modify the OAI-PMH endpoint that had been set up for other projects.

The following challenges arose during integration of content providers and OICS and are concerned specifically with adapting the provided metadata to the constraints defined in the ICOPER LOM AP.

**Validation of learning resource type:**

The validation of the learning resource type element has been customized to meet the needs of the ICOPER Application Profile. Following the requirements of ICOPERs’ use cases and

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prototypes, we need to be able to distinguish each LOM instance in terms of being either an assessment method, a teaching method, a learning design, an assessment design, an assessment resource or any other learning content. Therefore, a new vocabulary has been added in the ICOPER AP. Because this vocabulary is conceptually an extension of the existing vocabularies for the learning resource type element in LOM, we decided not to create a new LOM element for this purpose. Instead we added this new vocabulary to the existing learning resource type vocabulary.

To enforce the use of the new vocabulary, we created a custom rule in the validation scheme of ICOPER, which requires one of the new ICOPER values to be used, but also validates other values against the existing vocabulary when present to provide compatibility with IEEE LOM. This means that a subset of the learningResourceType vocabulary would have to be made mandatory. Normally when a vocabulary is made mandatory any value of the vocabulary is sufficient to comply with the rule.

In the validation service the check for presence of mandatory elements and the check for allowed values in a vocabulary are done by two different components. This means that with the existing components we can impose that certain elements are mandatory (regardless of the contents), but we cannot force for an element to use a subset of a vocabulary at least once. Hence we created a small custom component (done in Schematron) that does an explicit check on this condition.

The drawback of this approach is that the custom component has the values hard coded and does not make use of the vocabulary service anymore. To solve this, it is possible to write a component that also extracts its values from the vocabulary bank, but this is not really required at the moment.

**Multiple occurrence of same language in one langstring:**

IEEE LOM has the following definition for langstrings:

A datatype that represents one or more characterstrings. A LangString value may include multiple semantically equivalent character strings, such as translations or alternative descriptions. (IEEE 2002, p.24)

While in the XML binding of langstrings, one element with the name of the field should wrap multiple string elements with different language attributes that contain those semantically equivalent character strings, in some of the harvested data, multiple semantically distinct values from the same language were erroneously wrapped into one element. For example, a resource with two keywords “Art” and “France” had the following XML:

```xml
<keyword>
  <string language="en">Art</string>
  <string language="en">France</string>
</keyword>
```

instead of:

```xml
<keyword>
  <string language="en">Art</string>
</keyword>
<keyword>
  <string language="en">France</string>
</keyword>
```
Catching these errors through the validation service proved to be difficult: We implemented a rule for doing so, using Schematron and XPath expressions, so this could be added next to the existing validation components. Unfortunately the used xpath expression made langstrings without an explicit language attribute also invalid. As this issue meant the validation process blocked the complete ingestion workflow, we decided to disable this check until a bug free alternative has been found.

**Qualifying the location of an object:**

IEEE LOM provides a field for representing the URIs of an object (Technical.Location), but no mechanism for qualifying these. It is thus not possible to distinguish between different manifestations of an object.

While experience has been building up in both ICOPER and many other eContentPlus projects such as MACE and MELT, a number of interrelated shortcomings of LOM have been identified:

1. The need for describing different versions of a learning object (LO) became apparent because Learning Objects are nowadays often available in different formats. For example, the OpenLearn initiative of the Open University (UK) produces its content in eight different formats such as SCORM, Common Cartridge, etc.
2. Besides that, there may be different versions available for an individual LO such as different language versions, but e.g. also several versions for people with disabilities. Examples may be: an audio version for the blind, a version avoiding red for the colour blind, etc.
3. Furthermore, each different version or format of a learning object could have some different metadata facets such as audience or rights.

Solutions for these shortcomings have been presented in Van Assche et al. (2010).

For the OICS, we have studied in detail the possibilities opened by the ILOX (Information for Learning Object eXchange) framework, developed as part of the IMS Learning Object Discovery & Exchange (LODE) specification. ILOX distinguishes between a work (a distinct creation), its expression (for example in different language versions), its manifestation (embodied in a specific distribution format), and items (as logical or physical location, where those can be retrieved) (Massart et al. 2010). ILOX allows to distinguish between those distinct levels of materializations of a learning object and to attach metadata to any of those, thus allowing qualifying not only the locations of different copies of a resource, but any other metadata that might have different values on those levels. Finally, we have decided to implement the solution that makes it easy for clients to retrieve the most appropriate representation of an object if available by including knowledge about these locations into the resolution service. See Section 4.3 for a detailed description of this functionality.

**Handling ICOPER identifiers:**

We decided to link learning designs to learning outcome definitions based on a persistent identifier, in order to make this links resilient against changes in DNS names and topology of services and collections. We thus included a resolution service into the OICS Middle layer.

**Dealing with foreign vocabularies:**

Metadata harvested for the OICS is also used for other consuming applications, and thus often contains information with semantics defined in different context. Examples include vocabularies for learning resource types defined in the context of projects like LRE,
OERCommons. The question has come up whether it would be possible to still validate known vocabularies, but also accept unknown vocabularies.

This is a challenge because it goes against the principles used to validate vocabularies. This is usually done by checking whether a valid pair of values in the source and value elements is used. This means that with this way of working the pairs of unknown vocabularies will be invalidated.

A possible solution for this challenge would be to only check the value of a value element when the source element has a known value. This would however have a major drawback. The value of the source element would not be checked anymore against use of invalid values. This would allow for metadata which is invalid against the Application Profile to enter the repository. For this reason this approach has not been implemented, thus incurring the drawback of using the semantics expressed in the foreign vocabulary. We have tried to map these values to the ICOPER defined vocabulary. See Appendix 2 for the mapping tables.

**Encoding the package type of an object:**

In order to provide clients with reliable information on which representation of an object is stored in the OICS, we have profiled the field `Technical.OtherPlatformRequirements` in order to allow a special language identifier ―x-t-icoper-package-format‖, following the approach suggested by the LRE application profile for the encoding of the Creative Commons license used for an object. The OICS infrastructure formerly only accepted language codes for langstrings and was modified in order to support these identifiers.

**Create learning outcome definitions from harvested metadata:**

Only OpenLearn provides information about “author anticipated learning outcomes” as part of the metadata exposed through OAI-PMH. But these learning outcome definitions are not stored in a repository and linked to, but stored into the LOM classification category. In order to make these resources amenable to the OICS services, we have transformed the metadata, first by extracting the learning outcome definitions, and storing them into the OICS LOD repository. A title was constructed by submitting the definition to the Yahoo term extraction service\(^1\), and a hash of the definition was used as a local collection specific identifier for the object. A link to the created learning outcome was inserted into the metadata for the learning design. This transformation happens on-the-fly while ingesting the harvested metadata into the OICS.

**Managing vocabulary terms from different sources:**

The repository software used for the OICS originally associated exactly one source with each vocabulary used in LOM. Interoperability with applications that are only familiar with the IEEE LOM base schema is only possible if each term is correctly associated with the source where it is defined, thus creating the need for mixed vocabularies where terms are defined in different contexts. For example for Relation.Kind, we included all terms from IEEE LOM in the ICOPER AP, and added five additional terms. The OICS repository now correctly associates terms and sources.

\(^1\) http://developer.yahoo.com/search/content/V1/termExtraction.html
Validating elements from different namespaces:
ICOPER has extended the base LOM scheme with extra elements, which are defined in its own ICOPER namespaces.

This extension did not impose a big issue per se, as all components of the validation service are fully namespace-aware. However the functionality of the component that checks for the presence of mandatory elements has been extended. It now automatically verifies that only the specifically defined elements can be used in a certain namespace. This ensures that the elements are spelled correctly and are used with the correct namespace.

Implement a proof of concept for storing contextual information:
In ICOPER, context, being a subject domain (e.g., physics, chemistry, medicine, etc.) or any other type of context like location or situation, is relevant for

- describing in which context learning-outcomes should be or have been achieved;
- searching learning outcomes and resources;
- identifying differences between contexts of potential usage;
- recommending resources for intended learning outcomes of learners / teachers.

We have analysed and formalized, in D2.2, contextual information that describes the situation and the context where learning has happened, i.e., in what context skills, knowledge or abilities have been applied/obtained (see Figure 11). Based on this generic way of context representation, as a proof of concept, we have created a repository and related web services for subject-domain contexts. The repository was populated with the The CSO Standard Fields of Education Classification (CSO, 2010) which is based on the International Standard Classification of Education (ISCED).

![Figure 11: Data captured about context in Personal Achieved Learning Outcomes (PALO) data model (D2.2)](image)

The repository services enable referring to a context value by a URI that contains the Scheme (e.g. CSO) and Value (e.g. computer science). For example “http://oics.icoper.org/resolve-context/CSO-FoE/4.8.1” refers to the value “Computer science” in the CSO taxonomy. This, for example, will enable applications that produce PALO data to refer to the context where a learning outcome is achieved using a single unique URI. In this way, it is possible to store, refer to and identify context values that may belong to different ontologies.

The OICS metadata editor was extended with a feature that allows the selection of values from this taxonomy through a dialog and populates a LOM classification structure with it.
Uniqueness of identifiers for metadata records

Some content providers do not use unique identifiers for Metametadata.Identifier. This makes handling of resources difficult, since this identifier is used by the harvester to store the record. A debugging feature of the harvester allowed identifying these records, and most content providers were able to correct their metadata.

Handling of foreign vocabularies

Metadata harvested for the OICS is also used for other consuming applications, and thus often contains information with semantics defined in different context. Examples include vocabularies for learning resource types defined in the context of projects like LRE, OERCommons. We have tried to map these values to the ICOPER defined vocabulary. See Appendix 2 for the mapping tables.

5.2.3 Providers of Educational Content and Instructional Models

In the following we enumerate all content providers connected to the OICS. Numbers of hours are counted as far as they have been provided through the field Educational.typicalLearningTime of the metadata records.

5.2.3.1 Slidestar

Description of content: This library for free and open learning resources for academics and students includes video-lectures, audio-casts, PowerPoint slides, PDF and Word documents.

OAI-PMH endpoint: http://slidestar.de/oai

Contact person: Johannes Götzinger

Resources: 288 learning designs; no information about typical learning time.

Most important keywords: Berlin, BPM, Aris, eLearning, PW08, Business Process Management, BPA, Business Process Analysis, LW08, Web 2.0
5.2.3.2 Spindeln

**Description of content:** Umeå is providing this Swedish learning repository federation that includes text, images, sounds, movies, and more complex learning objects.

**OAI-PMH endpoint:** [http://spindeln.iml.umu.se:9090/oai/OAIHandler](http://spindeln.iml.umu.se:9090/oai/OAIHandler)

Contact person: Mikael Karlsson

**Resources:** 7577; 2 teaching methods, 3967 learning designs, 3608 learning contents; no information about typical learning time.

Most important keywords: sport, Electrical Engineering and Computer Science, animal, history, Mechanical Engineering, culture, politics, town, gender, water

5.2.3.3 CDK

**Description of content:** Course Development Kit is an e-content (e-books and distance learning courses) developing system. With this tool text, illustrations, self-control questions/answers and links to external sources are transformed into electronic form, suitable to publish on the Internet. This way, people are able to create quality e-learning courses without any hypertext (html) markup knowledge and without deep IT area understanding. There are about 2 thousand e-courses in CDK system at KTU, most of them are university learning material.


Contact person: Evaldas Karazinas

**Resources:** 1891 learning contents. No keywords provided.

5.2.3.4 ViPS

**Description of content:** ViPS is used to broadcast interactive lectures and presentation over the Internet. It is used for broadcasting live events and can perform recording to archive where records can be accessed on demand. There are about 5 thousand records stored on ViPS system that is installed on KTU server of conferences, seminars, lectures recordings.


Contact person: Evaldas Karazinas

**Resources:** 4970 learning contents

Most important keywords: conference, project, education, e-learning, WITFOR, commission, technology, KTU, telda, leonardo

5.2.3.5 OpenLearn

**Description of content:** Courses “designed for open learners” (quality assured and experimental).

**OAI-PMH endpoint:** [http://openlearn.open.ac.uk/local/oai/oai2.php](http://openlearn.open.ac.uk/local/oai/oai2.php)

Contact person: Jenny Gray

**Resources:** 554 learning designs; 6539 hours.

Most important keywords: Science, Arts and Humanities, Social Sciences, Mathematics and Statistics, Education, Health and Social Care, Engineering and Technology, Business and Management, Skills, Scotland
Issues:
1. Technical.location missing. Solution: Enrichment upon ingestion.
2. Metadata does not include links to packaged formats that are of interest for prototypes. Solution: resolution service
3. Learning outcomes are encoded in a different way than defined in ICOPER LOM AP. Solution: Transformation upon ingestion

5.2.3.6 Hive
Description of content: HarvestRoad Hive® is a secure, easily accessible store for any type of digital content item, or for data that describes the stored digital content item (“metadata”). It provides repository services to manage the content items and metadata, including version control, controlled editing, workflow routing, copyright management, contents format conversion, searching and browsing to discover the stored digital data.
OAI-PMH endpoint: http://icoper.hive.giuntilabs.com/oai/oai.cgi
Contact person: Michele Dicerto
Resources: 23 learning contents
Most important keywords: art, painter, QTI, science

5.2.3.7 Waramu
Description of content: Quality controlled PowerPoint presentations and Word documents for K12.
OAI-PMH endpoint: http://koolitaja.eenet.ee:57219/Waramu3Web/OAIHandler
Contact person: Martin Sillaots
Resources: 4739 (459 teaching methods, 1586 learning designs, 210 learner assessments, 2484 learning contents); no information about typical learning time.
Most important keywords: English as foreign language, Estonian language, Basic Education, Topics for reading and listening and writing, Special education, German, Biology, Computer Science, Language education, Chemistry
Issues:
1. General.language missing or invalid values
2. Empty vcard or missing entity for contribute
3. Multiple strings with same language grouped into one langstring
4. Erroneous source identifiers for vocabulary terms
456 records had unresolvable issues

5.2.3.8 Waramu Questions and tests
Description of content: Questions and tests
OAI-PMH endpoint: http://htk.tlu.ee/Waramu3Web/OAIHandler
Contact person: Martin Sillaots
Number of resources: 651 learner assessments
Most important keywords: ICT Cert, XDSL techniques, IP routing, ISO OSI, IP Protocol, TCP and UDP protocols, english, Broadband settings, Network protocols, present simple
Issues: In addition to the issues listed in 5.2.3.7, type of assessment resource is encoded into learningResourceType. We recommend moving this information into Classification category. 26 records had unresolvable issues

5.2.3.9 Media42
Description of content: Media Assets (Images, Video, Audio, Documents) that are created and maintained by the medialibrary user community and can be reused in authoring processes.
OAI-PMH endpoint: http://80.237.233.156:8080/oaitarget/OAIHandler
Contact person: Sören Unruh
Resources: 62 learning contents
Most important keywords: ecdl, firefox, podcast, vienna, search, beschreibung, en, description, doc, de

5.2.3.10 OpenER
Description of content: Open University of the Netherlands institutional repository, member of the Open Courseware Consortium. High quality materials for High School to MBA level.
OAI-PMH endpoint: http://145.20.132.28:8000/oaitargetOU/OAIHandler
Contact person: Roland Klemke
Resources: 24 learning designs, 1 learner assessment; 508 hours.
Most important keywords: managementwetenschappen, gratis, natuurwetenschappen, informatica, politiek, biologie, milieu, cultuurwetenschappen, inleiding, rechtswetenschappen
Issues: Three OpenER resources are enriched upon import to the OICS with links to learning outcomes and assessment items

5.2.3.11 ARIADNE
Description of content: The ARIADNE foundation is a European Association open to the World, for knowledge sharing and reuse. The core of the ARIADNE infrastructure is a distributed network of learning repositories.
Contact person: Joris Klerkx
Resources: 3288 (1433 learning designs, 281 learner assessments, 1574 learning contents); 5274 hours.
Most important keywords: java programming, Automatics/Control Engineering, Microtechnics, Databases, people management, class design, concept, business and information technologies, General/Sundry, learning
Issues: vcard validation, identifier for vocabulary source, general.language missing
5.2.3.12 OERCommons

Type of content: OER Commons has forged alliances with over 120 major content partners to provide a single point of access through which educators and learners can search across collections to access over 24000 resources that are publicly available for all to use, and principally through Creative Commons licensing, many thousands are legally available for repurposing, modifying and improving.


Contact person: Joris Klerkx

Number of resources: 30903 (16255 learning designs, 4541 teaching methods, 800 learner assessments, 9307 learning content); no information about typical learning time.

Most important keywords: Earth Science, Astronomy, Space Science, Physical Sciences, Languages And Literature, Biology, Geography, Atmospheric Science, Dutch, Meteorology

Issues:

1. There are two fields of //lom:lom/lom:metaMetadata/lom:contribute/ with role provider, but in one of them the source is not set to "LREv3.0", but empty.

2. The term "ispartof" for //lom:lom/lom:relation/lom:kind is used with source "LREv3.0" instead of "LOMv1.0".

5.2.3.13 LeMill

Description of content: Web community for finding, authoring and sharing learning resources.

OAI-PMH endpoint: [http://lemill.net/content/OAI-script](http://lemill.net/content/OAI-script)

Contact person: Jukka Purma

Resources: 12523 (1644 learning designs, 739 teaching methods, 10139 learning contents); no information about typical learning time.

Most important keywords: calibrate, English, Microsoft, Microsoft office live, partners in learning, windows live, live@edu, lemill, dhtml, grammar

Issues:

1. two resources have metadata identifiers too long for storage on disk

2. The term "higher education" for //lom:educational/lom:context is used with source "LREv3.0" instead of "LOMv1.0".

5.2.3.14 Unit

Description of content: Portal serving 50 French HEIs in Engineering, one of 7 Digital Campuses with financial support from the French Ministry of Education

OAI-PMH endpoint: [http://www.unit.eu/ori-oai-repository/OAIHandler](http://www.unit.eu/ori-oai-repository/OAIHandler)

Contact person: Katherine Maillet

Resources: 589 (520 learning designs, 15 learner assessments, 54 learning contents); 5265 hours.
Most important keywords: fuscia, modélisation, OPI, sciences de l'ingénieur, traitement de l'image, module multimédia, logiciel R, Optique Pour l'Ingénieur, TIM, mécanique

**Issues:**

1. Unit uses the LOMFR profile. Some vocabulary values could be ignored since they refine values from base LOM. But for others no equivalent value in LOM exist:
   a. relation.kind defined in http://lom-fr.fr/vdex/lomfrv1-0/lomfr-1/vdex_relations.xml/view
   b. liveCycle.contributor.role defined in http://lom-fr.fr/vdex/lomfrv1-0/lomfr-1/vdex_lc_roles.xml/view
   c. technical.requirement.orComposite.name (with type = ‘operating system’) defined in http://www.lom-fr.fr/vdex/lomfrv1-0/lomfr-1/vdex_tec_os.xml/view

   Leaving them out incurred the cost of losing information.

2. Vcards missing version attribute
3. Relation.kind, relation.ressource.identifier.entry or relation.ressource.identifier.catalog elements missing
4. General.language element missing
5. Lifecycle.contribute.role.value missing

**5.2.3.15 Educanext**

**Description of content:** EducaNext is a non-profit association that aims at: (1) supporting the creation, exchange and dissemination of knowledge using Information and Communication Technology (ICT); (2) fostering collaboration among higher education institutions, research institutions, and other organisations producing knowledge, both at an individual and institutional level and (3) increasing excellence in teaching, learning and research. Resources for which authors have granted public read access and that have optionally been released under a Creative Commons license, have been exposed through OAI-PMH.

**OAI-PMH endpoint:** [http://www.educanext.org/new-lors/oai-pmh-global-educanext](http://www.educanext.org/new-lors/oai-pmh-global-educanext)

Contact person: Andreas Mulley

**Resources:** 173 learning contents. No keywords provided.

**5.2.3.16 University of Vienna**

**Description of content:** The University of Vienna set up a collection of teaching methods, which are grounded in research or stem from accounts of usage. The teaching methods are systematically and consistently described, and available as IMS LD learning designs. Teaching methods can be adjusted or used within IMS LD course authoring software like OpenGLM.

**Data source:** Published to the OICS through a custom interface developed by Michael Derntl.

Contact person: Susanne Neumann

**Number of resources:** 34 teaching methods
5.2.3.17 OUNL Itunes U channel

Description of content: In the context of its OER strategy, the Open University of the Netherlands automatically exports some of its educational video productions to both iTunes U and YouTube EDU. Apple’s iTunes U architecture strongly relates to a harvesting architecture and requires all partners to export content through either ATOM or RSS feeds. In the effort to make the OUNL video metadata available to iTunes U, the architecture was also complemented with an OAI-PMH target, making these materials available to the ICOPER community.

OAI-PMH endpoint: [http://ounlitunesu.appspot.com/OAI](http://ounlitunesu.appspot.com/OAI)
Contact person: Stefaan Ternier

Resources: 627 learning contents

5.2.3.18 Jorum

Description of content: Through Jorum, you can find, share and discuss learning and teaching materials, shared by the UK Further and Higher Education community.

OAI-PMH endpoint: [http://open.jorum.ac.uk/oai/request](http://open.jorum.ac.uk/oai/request)
Contact person: Gareth Waller

Resources: 10456 learning contents.
Most important keywords: ukoer, corematerials, medev, DoITPoMS, University of Cambridge, Veterinary, OOER, MEDEV, bioscience, Anatomy.

5.2.3.19 MACE

Description of content: OUNL created IMS-Learning Designs about Modern Architecture that integrate the MACE portal and selected MACE content.

Data source: provided by Marion Gruber and added manually through Web UI

Resources: 4 learning designs, 1 teaching method; no information about typical learning time.
Most important keywords: IMS-LD, learning design, modern architecture, education, teaching, MACE, adaptation, iCOPER, GRAPPLE, personalisation, MACE, orchestration

5.2.4 Learning Opportunities

Learning opportunities are stored using the data model described in Section 2.6in a specialized repository instance at [http://oics.icoper.org/MLO/](http://oics.icoper.org/MLO/).

The OICS repository for learning opportunities has been seeded with information extracted from the course catalogues of UNIVIE (52 specifications and 144 instances).

5.3 Integration Mini Case Studies: End User Tools

The following hypothetical scenario illustrates how university administration, faculty and learners can benefit from making the systems that manage teaching and learning processes interoperable through the adoption of the IRM.
1. At University X, a new curriculum for a course program is developed. Each course description is linked to learning outcome definitions (LOD) and suggested teaching methods (TM), both stored in the OICS.

2. Best practices for teaching methods (TM) have been elaborated by a consortium of universities, and for each of them a template has been elaborated that can be used by instructional designers.

3. An instructional designer creates a new learning design (LD) for the program. She retrieves the LODs mentioned in the curriculum from the LOD repository and searches the TM repository for a suitable template including assessment methods. She imports it into her authoring environment, adds learning content and includes assessment designs retrieved from the OICS. Since assessment designs are linked to learning outcomes and assessment methods, she is able to retrieve the most relevant content. The LD is made available for feedback in a restricted collection.

4. Additional links to learning outcomes and teaching methods can be added by program management.

5. Once the LD has been approved by the program management, the LD is published.

6. It is imported into the institutional LMS, and automatically a learning opportunity is pushed to a registry service for learning opportunities.

7. Upon each completion of the LD, feedback from teachers and learners is collected and the metadata is enriched.

8. Learners completing the LD, including the successful finishing of learning assessment (LA), have their learning outcome profile augmented with entries for each achieved learning outcome. The achieved learning outcomes are evidenced by assessment records (AR), results of the assessment process.

9. Prospective learners that use the OICS LOD repository for identifying learning outcomes that correspond to their learning needs will be able to retrieve other learners that already have achieved these outcomes, and since their profile also links to learning designs and learning opportunities, relevant recommendations can be presented to the learner.

For each of the applications, we describe by who it has been and is being developed, its type, its target audience and the environment where it is executed. Following a short presentation of how the prototype works, we analyze its integration with the OICS from the standpoint of a SWOT analysis (strengths, weaknesses, opportunities and threats). This analysis is based on an engineering evaluation\(^1\) that has been conducted with stakeholders from all partners that have developed prototypes. Detailed instructions for users can be found on the ICOPER training infrastructure\(^2\). Appendix C provides a table explaining how some of the prototypes relate to above scenario.

---

\(^1\) See Appendix E for the survey sent to application developers.

\(^2\) http://training.icoper.org/
5.3.1 OpenGLM – Open Graphical Learning Modeller

**Developing institution:**
University of Vienna

Contributors: Philipp Prenner, Michael Derntl, Susanne Neumann, Petra Oberhuemer

**Type:** Desktop application

**Target audience:** Learning designers, Teachers, Course developers

**Application environment:**
OpenGLM is a cross-platform Java application based on PROLIX GLM, which is based on RELOAD and Eclipse. OpenGLM is open source software that is available for download from sourceforge at http://sourceforge.net/projects/openglm/. There are builds for Windows, Mac, and Linux.

**Application description:**
OpenGLM allows users to develop a new instructional model (learning design or teaching method) or to reuse an existing instructional model, for example one retrieved from the OICS. It is able to manipulate instructional models compliant with the IMS Learning Design specification. It was built to visually support the creation and reuse of teaching methods and learning designs.

The following features make use of the OICS services:

- **Importing an instructional model from the OICS.** Users can search the OICS for available learning designs and teaching methods. Those learning designs and teaching methods that can be imported into OpenGLM have in their LOM metadata record "application/zip" in the Technical.Format element and "imsld_v0p1" in the Technical.OtherPlatformRequirements element.

- **Enrichment of the instructional model** with meta-information and intended learning outcomes that are stored as metadata in the LOM record upon export to OICS. Definitions for learning outcomes can either be retrieved from the OICS or created by the user and exported to the OICS.

- **Adding educational resources.** The OICS hosts several thousand sharable educational resources of different types (from single pictures to complete web-based courses). These resources can be searched from OpenGLM and added to the current learning design. The use of the resource is recorded in the Relation category of the learning design’s LOM record.

- **Implementing teaching methods.** In the pane on the lower right-hand side there is a list of teaching methods available to be dragged and dropped into the modelling pane, which will add the teaching method’s activities to the learning design. Using this feature is interpreted as the teaching method being implemented in the current learning design. OpenGLM will therefore enrich the LOM metadata of the learning design with relation links to all teaching methods reused this way.

- **Exporting instructional models to OICS.** OpenGLM makes sure that learning designs and teaching methods exported to the OICS are complete and valid. When working on a
learning design or teaching method previously imported from OICS, users can either replace the current version or create a new one.

**Screenshot:**

![Add learning outcome from OICS](image)

**Figure 13:** List of learning outcomes in OpenGLM retrieved from OICS

**Integration with OICS:**

<table>
<thead>
<tr>
<th>OICS services and operations</th>
<th>Use cases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Search and Retrieval Service:</strong></td>
<td>Search for learning design or teaching method; Retrieve learning design or teaching method; Annotate learning design or teaching method.</td>
</tr>
<tr>
<td>getLearningOutcomeDefinitions, getTeachingMethods, getLearningDesigns, getLearningResources, getMetadata, getObject, resolveIdentifier</td>
<td></td>
</tr>
<tr>
<td><strong>Publication Service:</strong></td>
<td>Upload learning design or teaching method; Annotate learning design or teaching method.</td>
</tr>
<tr>
<td>submitObject, submitMetadata, submitEnrichment, submitRelation</td>
<td></td>
</tr>
<tr>
<td><strong>User Management and Learning Outcome Profile Service:</strong></td>
<td>Upload learning design or teaching method; Annotate learning design or teaching method.</td>
</tr>
<tr>
<td>getUser</td>
<td></td>
</tr>
</tbody>
</table>
Evaluation and recommendation: Performance issues caused by inefficiency of the result format and limitations of the signature of the search method were the main concern voiced by the application developer at the time the engineering evaluation was conducted. In later generations of the OICS system these issues were partially addressed.

Further information about OpenGLM can be found in D3.2 (Section 5).

5.3.2 Recommendation Widgets in Moodle

Developing institution:
Kaunas University of Technology
Contacts: Gytis Cibulskis and Evaldas Karazinas
Type: Moodle plugins (blocks)
Target audience: teachers, learners
Application environment:
Widgets are implemented as Moodle blocks (Moodle 1.9.x version). They can be tested at http://distance.ktu.lt/moodle2/.

Application description:
This prototype is divided into four widgets:

- Join OICS
- Similar local teachers
- Similar local courses
- Related LDs

They retrieve users’ learning outcome profile (LOP), then by matching records from the LOP and using the retrieval service for LDs, other items are recommended. A caching mechanism has been implemented in order to prevent stressing the server on every refresh of the widget.
Screenshot:

![Recommendation widgets in Moodle](image)

**Figure 14: Recommendation widgets in Moodle**

**Integration with OICS:**

**Table 8: Integration between Recommendation widgets in Moodle and OICS**

<table>
<thead>
<tr>
<th>OICS services and operations</th>
<th>Use cases</th>
</tr>
</thead>
</table>
| **User Management and Learning Outcome Profile Service:**  
getUser  
getLearningOutcomeProfile  
recommendUsers | • Recommendation of Learning Designs,  
• recommendation of teachers and  
• recommendation of courses.  
The widget recommends Learning Designs by matching information from user’s profile with the Learning Outcome repository. Links to resources’ metadata are provided by resolving identifiers. Additionally users are recommended through the recommendUsers method. |
| **Search and retrieval service:**  
resolveIdentifier  
getLearningOutcomeDefinitions  
getLearningDesigns | |
Evaluation and recommendation: According to the widget’s developers, the OICS Middle layer provides the opportunity to make learning objects from the institutional repository available for international students thus improving the university’s reputation. Scalability was seen as a potential threat if the OICS became a widely used service.

5.3.3 .LRN Prototype for Managing Assessment Resources

Developing institution:
Carlos III University of Madrid

Developers: Andres Franco, Israel Gutiérrez Rojas and Derick Leony

Type: .LRN package, called "ICOPER assessment package".

Target audience: Teachers and course developers. Learners could be also targeted using the ICOPER package jointly with the already existing assessment packaging that provides features for authoring and managing IMS QTI 1.2.1 assessment resources.

Application environment:
The developed prototype consists in a package for the open source learning management system (LMS). An online demonstration is available at http://mozart.gast.it.uc3m.es:9000/.

Application description:
Three use cases are supported by this prototype:

- Search of assessment designs: Teachers can search by keywords and filter results by learning outcome and/or assessment method. They can review the assessment details, download the IMS QTI and import assessment directly into an existing course.

- Publication of assessment designs: Any assessment resource can be published to the OICS and described through metadata.

- Annotation of assessment designs: Annotations to the assessment design can be included into the resource’s metadata.
D1.2 Open ICOPER Content Space
Implementation of 2nd Generation of Open ICOPER Content Space including Integration Mini Case Studies

Screenshot:

![Home : ICOPER Assessment](image1)

**Publish / Update assessment into OICS**

**ICOPER Test Community**

<table>
<thead>
<tr>
<th>Title</th>
<th>OICS Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>.LRN assessment prototype</td>
<td>Update</td>
</tr>
<tr>
<td>.LRN assessment prototype (new)</td>
<td>Publish</td>
</tr>
<tr>
<td>Test 1</td>
<td>Update</td>
</tr>
</tbody>
</table>

Figure 15: Publication of assessment designs from .LRN

**Integration with OICS:**

**Table 9: Integration between .LRN prototype for managing assessment resources and OICS**

<table>
<thead>
<tr>
<th>OICS services and operations</th>
<th>Use cases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Search and Retrieval Service:</strong></td>
<td></td>
</tr>
<tr>
<td>getAssessmentDesigns</td>
<td>Search of assessment designs.</td>
</tr>
<tr>
<td>getLearningOutcomeDefinitions</td>
<td></td>
</tr>
<tr>
<td>getTeachingMethods</td>
<td></td>
</tr>
<tr>
<td><strong>Publication Service:</strong></td>
<td></td>
</tr>
<tr>
<td>submitObject</td>
<td>Publication of assessment designs;</td>
</tr>
<tr>
<td>submitMetadata</td>
<td>Annotation of assessment designs.</td>
</tr>
<tr>
<td>submitEnrichment</td>
<td></td>
</tr>
<tr>
<td><strong>User Management and Learning Outcome</strong></td>
<td></td>
</tr>
<tr>
<td>Profile Service createUser</td>
<td>Publication of assessment designs;</td>
</tr>
<tr>
<td><strong>Profile Service</strong> createUser</td>
<td>Annotation of assessment designs.</td>
</tr>
</tbody>
</table>

**Evaluation and recommendation:** According to the developers, the major problem encountered was the weakness of the ATOM format from the point of view of efficiency. That is, the necessity to parse a very verbose XML document.

**Further information** about the .LRN prototype can be found in D6.2.
5.3.4 OICS Learning Design Search and Import, Learning Outcome export

Developing institution:
Umeå University, Sweden
Developers: Mikael Karlsson and Henning Eriksson

Type: Moodle block

Target audience: teachers, course developers, learners

Application environment:
The prototype is implemented as a Moodle block. Online demonstrations can be found at http://develix.iml.umu.se/moodle/.

Application description:
This module allows searching and importing learning designs from OICS. The learning design can be imported into an existing course or to a new course. The learning design will be stored as Moodle Resources. The module also provides functionality to export learning outcomes from the learning design to users’ learning outcome profile at OICS.

The following workflows are realized:

- Search/import learning design (teacher/course developer): Users can search the OICS for available learning designs. Learning designs retrieved from OICS are imported into an existing course or to a new course and stored as Moodle Resources inside the course.

- View/export Learning Outcomes (teacher/course developer): The teachers can view the courses they teach and the learning outcomes (extracted from imported learning designs). Those can be exported to her Learning outcome profile at OICS.

- View/export Learning Outcomes (learners): The learners can view the courses they are enrolled in and the learning outcomes these contain. Once the learners complete a course (explicit clearance is given by the teacher\(^1\)), the learners can update their learning outcome profile at OICS with the achieved learning outcomes. These published achievements are also evidenced by an assessment record, which is an official record with title, description, date, type and the University as the assessing body.

---

\(^1\) Moodle 1.9 has no built in support for a teacher to set that a student has finished a course. This feature was implemented for the purpose of this prototype.
Figure 16: Learning Design search interface in Moodle.
D1.2 Open ICOPER Content Space
Implementation of 2nd Generation of Open ICOPER Content Space including Integration Mini Case Studies

Figure 17: Publish achieved and taught learning outcomes from Moodle

Integration with OICS:

Table 10: Integration between OICS Learning Design Search and Import, Learning Outcome export and OICS

<table>
<thead>
<tr>
<th>OICS services and operations</th>
<th>Use cases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Search and Retrieval Service:</strong></td>
<td>-Search for learning designs in OICS.</td>
</tr>
<tr>
<td>getLearningDesigns</td>
<td>-Import learning designs as resources in Moodle.</td>
</tr>
<tr>
<td>getLearningOutcomes</td>
<td>-After importing a learning design to a course, Moodle “knows” what achieved outcomes are to be added to the OICS learning outcome profile of learners who pass the course.</td>
</tr>
</tbody>
</table>

| User Management and Learning Outcome Profile Service: | -Adds an achievement information to a user’s learning outcome profile.  |
| addAchievement                  | -Adds information of an Assessment record that is an evidence of the achievement.  |
| addAssessmentRecord             |                       |
Evaluation and recommendation: The OICS does not yet provide a method for submitting ratings of learning resources. It was originally planned to provide this functionality through this prototype.

5.3.5 OICS Recommendation Viewer

Developing institution:
Umeå University, Sweden
Developers: Henning Eriksson and Mikael Karlsson

Type: Wookie widget

Target audience: Teachers

Application environment:
The OICS Recommendation Viewer widget is implemented as a Wookie widget and runs on a Wookie server. Wookie follows the W3C Widget Specification and therefore the widget can be run in other widget containers following the W3C Widget Specification. The widget can also be embedded in an html-page. It was tested using the Wookie Moodle plugin to include it in Moodle (there exists Wookie plugins for other platforms, for example Elgg). Online demonstrations can be found at http://develix.iml.umu.se/moodle/course/view.php?id=5.

Application description:
Based on the user's (logged in teacher) taught Learning Outcomes the widget gives recommendation of other teachers with similar learning outcomes. The user can toggle between two different views of the recommendation, as an unsorted list teachers or a list sorted by learning outcomes.

Screenshot:

Figure 18: Teacher recommendations in Moodle
Integration with OICS:

Table 11: Integration between OICS Recommendation Viewer and OICS

<table>
<thead>
<tr>
<th>OICS services and operations</th>
<th>Use cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>User Management and Learning Outcome Profile Service:</td>
<td>User logs in. OICS registered through the widget. When a user logs in, the taught learning outcome profile for the user is retrieved.</td>
</tr>
<tr>
<td>listUsers</td>
<td></td>
</tr>
<tr>
<td>createUser</td>
<td></td>
</tr>
<tr>
<td>getLearningOutcomeProfile</td>
<td></td>
</tr>
<tr>
<td>Recommendation Service:</td>
<td>Based on the learning outcomes in the taught learning outcome profile recommendations of other teachers are retrieved from OICS.</td>
</tr>
<tr>
<td>recommendUsers</td>
<td></td>
</tr>
</tbody>
</table>

Evaluation and recommendation: The recommendation service returns the user using the service, no problem filtering it out in the prototype. But we recommend removing it from the OICS middle layer recommendation service response.

5.3.6 OICS Achievement (Learning Outcome) Viewer

Developing institution:
Umeå University, Sweden

Developers: Henning Eriksson and Mikael Karlsson

Type: Wookie widget

Target audience: Teachers, Learners.

Application environment: same as “OICS Recommendation Viewer” (see above)

Application description:
This widget allows the user to view his/her learning outcomes. Teachers will be able to see learning outcomes of courses they are teaching (or have taught).
Integration with OICS:

Table 12: Integration between OICS Achievement (Learning Outcome) Viewer and OICS

<table>
<thead>
<tr>
<th>OICS services and operations</th>
<th>Use cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>User Management and Learning Outcome Profile Service:</td>
<td></td>
</tr>
<tr>
<td>listUsers</td>
<td>User logs in.</td>
</tr>
<tr>
<td>createUser</td>
<td>User registers new user at OICS through the widget.</td>
</tr>
<tr>
<td>getLearningOutcomeProfile</td>
<td>When a user logs in, the achieved learning outcome profile and the taught learning outcome profile for the user are retrieved from OICS.</td>
</tr>
</tbody>
</table>

5.3.7 iPolio - ICOPER Elgg Based E-portfolio

Developing institution:

Tallinn University, Institute of Informatics, Centre for Educational Technology

Developers: Martin Sillaots, Aili Madisson and Pjotr Savitski

Type: web based e-portfolio system. VLE

Target audience:

a. facilitators - course designers, training instructors and teachers (course owners)
b. students (course members)

Application environment:

iPolio is based on Elgg e-portfolio environment (http://elgg.org/). Elgg is an open source social networking platform useful for online or blended learning course planning and
execution. Elgg provides a range of tools for publishing learning materials and for supporting learning activities.

**Application description:**

Elgg ICOPER prototype is based on searching for Learning Designs (LD) and importing those into Elgg as courses, based on the Groups plugin. ICOPER Elgg plugin is extending the default Groups for them to be able to handle the additional information. Each LD entity can have multiple Learning Outcome Definitions (LOD) assigned to it, along with Assessment Methods and Teaching Methods. The single LD entry holds pointers to instances of every type that are situated in according repositories of OICS portal. Prototype is able to show information for those in single entry view page along with other information. Elgg prototype prefers not to store the data inside its own database, in most of the cases only unique identifiers are stored. Later the system fetches the information from corresponding ATOM feeds on demand.

**Screenshot:**

![Course overview in Elgg](image)

**Figure 20: Course overview in Elgg**

**Integration with OICS:**

<table>
<thead>
<tr>
<th>OICS services and operations</th>
<th>Use cases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Search and Retrieval Service:</strong></td>
<td>Search for Learning Designs. Import Learning Design into the system as a course. A course is assigned Learning Outcomes, Teaching Methods and Assessment Methods from the imported LD (Learning Outcomes are later issued to the participant).</td>
</tr>
<tr>
<td>getLearningContent</td>
<td></td>
</tr>
<tr>
<td>resolveIdentifier</td>
<td></td>
</tr>
<tr>
<td>getObject</td>
<td></td>
</tr>
</tbody>
</table>
The `resolveIdentifier` method is used for retrieving the Atom entry of the Learning Outcome, Teaching Method and Learning Assessment to extract the needed information, since the system only stores their identifier.

<table>
<thead>
<tr>
<th>User Management and Learning Outcome Profile Service:</th>
<th>User registers at OICS within the personal settings page (user can also enter username and password for existing user). Learner can submit achievements into OICS profile (those are issued by the teacher). System shows learner his or her personal Learning Outcome Profile.</th>
</tr>
</thead>
<tbody>
<tr>
<td>createUser</td>
<td></td>
</tr>
<tr>
<td>getUser</td>
<td></td>
</tr>
<tr>
<td>addAchievement</td>
<td></td>
</tr>
<tr>
<td>getLearningOutcomeProfile</td>
<td></td>
</tr>
</tbody>
</table>

**Evaluation and recommendation:** The main deficiencies of the OICS Middle Layer spotted by the developers were lack of result count in the search service, and missing support for ratings that could be used for recommendations.

### 5.3.8 Facebook Learning Outcomes Profile Application - FLOP, My Skills

**Developing institution:**
AGH University of Science and Technology, Centre of e-Learning

Developers: Jacek Bubak

**Type:** web application

**Target audience:** learners

**Application environment:**
Facebook Learning Outcomes Profile (FLOP) is a simple web-based application using mysql database to store needed information.

It enables connection with Facebook and gives possibilities to develop profiles and share learning outcomes with other users.

**Application description:**
The main objective of FLOP is to share your learning outcomes among social websites. The application connects with Facebook and places learning outcomes list in the new tab on user's profile website. In order to achieve these results, application obtains learning outcomes from Personal Achieved Learning Outcomes profile repository from OICS. Learning outcomes that appear in users' facebook profile are the most current and are directly imported from OICS. There is a possibility to display Personal Thought Learning Outcomes too. Users can manage which of learning outcomes will be shared.
**Screenshot:**

![Figure 21: PALO profile displayed in Facebook](image)

**Integration with OICS:**

Table 14: Integration between *Facebook Learning Outcomes Profile Application - FLOP, My skills and OICS*

<table>
<thead>
<tr>
<th>OICS services and operations</th>
<th>Use cases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>User Management and Learning Outcome Profile Service:</strong></td>
<td>User registers typing username and password or just logs in using valid OICS credentials.</td>
</tr>
<tr>
<td>createUser</td>
<td>Website downloads information about user’s learning outcomes profiles.</td>
</tr>
<tr>
<td>getUser</td>
<td>Application imports specified learning outcomes profile.</td>
</tr>
<tr>
<td>getLearningOutcomeProfile</td>
<td></td>
</tr>
</tbody>
</table>

**5.3.9 ULA4eXact LCMS – UoLs, LOPs and Assessments Management into eXact LCMS**

**Developing institution:**
eXact learning solutions S.p.A., R&D department

**Type:** software application – extension of eXact learning solutions (formerly Giunti Labs)
eXact LCMS for incorporating management of Learning Designs (LDs), Learning Outcome Profiles (LOPs) and Assessments from/towards OICS

**Target audience:** learners and learning facilitators; software developers
Application environment:
The system runs on Windows Server platforms. The prototype extension includes a CopperCore engine and SLED player. For a demo account please contact e.parodi@exact-learning.com

Application description:
This prototype aims at supporting and promoting the usage of outcome-based teaching and training via integrating it into a sound LCMS environment, including IMS LD playing facilities. It envisages two roles: Tutor and Learner. The Tutor is responsible for the set up of the learning “environment” that will be later exploited by the Learner.

Tutors can search and import Learning Designs and Assessments with the related Learning Outcome Definitions either by keywords or by learning outcomes. Once the Tutor finds an interesting LD/Assessment, that he would like to assign to Learners, he can import it into the system, create a run and enrol Learners. Then this run is added to a course of the LCMS.

Learners enrolled to a course will have learning designs and assessments executed through the appropriate players. They can post annotations about LDs/Assessments, these annotations are personal comments aiming at providing feedback to other users (Tutors and Learners).

Once played a LD/Assessment, the Tutor is notified about this and can update the Learner’s LOP accordingly.

Screenshot:

![List of learning designs in eXact](image)

Figure 22: List of learning designs in eXact

Integration with OICS:

Table 15: Integration between ULA4eXact LCMS – UoLs, LOPs and Assessments management into eXact LCMS and OICS

<table>
<thead>
<tr>
<th>OICS services and operations</th>
<th>Use cases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Search and Retrieval Service:</strong> getLearningDesigns</td>
<td>A tutor is able to search and retrieve Learning Designs from OICS directly from within the LCMS. He can import them into the LCMS, and create runs inserted into</td>
</tr>
</tbody>
</table>
D1.2 Open ICOPER Content Space
Implementation of 2nd Generation of Open ICOPER Content Space including Integration Mini Case Studies

<table>
<thead>
<tr>
<th>Publication Service:</th>
<th>Users can comment/leave feedbacks, these are sent to OICS and can be seen by other users.</th>
</tr>
</thead>
<tbody>
<tr>
<td>submitComment</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>User Management and Learning Outcome Profile Service:</th>
</tr>
</thead>
<tbody>
<tr>
<td>getUser getLearningOutcomeProfile</td>
</tr>
</tbody>
</table>

| PALO user profile is retrieved from OICS and can be updated adding learning outcomes. |

**Evaluation and recommendation:** More flexible support for additional metadata properties is the most important suggestion for improvement of the OICS Middle Layer that would facilitate further development of this prototype.

**5.3.10 OICS Roundtrip Authoring Use Case**

**Developing institution:**
Open University of the Netherlands: Roland Klemke
Humance: Sören Unruh (Software Engineer) and Peter Grünwald (Software Developer)

**Type:** software application

**Target audience:** media designers and content authors using OICS to create new learning materials by re-using existing OER offers

**Application environment:**
The prototype is a combination of MediaLibrary asset management software, author42.ICOPER Authoring environment, OLAT LMS and OICS services.

- OLAT LMS: http://80.237.233.158/olat_icoper

Please contact Peter Grünwald at Humance for login: pgruenwald@humance.de.

**Application description:**
In general terms the OICS roundtrip authoring re-use prototype addresses the authoring and creation of learning designs. The overall aim of the MediaLibrary is to support the multiple and different authoring processes that may be required to create increasingly complex learning designs. This is achieved by producing multiple variants from the same original material.

The OICS roundtrip authoring prototype focuses on three main processes:

1. The collaborative collection and organization of media assets. Media assets comprise individual content elements such as texts, pictures, videos, and audios. These atomic elements form the basis of all content productions.

2. The collaborative creation of learning designs based on these media assets. Learning designs are navigable and interactive learning contents built out of individual media assets.

3. Preparation for re-use. A background harvesting process, which updates the metadata repository of OICS in order to make updated contents searchable and retrievable, supports the previous two processes.
5.3.11 CLIX ICOPER: A Learning Outcome-Based IMS-LD Learning Delivery Solution

Developing institution:
IMC
Developer: Patrick Pekczynski
Contributors: Daniel Müller, Nils Faltin

Type: Web Application (Learning Management System [LMS] with integrated and learning outcome-based IMS-LD player)

Target audience: Learners, Course Designer/Learning Facilitator

Application environment:
CLIX ICOPER is a Java J2EE web application based on the CLIX LMS, i.e. on the PROLIX version of CLIX named LPEP (Learning Process Execution Platform). In order to integrate a Java-based OICS binding CLIX has been extended using the “rome” rss and atom feed library.

To use Open ICOPER Content Space (OICS)-related features a CLIX ICOPER user has to specify his OICS-profile credentials in his CLIX-account. The same counts for third party environments such as iGoogle, LinkedIn, etc.
Application description:

CLIX ICOPER constitutes an IMS-Learning Design compliant player which executes Learning Designs that are built according to the IMS-Learning Design Specification. CLIX ICOPER was built to facilitate a Learning Outcome-oriented learning as well as the storage, updating and publication of a learner’s PALO in the LMS/VLE CLIX ICOPER itself as well as in the OICS and further internet platforms (e.g. iGoogle) to show learner’s latest Learning Outcomes to his/her fellow students and/or potential employers.

CLIX ICOPER publishes a learner’s PALO in the OICS after successful completion of a particular Learning Opportunity in CLIX ICOPER by use of the ATOM feed solution.

Screenshot:

![CLIX ICOPER: Add Learning Outcome to IMS-LD Learning Design](image)

Figure 24: CLIX ICOPER: Add Learning Outcome to IMS-LD Learning Design

Integration with OICS:

Table 17: Integration between CLIX ICOPER: A Learning Outcome-Based IMS-LD Learning Delivery Solution and OICS

<table>
<thead>
<tr>
<th>OICS services and operations</th>
<th>Use cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>User Management and Learning Outcome Profile Service:</td>
<td>Publish learners’ PALO into the OICS</td>
</tr>
<tr>
<td>getUser</td>
<td></td>
</tr>
<tr>
<td>getLearningOutcomeProfile</td>
<td></td>
</tr>
<tr>
<td>addAchievement</td>
<td></td>
</tr>
<tr>
<td>addAssessmentRecord</td>
<td></td>
</tr>
</tbody>
</table>

Evaluation and recommendation: A feature request voiced by the developer (the possibility to delete entries in a learning outcome profile of a user) has been subsequently added to the learning outcome service.

Further information about CLIX ICOPER can be found in D5.3.

5.3.12 Learn@WU

Developing institution:

WU Wien – Vienna University of Economics and Business
Contributor: Franz Müller
Developers: Thomas Renner, Günter Ernst

Type: .LRN package

Target audience: Teachers and Course developers

Application environment:
The developed prototype is implemented as a package for the eLearning platform Learn@WU which is based on the OpenACS Community System in combination with .LRN, an open source eLearning system.

Application description:
This prototype does not directly interact with the OICS. Rather, it tries to adopt the concepts of the IRM in the way that inside Learn@WU a learning outcomes repository is provided for the several study programmes of WU and its courses. In more detail, for each study programme a catalogue can be created in which learning outcomes on a curricular level can be stored. Within each course a teacher or course developer can import learning outcomes from the catalogue of the related study programme to show them in the course catalogue afterwards.

Three use cases are supported by this prototype:

- **Importing learning outcomes from the study programme:** Teachers and course developers can browse through available learning outcomes of the study programme and import them into their course.

- **Changing imported learning outcomes:** The title and the description of the imported learning outcomes can be changed so that it corresponds better with the course.

- **Create new learning outcomes in the course:** The teachers and course developers have also the possibility to create new learning outcomes and store them in the course.

Screenshot:

![Learning outcomes of study program](Figure 25: Display of learning outcomes in Learn@WU)
Integration with OICS:

As mentioned above, the prototype uses no services and operations provided by the OICS. The learning outcomes are stored in Learn@WU in the schema for learning outcome definitions presented in the deliverable D2.2. From the evaluated study programme Business Education 52 learning outcomes were exported to the OICS and stored in the catalogue http://oics.icoper.org/LOD/WU_WiPaed.

Evaluation and recommendation:

Findings of the evaluation are described in deliverable D2.3.

5.3.13 2know2

Developing institution:
Knowledge Markets Consulting Ges.m.b.H.
Contributor: Franz Müller
Developers: Wolfgang Buchta, Peter Kreuzinger

Type: extension of 2know2, a web based event management platform, formerly known as Evaluate

Target audience: Teachers, Course developers, Learners

Application environment:
The developed prototype is implemented as a package for the Knowledge Markets’ platform 2know2 which is based on the OpenACS Community.

Application description:
This prototype allows teachers and course designers to announce learning opportunities that are linked to learning outcomes and teaching methods. The learning outcomes and teaching methods are directly stored in and retrieved from the OICS via the search, retrieval and publishing services of the OICS Middle Layer. New learning opportunities can be announced at the 2know2 platform with a news article and an RSS feed and can also be published in the repository for learning opportunities at the OICS.

The following features make use of the OICS services:

- **Importing metadata of learning outcomes or teaching methods from the OICS**: Users can search the OICS for available learning outcomes and teaching methods and import the identifiers of the relevant ones into courses in 2know2.
- **Adding learning outcomes and teaching methods to the OICS**: Within 2know2 learning outcomes and teaching methods can be created and directly stored in the OICS.
- **Deleting learning outcomes and teaching methods in the OICS**: Within 2know2 it is also possible to delete learning outcomes and teaching methods directly in the OICS.
- **Publishing new learning opportunities at the OICS**: New learning opportunities (called events within 2know2) can be published in the repository for learning opportunities at the OICS.
D1.2 Open ICOPER Content Space
Implementation of 2nd Generation of Open ICOPER Content Space including Integration Mini Case Studies

Screenshot:

Figure 26: Learning opportunity in 2know2

Integration with OICS:

Table 18: Integration between 2know2 and OICS

<table>
<thead>
<tr>
<th>OICS services and operations</th>
<th>Use cases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Search and Retrieval Service:</strong></td>
<td><strong>Search and browse for learning outcomes or</strong></td>
</tr>
<tr>
<td>getLearningOpportunities</td>
<td><strong>teaching methods</strong></td>
</tr>
<tr>
<td>getLearningOutcomes</td>
<td><strong>Retrieve learning outcomes or teaching</strong></td>
</tr>
<tr>
<td>getTeachingMethods</td>
<td><strong>methods</strong></td>
</tr>
<tr>
<td>getMetadata</td>
<td><strong>Search for learning opportunity</strong></td>
</tr>
<tr>
<td><strong>Publication Service:</strong></td>
<td><strong>Upload learning outcome or teaching method</strong></td>
</tr>
<tr>
<td>submitObject;</td>
<td><strong>Delete learning outcome or teaching method</strong></td>
</tr>
<tr>
<td>submitMetadata;</td>
<td><strong>Upload learning opportunity</strong></td>
</tr>
<tr>
<td>submitEnrichment;</td>
<td><strong>Delete learning opportunity</strong></td>
</tr>
<tr>
<td>deleteObject</td>
<td></td>
</tr>
</tbody>
</table>

Further information on how this application allowed to test the ICOPER outcome-oriented approach in the sector of corporate competence management can be found in D2.3.

5.3.14 OICS Interface on ICOPER Web Site

Developing institution:
University of Cyprus
Developer: Natalie Masrujeh
Type: built into the ICOPER website

Target audience: give an overview of content and functionality available in OICS to general audience
Application environment:
The application is built using PHP, SOAP, javascript and jQuery, integrated into the ICOPER web site, built with the Joomla content management system.

Application description:
The functionalities of the application are:

- Searching and retrieving
  - of Learning Designs
  - of Teaching Methods
  - of Learning Outcomes
  - of Assessment Designs
  - of Learning Opportunities
- OICS Account creation
- Profile Management
  - Preview of Learning Needs
  - Preview of Personal Achieved Learning Outcomes
  - Preview of Personal Taught Learning Outcomes
  - Preview of Assessment Records

For each learning resource type, we provide a search page, where the search interface contains a text input field, for entering search terms that can either be used in a full text search or limited to keywords, and the context filters. The context filters are populated through the faceted search facility provided by K.U.Leuven SQI target.

For each result we display the title which is linked to location of the resource, description, link to the metadata page and commenting functionality.

Searching can be done for learning outcomes and learning opportunities. In addition, the user can retrieve the related learning resources per learning outcome by following the “View Learning Resources” link.

Learning Opportunities are grouped by their provider. A learning opportunity might have multiple learning instances. For each learning instance the application shows the related metadata. Among the metadata, the user can identify possible prerequisites, teaching methods, objectives.

Users of the application can login or create an account to the OICS Middle layer. If a user is logged in, then it is possible to add comments to the resources, add a learning outcome as a their learning need and of course preview their profile in respect to their learning needs, personal achieved learning outcomes, personal taught learning outcomes and assessment records.
Screenhots:

**Figure 27:** Context filters for searching OICS content

**Figure 28:** Search interface for learning outcomes

**Figure 29:** Preview of learning needs
Integration with OICS:

Table 19: Integration between ICOPER web site and OICS

<table>
<thead>
<tr>
<th>OICS services and operations</th>
<th>Use cases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Search and Retrieval Service:</strong> resolveIdentifier</td>
<td>This application does not use the Middle Layer API for retrieving content from the OICS, but directly talks to the underlying SQI target, because the faceted search facility is not exposed in the Middle Layer. The resolveIdentifier and resolveContext methods are used for retrieving information about resources and fields of education.</td>
</tr>
<tr>
<td><strong>Publication Service:</strong> submitComment</td>
<td>Users can submit comments on any OICS resource.</td>
</tr>
<tr>
<td><strong>User Management and Learning Outcome Profile Service:</strong> createUser getUser getLearningOutcomeProfile addAchievement</td>
<td>User can create an OICS account, add learning needs to his profile, and display all parts of the profile (learning needs, achievements, assessment records).</td>
</tr>
</tbody>
</table>

6  Strategy for Future Development of OICS Content and Services

In the following two sections, we describe how what we have learned during the design, deployment and the administration of the OICS translates into possible new directions for making content available for innovative processes of outcome oriented learning. First we enumerate elements of a strategy for making additional sources of content accessible. Second we describe one example of transferring OICS services into new domains.

6.1  Content Harvesting Strategy

Throughout the whole life cycle of design, setup and deployment of the OICS, the main challenge consisted in bringing together its two main requirements: to provide an innovative platform for supporting processes of learning outcome oriented education, and to make a critical mass of content available for these processes. We achieved the first requirement through the provision of services that can be easily integrated into a variety of platforms. The use of the ARIADNE registry service makes it very easy to connect new content providers to the OICS. Simply by publishing some information about the content and its OAI-PMH endpoint into the registry, the repository is available in the harvester instance used for the OICS. But in order to improve the relevance of new content for the OICS, we have successfully dealt with a series of challenges and are now able to apply the following strategy.

**Transformation of metadata into LOM format:** Some repositories expose information about their content in DublinCore format instead of LOM. While it was not difficult to implement support for ingestion of DublinCore metadata, care has to be taken to analyze the details of data serialization used by a content provider. For example, while importing content from the OpenJorum repository to the OICS, the harvested data appeared to be inconsistent in several respects:
Distinct keywords were serialized either as separate subject elements, or as a colon-separated list into one subject element.

The Identifiers provided were not unique, and thus were not usable as local identifiers. Instead those were extracted from the URI of the resource’s presentation page in Open Jorum.

**Enrichment:** Since the mission of the OICS is to provide services for learning outcome oriented education, the value of learning resources for the OICS depends on the availability of linkages between learning designs, assessment designs, learning outcome definitions, learning opportunities or learning contexts. These linkages are not yet provided by content providers in the format specified by the ICOPER LOM AP, but sometimes they are available in a different format (e.g. as for OpenLearn), or they are implicitly available from other data sources.

Upon ingestion of a new content collection into the OICS, an enrichment hook can be defined that can alter the submitted metadata record. This can be used for correcting errors as explained in Section 5.2.2. But it also allowed us to map subject classifications to the taxonomy for fields of education that we have decided to use for the OICS as a proof of concept, or to transform the OpenLearn format for learning outcomes to the ICOPER one.

**Handling of LOM application profiles:** A special case of transforming metadata upon ingestion into the OICS is the handling of application profiles, as for example LOM-FR, defined in the context of the French educational sector and used by the UNIT repository. Currently the ICOPER LOM AP does not allow vocabulary values defined by authorities other than LOM, ICOPER and LRE. Thus values defined in LOM-FR either had to be mapped to semantically related values, or removed completely from the metadata records. In both cases, information relevant for the French context is lost.

**Learning objects, opportunities and outcomes:** The OICS brings together learning resources with learning outcome definitions and learning opportunities. Linking these types of resources is not yet systematically done by content providers, and we have both manually created these linkages for the purpose of testing OICS services, and implemented into the 2know2 prototype functionality where the learning opportunities published to the OICS provide links to learning outcomes, teaching methods and learning designs. Through dissemination of ICOPER results - for example Totschnig et al. (2010) – we try to demonstrate the benefits of providing these links as part of metadata, and convince content providers to enrich their targets in order to improve the usefulness of OICS services.

**Podcasts:** The OICS has also successfully incorporated feeds from the iTunes university channels managed by OUNL and OUUK.

**Web 2.0 content:** In order to open up the OICS to data sources not accessible through the established harvesting approach, we have investigated providing OICS users with easy access to content openly available through services offered by popular Web2.0 sites through their APIs. Due to the dynamic nature of these data sources and also their size, replication of resources, even when done on a regular basis, is not a viable option, since users would quickly become disappointed by differences between the original and the copied data. As an example, we have therefore looked closer into the available options for Wikipedia content that would allow retrieving resources directly and make them available as part of the OICS services:

- Wikipedia offers publicly available database dumps, and a restricted OAI-PMH target that could be used for replicating all content. As stated above, these options were not investigated further.

• DBpedia: More interestingly, structured information from Wikipedia has been extracted by the DBpedia project and is publicly available as semantic-web aware linked data. This information can be queried using a semantic web query language like SPARQL exploiting relationships and properties of Wikipedia resources. A sample query could list “skyscrapers in Hong Kong with more than 50 floors”. Although this approach certainly opens up interesting perspectives, making use of this approach for outcome-based education requires pedagogical information about the resources to be part of the linked data, which is currently not the case in Wikipedia due to its encyclopedical nature.

E-portfolio: The OICS service for managing users’ learning outcome profiles is based on the same repository backend as the repositories for learning resources, learning outcome definitions and learning opportunities. This allows us to envision for a future release of the OICS functionality that provides users with deeper integration between consumption of available learning content either as learners or teachers, and production of new content based on the rich linkages between OICS artefacts. Users will then be able – beyond storage of achievements and assessment records – to use their profile as a generic E-portfolio where they store information about their learning and teaching history, and make it available as additional metadata referring to existing resources or as re-used content.

6.2 Transfer of OICS Services

The infrastructure as realized by the ICOPER prototype can serve different learning delivery scenarios. As an open source infrastructure it can be transferred to different contexts and different target groups. In the following, we describe how the ICOPER infrastructure is used to support the realization of competency-development within the game-based learning project SpITKom [http://www.spitkom.de] and how the concepts defined for the OICS Middle Layer have inspired the design of the Service Layer of the federation of learning content for Austrian Schools (Bildungspool 2009).

6.2.1 Game-based Learning in SpITKom

The German BMBF-funded research project SpITKom (game based impartment of IT-competence) focuses on individualized learning. As opposed to the ICOPER use cases, SpITKom is directed at learners difficult to reach (third chance education programmes offered by the Education Centres for the Building Industry - BZB). The target group consists of predominantly male participants. They are between 15 and 21 years old. None of them has a school leaving certificate. Their level of literacy is very low. Also they have strong personal and social deficits that hamper or even inhibit finding an apprenticeship (Adam et al. 2010).

Instead of a computer, this target group is rather in possession of television and gaming consoles (MPFS 2009). Thus, they have developed little or no competence in using the computer as a medium for information and/or working (Schmitz and Czauderna 2010). By now, most jobs require at least basic media competencies though. This also applies to the building industry which increasingly relies on the use of computers for day to day communication or logistic matters for instance. SpITKom therefore focuses on the acquisition
of IT-knowledge as one of the key competencies and requirements of today’s labour market. It has chosen to integrate the ECDL (European Computer Driving Licence) as a commonly accepted standard that reflects and certifies up-to-date skills and knowledge in the use of a computer and common applications. SpITKom is based on the current syllabus version 5.0 that comprises seven modules, including topics such as “Using the computer and managing files“, “Word processing “ and „Web Browsing and Communication“ (see: www.ecdl.org).

Within SpITKom, the main user interfaces for the learner are the learning game (Figure 30) and the IT-Café (Figure 31). With the game-based learning approach, SpITKom aims at utilizing the pedagogical potential computer games provide (cf. Gee 2007 and Ritterfeld et al. 2009). Based on this approach, the project hopes to initiate intrinsic motivation that compared to extrinsic motivation supports learning efficiency (Schiefele and Schreyer 1994).

The game guides the learner through building and construction projects. In the course of the game test items related to IT-Knowledge (ECDL) are displayed to the user. The answers influence the game play (score, money). By matching the ECDL learning outcomes against the learner’s concrete abilities it analyses the learner’s needs and offers questions and Learning Designs that can each be traced back to a single learning outcome. The questions are rated 1 (easy) to 3 (difficult). Depending on the learner’s performance (right/wrong), the system’s core backend component, the CCT - Competency Checker and Trainer - (Figure 31) chooses the follow-up question in an adaptive manner in order to rate the learner’s knowledge. Also, answers of learners are collected and stored in the learner’s profile. The learner can enter the IT-Café to perform some explicit learning tasks (access learning contents, perform comprehensive tests, review own profile). Additionally, the learner can communicate with co-learners and teachers.
SpITKom’s requirements can be matched to the repositories and services offered by the ICOPER infrastructure (see Figure 32 for an overview over the complete SpITKom architecture with ICOPER components included):

- Items of the ECDL syllabus can be represented as LODs stored in the learning outcome repository.
- ECDL learning contents are realised as SCORM units stored in the OICS content repository.
- ECDL tests are stored in QTI format in the OICS assessment repository.
- The individual tests are played using the open source QTIEngine (http://www.qtitools.org/landingPages/QTIEngine/). Assessment results delivered from QTIEngine are stored back in PALO format into the profile repository.
- The webservice infrastructure of the ICOPER components is used to integrate the services into a completely new SpITKom user interface comprising the game and the IT-Café.
6.2.2 Bildungspool LMS Connector

In the context of the federation of learning content for Austrian Schools, Bildungspool, the repository architecture has been redesigned based upon the experiences made with the OICS infrastructure. The central component for the management of learning resources, xoLRN, incorporated the same backend for metadata management as the OICS. It supports:

- creation of wiki pages (based on the xoWiki component)
- management of content using folder structures
- management of metadata
- content collection and provision via SPI
- CP and SCORM support
- WebDav support

The interface specification for the Bildungspool, called “LMS connector” was rewritten based on the OICS Middle Layer (Simon, in preparation). Content providers can publish educational content into collections; the learning management systems subscribe to these collections, and teachers are able to adapt the available content packages to their needs. Figure 33 illustrates a content collection provided by the Bildungspool and displayed in the LMS. The content provided in the picture has been published by the Austrian Press Agency and covers a variety of topics (societal and healthcare implications of smoking, the geography and political situation of the Lebanon, and a report of the Roma and Sinti minority in Europe and associated political implications).
7 Recommendations

Methodology

The development of the OICS has been driven mainly by two goals: explore best practices for the integration of content repositories and provide the technical infrastructure for the pilots of WP2 to WP6 by implementing all relevant parts of the IRM. Based on existing experience of consortia members and on the requirements of the ICOPER use cases, content harvesting was selected as technological paradigm, with the ARIADNE harvester application as a central building block. Experience with managing the harvesting infrastructure has been translated into recommendations 1, 3 and 11.

Prototypes for OICS client interfaces and tool have been developed based on mock-ups derived from use cases defined by WP2 to WP6. The services needed by these interfaces were translated into a Middle layer API, that should be both consistent with concepts and data models defined in the IRM, and easy to understand and use. Experience with managing the development, setup and deployment of this API has been translated into recommendations 2, 10 and 12. We conducted an evaluation of the API and its implementation with the developers and derived recommendation 7 from it.

The end-user evaluation of these prototypes conducted by each partner responsible for the development and coordinated by WUW and ULE, led us to understand end users’ perception of the OICS and allowed us to refine the requirements for its evolution into a sustainable platform for learning-outcome based repository services. These findings are collected in recommendations 4, 5, 6, 8 and 9.

For all of the following recommendations, the main target audience are technology providers, i.e. institutions responsible for the design, organization and deployment of educational brokerage environments. Only recommendation 1.1 is considered also to be relevant for standardization bodies. The recommendations are grouped by the development life cycle phase they address. Next to a unique ID, each recommendation has a heading. A justification accompanies each recommendation and references sections of this report that provide evidence for the recommendation.
7.1 Recommendations Addressing the Design Phase

<table>
<thead>
<tr>
<th>R1.1 A registry for learning object repositories is needed for maintaining consistent technical information.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stakeholders: technology providers, standardization bodies</td>
</tr>
<tr>
<td>We recommend the use of a registry for learning object collections to make learning objects discoverable through a network of interoperable repositories and to maintain technical information in a consistent manner.</td>
</tr>
</tbody>
</table>

Justification

A Learning Object Collection Registry service is a catalogue service that provides up-to-date information on learning object repositories (LORs). It provides the information necessary for systems to be able to select the appropriate protocols such as OAI-PMH, SQI, SPI, SRU/SRW supported by a given learning object repository. The registry service facilitates interoperability between numerous learning object repositories. Besides that, creating a network of interoperable LOR registries, allows for the automatic discovery of new repositories with interesting material.

We have explained the design of a registry service in Section 3.8 and have explained the vital role it plays in the OICS infrastructure in Section 5.1.

<table>
<thead>
<tr>
<th>R1.2 Maintain a managed process for the development of a Middle Layer API taking into account developers’ feedback.</th>
</tr>
</thead>
<tbody>
<tr>
<td>We recommend the definition of an API that facilitates the integration of an educational brokerage system with heterogeneous client environments. This API should be aligned with established standards in technology-enhanced learning domain and also in the wider domain of web technology. This API should clearly state its purpose and be based on a clear analysis of the use cases it serves. All stakeholders should be invited to take part in its development through an open community process.</td>
</tr>
</tbody>
</table>

Justification

The main challenge during the development of the OICS Middle Layer API was to bring together, on the one hand concepts and ideas defined by ICOPER’s work packages (and materialized in a series of mock-ups) and on the other hand technical and organizational constraints of the infrastructure used for the services and the clients. We have used a document shared via Google’s online collaborative writing tool GoogleDocs for defining and commenting the Middle Layer API and documenting its implementations. While this rather informal process allowed for a rapid development cycle, it created occasionally some confusion, because developers had to check regularly in order to stay informed about changes in the definition of the services. During the engineering evaluation, several developers stressed the importance of complete and accurate documentation including illustrative examples. We have therefore, at the time of publication of this document, moved the documentation to the ICOPER web site, as its version 1.0, and will handle subsequent changes through the OICS bug tracker, that also handles change requests.
R1.3 Application profile management and validation is necessary for an effective brokerage infrastructure.

We recommend the definition of a metadata application profile that expresses specific requirements for the storage of metadata about shareable educational resources.

**Justification**
An application profile is an assemblage of metadata elements selected from one or more metadata schemas and combined in a compound schema (Duval et al. 2002). The purpose of an application profile is to adapt or combine existing schemas into a package that is tailored to the functional requirements of a particular application, while retaining interoperability with the original base schemas. Part of such an adaptation may include the elaboration of local metadata elements that have importance in a given community or organization, but which are not expected to be important in a wider context. To ensure that only compliant metadata are stored in the OICS, the use of a validation service is recommended to check both the syntactic and semantic validity of the metadata instances against the used profiles.

R1.4 Allow users to rate resources and present them with meaningful rankings.

We recommend that a rating functionality and ranking of resources based on the user’s profiles and queries should be considered in order to improve perceived usefulness of the repository service.

**Justification**
The rating/ranking system would help users find their relevant resources more easily. Currently the system returns all the results related to the search-keyword provided by the user. Then the user needs to go through all of them to select what he/she wants. If there were a rating or ranking of learning designs by a community, then he/she would not have to go through all of them.

ICOPER is contributing to the CEN WS-LT expert group on social data about learning objects that is investigating standardized ways of sharing user contributed metadata (e.g. tags, ratings, comments, bookmarks) that can be used to calculate rankings meaningful in the context of specific communities.

R1.5 Take into account users’ concerns about copyright and privacy.

We recommend the implementation of clear policies for handling IPR aspects of shared educational resources and privacy aspects of user’s interactions with them giving users full control of what they share with whom.

**Justification**
The end user evaluation of the OICS prototypes showed that IPR issues also need to be considered when users can share and exchange their course designs and other content through
D1.2 Open ICOPER Content Space
Implementation of 2nd Generation of Open ICOPER Content Space including Integration
Mini Case Studies

the OICS. For the OICS we have adopted the encoding of Creative Commons License through the “x-t-cc-url” token language identifier, as defined in the LRE 4.0 Application Profile (LRE 2010). This allows highlighting these resources in user interfaces.

When users can share and exchange their course designs and other content, the rights and privacy is definitely an important issue. One testee expressed that “obviously even though you are not sharing any content within a particular (sic!) maybe you’re competitive with your colleagues so you don’t want to reveal everything you are planning”. Another one said that “if you share all the information then maybe you know people will copy your course and use”. Another testee also expressed her concerns that copyright issues are threats to organisations because teachers are always worried about the content.

R4.2 argues for the dissemination of the openness philosophy that the OICS adopts in several respects: by providing services through an open API, by making open content accessible in processes of outcome oriented learning, and by making source code for the repository system available under an Open Source licence.

### R1.6 Enable links between educational processes and social networks.

We recommend connecting learning object repositories to social network sites such as Facebook or LinkedIn.

**Justification**

When discussing the usage of Facebook for sharing Learners Achieved Learning Outcomes, the testees suggested that the OICS should be integrated with social websites. In that case, it may not be necessary to create other tools to access the data stored in the OICS. Actually, many users are familiar with social websites and the number of users of such websites is so huge. Consequently it should be much more useful and easier for employers to find the right PALOs.

### R1.7 Consider the efficiency of API result format for different client contexts.

Additional stakeholders: standardization bodies

We recommend providing alternative result formats for repository APIs in order to make access to repository services easy to implement in a variety of platforms.

**Justification**

The efficiency of the result formats returned by the search and retrieval service proved to be of high importance for implementers of OICS interfaces. Providing two implementations for this service using different result formats (ATOM, JSON) allowed us to identify strengths and weaknesses of both: While the ATOM format integrates well in platforms that provide sophisticated libraries for managing feeds, JSON is a lightweight data format easy to use in web development due to its simplicity (e.g. native evaluation of results in JavaScript) compared to the traditional XML data format approaches, which often require cumbersome DOM-based processing. Additionally we implemented accessor methods for individual data fields returning the standard XML binding for LOM or LOD. Of course, the trade-off between
the ease of use of the API for developers and the maintenance cost for the providers has to be taken into account.

Additionally, according to a feature request voiced by one developer, efficiency could be improved by merging information about linked objects: Learning designs use identifiers for linking to learning outcomes, and a client retrieving information about a learning design has to issue additional calls in order to resolve those identifiers. A merged representation of the learning design where the links are already resolved to titles and descriptions would improve efficiency and ease of use of resource retrieval.

### 7.2 Recommendations Addressing the Setup Phase

<table>
<thead>
<tr>
<th>R1.8 Provide users with information about origin and quality of content.</th>
</tr>
</thead>
<tbody>
<tr>
<td>We recommend that users should be provided with information about the origin and quality of content. This would help them consider the quality of the content and thus help them know how to use the content more effectively.</td>
</tr>
</tbody>
</table>

**Justification**

End users exposed to OICS content lacked clear indication about the context of a resource, such as where it has been produced, which quality assurance processes have been applied to it, how it is distributed, which use cases it has already served, etc. During the evaluation, one testee stated that “if it’s a federated search I would like to know from which repository these resources are coming from”. Another testee stated that the OICS might be a questionable repository of open resources for many teachers, since they would not know anything about its content and quality of such content. While LOM provides some fields for this information through the Lifecycle category, this information generally is not expressive enough in itself for giving users a clear idea about a resource’s context.

R3.10 recommends the use of instructional modeling specifications to support the documentation, sharing, communication, provision, and analysis of innovative, quality controlled teaching practice among teachers and between higher education institutions.

<table>
<thead>
<tr>
<th>R1.9 Attract users through a critical mass of relevant content.</th>
</tr>
</thead>
<tbody>
<tr>
<td>We recommend that the content stored in an educational brokerage system should be in high quality. The OICS should also contain a high volume of data.</td>
</tr>
</tbody>
</table>

**Justification**

One testee suggested that a critical success factor of the OICS is the availability of the critical mass of resources and also the quality of the resources. Obviously, that will provide the users with more possibility to select high quality and appropriate content for their own purposes. It will eventually guarantee the success of the OICS.

As outlined in Section 6.1, we have set up the OICS infrastructure in order to facilitate integration of new sources of educational content:

- The integration of harvester and registry service facilitates the inclusion of repositories that expose metadata through OAI-PMH.
• The adoption of a repository backend capable of interpreting metadata in a variety of formats allows including repositories that do not use LOM, but rely on DublinCore instead.

• Enrichment of harvested metadata is essential not only for correcting errors in the data sources, but above all for transforming information into the representation defined by the adopted application profile. Thus the semantic information expressed in different profiles like LRE and LOM-FR is not completely lost.

• The OICS promotes the linkage of instructional models, learning opportunities and learning outcomes, thus allowing providers of learning opportunities to advertise them based on the quality of the used instructional models and allowing learners to find learning opportunities relevant for their learning needs. This creates new incentives for publishing learning resources as publicity for learning opportunities thus contributing to a critical mass.

• As a proof of concept, we have successfully imported into the OICS podcasts from OUNL and OUUK and documented future integration options with Web 2.0 sources like Wikipedia.

• Finally, the OICS support for content collections controlled by communities or users allows exploring new ways of social metadata generation and content re-use.

### 7.3 Recommendations Addressing the Deployment Phase

<table>
<thead>
<tr>
<th>R1.10 Maintain persistent identifiers for resources.</th>
</tr>
</thead>
<tbody>
<tr>
<td>We recommend the use of persistent, unique and resolvable identifiers that allow creating stable links to shareable educational resources.</td>
</tr>
</tbody>
</table>

**Justification**

ICOPER suggests the systematic linking between learning outcomes, teaching methods, learning designs and assessment designs. Maintenance of these links is sustainable only if each resource has a persistent identifier resilient against changes in layout and naming of services, collections and machines. We have therefore defined an ICOPER catalogue for identifiers and created a persistent, unique identifier for each resource ingested into the OICS. Management and resolution of these identifiers are described in Section 3.10.

<table>
<thead>
<tr>
<th>R1.11 Content providers should have access to self-testing tools for OAI-PMH endpoints.</th>
</tr>
</thead>
<tbody>
<tr>
<td>We recommend the setup of a public validation service for learning object repositories that expose metadata in LOM schema through OAI-PMH akin to those maintained by the Open Archives Community, that check for compliance with the Dublin Core metadata schema.</td>
</tr>
</tbody>
</table>

**Justification**

The process of identifying errors in the implementation of an OAI-PMH target proved to be cumbersome: invalid encoding of returned document, non compliance to requirements of the
protocol (response structure, error handling, and handling of resumption tokens) or failures during metadata validation. The harvester includes test functionality for the targets it manages, but this functionality is not available as a publicly accessible service.

**R1.12 Test and monitor services.**
We recommend using monitor services for achieving reliable repository services.

**Justification**
Because the OICS is a service-oriented infrastructure with distributed services over different partners such as KULeuven, WUW and others, key to the reliability of the services, is to know when something goes wrong. As soon as one service is down, measures need to be taken to ensure that the consequence of the down-time is minimized as much as possible. Therefore, we recommend using monitor services like for instance the CruiseControl framework that we have deployed to achieve a reliable OICS. This is an extensible framework for creating a custom continuous build process, to monitor the uptime and responsiveness of all services.

**8 Outlook and Conclusion**

The objective of this report was to situate the Open ICOPER content space (OICS) in the context of the ICOPER project, particularly the ICOPER reference model (IRM). We have stressed the role of the OICS as a reference implementation for the IRM, as a testbed for implemented specifications and standards and as a service oriented architecture for bringing processes of outcome-oriented education into a variety of client platforms via applications designed by ICOPER’s work packages 2 to 6, and implemented by their partners.

The OICS’ main contribution consists in the implementation of a Repository Service managing collections of shareable educational resources and their metadata making use of the data schemas of the IRM: ICOPER LOM AP, LOD, PALO and MLO. These services, published as the OICS Middle Layer, are consumed by prototypes that make outcome based learning processes available in a variety of environments: learning management systems (Moodle, dotLRN, OLAT, Clix, eLex), authoring environments (author42, OpenGLM), e-Portfolio systems (Elgg), social networks (Facebook), widget platforms (Wookie, Google gadget API). OICS functionality is thus easily included in any website, as demonstrated on the ICOPER public web site. Each connected tool is described in its own Integration Mini Case Study.

OICS content has been aggregated from a variety of sources through the established approach of content harvesting. We have summarized common difficulties encountered while dealing with the OAI-PMH and LOM standards.

Experiences made during the development of the OICS system have inspired two projects in domains outside higher education: vocational training targeting unemployed youth in the case of the German SpITKom project, school education in the case of the Austrian Bildungspool. These transfers are made possible through the distribution of the OICS interface specification and its source code under an Open Source Licence.
References


Massart D., Smith N., Tice, R. (2009). D2.2 design of data model and architecture for a registry of learning object repositories and application profiles. ASPECT Deliverable 2.2.
Open ICOPER Content Space
Implementation of 2nd Generation of Open ICOPER Content Space including Integration
Mini Case Studies

Retrieved 27 January 2011,


Appendix A: Tabular Representation of the ICOPER LOM Application Profile

v1.0, 30 November 2010

There are two conformance levels for the ICOPER LOM AP:

1. **Basic conformance** requires all mandatory elements to be present, while recommended elements may be omitted. The following table lists multiplicity constraints for this basic conformance level.

2. **Full conformance** requires mandatory and recommended elements to be present, i.e. the lower-bound of the multiplicity of recommended elements becomes 1.

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Description</th>
<th>Reference</th>
<th>Data Type</th>
<th>Multiplicity</th>
<th>Notes and Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General</td>
<td>This category groups the general information that describes this resource as a whole.</td>
<td>LOM</td>
<td>(CATEGORY)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Identifier</td>
<td>A globally unique label that identifies this resource.</td>
<td>LOM</td>
<td>(CONTAINER)</td>
<td>1..*</td>
<td>Mandatory element</td>
</tr>
<tr>
<td>1.1.1</td>
<td>Catalog</td>
<td>The name or designator for the identification or cataloging scheme for this entry. A namespace scheme.</td>
<td>LOM</td>
<td>Charstring</td>
<td>1</td>
<td>All resources stored in the OICS have an identifier with catalog set to ‘ICOPER’</td>
</tr>
<tr>
<td>1.1.2</td>
<td>Entry</td>
<td>The value of the identifier within the identification or cataloging scheme that designates or identifies this resource. A namespace specific string.</td>
<td>LOM</td>
<td>Charstring</td>
<td>1</td>
<td>e.g. “UOL.univie.3989248”</td>
</tr>
<tr>
<td>1.2</td>
<td>Title</td>
<td>Title of this resource.</td>
<td>LOM</td>
<td>Langstring</td>
<td>1</td>
<td>Mandatory element. Example: (“en”, “Basics of academic writing”)</td>
</tr>
<tr>
<td>1.3</td>
<td>Language</td>
<td>The primary human language or languages used within this resource to communicate to the intended user.</td>
<td>LOM</td>
<td>Charstring</td>
<td>1..*</td>
<td>Mandatory element. ISO 639:1988 (langcode) and ISO 3166-1:1997 (optional subcode) Example: “en-US”</td>
</tr>
<tr>
<td>1.4</td>
<td>Description</td>
<td>A textual description of the content of this resource.</td>
<td>LOM</td>
<td>Langstring</td>
<td>0..*</td>
<td><strong>It is recommended</strong> to give sufficient level of detail in the description of</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1.5</strong></td>
<td><strong>Keyword</strong></td>
<td>A keyword or phrase describing the topic of this resource.</td>
<td><strong>LOM</strong></td>
<td><strong>Langstring</strong></td>
<td><strong>0..</strong></td>
<td></td>
</tr>
<tr>
<td><strong>1.6</strong></td>
<td><strong>Coverage</strong></td>
<td>The time, culture, geography or region to which this resource applies.</td>
<td><strong>LOM</strong></td>
<td><strong>Langstring</strong></td>
<td><strong>0..</strong></td>
<td></td>
</tr>
<tr>
<td><strong>1.7</strong></td>
<td><strong>Structure</strong></td>
<td>Underlying organizational structure of this resource.</td>
<td><strong>LOM</strong></td>
<td>{atomic, collection, networked, hierarchical, linear} -- for a description of these values see LOM</td>
<td><strong>0..1</strong></td>
<td></td>
</tr>
<tr>
<td><strong>1.8</strong></td>
<td><strong>Aggregation Level</strong></td>
<td>The functional granularity of this resource.</td>
<td><strong>LOM</strong></td>
<td>{1, 2, 3, 4} -- for a Level 4 objects can contain level 3 objects, or can recursively</td>
<td><strong>0..1</strong></td>
<td></td>
</tr>
</tbody>
</table>

A learning resource in order to improve its discoverability and presentation to users.

Example: ("en", "Learners learn in three tasks how to write magazine stories for a target audience, in this case, for a teenage magazine.")

This data element should not be used for characteristics that can be described by other data elements.

Example: ("en", "Mona Lisa")

NOTE — This is the definition from the Dublin Core Metadata Element Set, version 1.1 [B1]. (http://www.dublincore.org/documents/dces/)

Example: ("en", "16th century France")

NOTE — A learning object could be about farming in 16th century France: in that case, its subject can be described with 1.5:General.Keyword="farming" and its 1.6:General.Coverage can be ("en", "16th century France").

NOTE — A learning object with Structure="atomic" will typically have 1.8:General.Aggregation-Level=1. A learning object with Structure="collection", "linear", "hierarchical" or "networked" will typically have 1.8:General.AggregationLevel=2, 3, or 4.
D1.2 Open ICOPER Content Space
Implementation of 2nd Generation of Open ICOPER Content Space including Integration Mini Case Studies

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Description of these values see LOM</th>
<th>Contain other level 4 objects.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Life Cycle</td>
<td>This category describes the history and current state of this resource and those entities that have affected this resource its evolution.</td>
<td>Learning designs and teaching methods should have at least level 2.</td>
</tr>
<tr>
<td>2.1</td>
<td>Version</td>
<td>The version of this resource.</td>
<td>LOM (CATEGORY) 0..*</td>
</tr>
<tr>
<td>2.2</td>
<td>Status</td>
<td>The completion status or condition of this resource.</td>
<td>LOM Langstring 0..1 Example: (“x-none”, “1.0”)</td>
</tr>
<tr>
<td>2.3</td>
<td>Contribute</td>
<td>Those entities that have contributed to the state of this resource during its life cycle.</td>
<td>LOM (CONTAINER) 0..*</td>
</tr>
<tr>
<td>2.3.1</td>
<td>Role</td>
<td>Role of contributing entity.</td>
<td>LOM { author, publisher, unknown, initiator, terminator, validator, editor, graphical designer, technical implementer, content provider, technical validator, educational validator, script writer, instructional designer, subject matter expert } 1</td>
</tr>
<tr>
<td>2.3.2</td>
<td>Entity</td>
<td>The identification of and information about entities (i.e., people, organizations) contributing to this resource. The entities shall be ordered as most relevant first.</td>
<td>LOM Charstring (vCard) 1..* Example: “begin:vcard</td>
</tr>
<tr>
<td>2.3.3</td>
<td>Date</td>
<td>The date of the contribution</td>
<td>LOM DateTime 0..1 Example: “2010-08-25”</td>
</tr>
<tr>
<td>3</td>
<td>Meta-Metadata</td>
<td>This category describes the metadata record itself</td>
<td>LOM (CATEGORY) 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(rather than the resource that this record describes)</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>-----------------------------------------------</td>
<td>---</td>
</tr>
<tr>
<td>3.1</td>
<td>Identifier</td>
<td>A globally unique label that identifies this metadata record.</td>
<td>LOM</td>
</tr>
<tr>
<td>3.1.1</td>
<td>Catalog</td>
<td>The name or designator of the identification or cataloging scheme for this entry. A namespace scheme.</td>
<td>LOM</td>
</tr>
<tr>
<td>3.1.2</td>
<td>Entry</td>
<td>The value of the identifier within the identification or cataloging scheme that designates or identifies this metadata record. A namespace specific string.</td>
<td>LOM</td>
</tr>
<tr>
<td>3.2</td>
<td>Contribute</td>
<td>Those entities (i.e., people or organizations) that have affected the state of this metadata instance during its life cycle (e.g. creation, validation).</td>
<td>LOM</td>
</tr>
<tr>
<td>3.2.1</td>
<td>Role</td>
<td>Kind of contribution.</td>
<td>LOM</td>
</tr>
<tr>
<td>3.2.2</td>
<td>Entity</td>
<td>The identification of and information about entities (i.e., people, organizations) contributing to this metadata instance. The entities shall be ordered as most relevant first.</td>
<td>LOM</td>
</tr>
<tr>
<td>3.2.3</td>
<td>Date</td>
<td>The date of the contribution.</td>
<td>LOM</td>
</tr>
<tr>
<td>3.3</td>
<td>Metadata Schema</td>
<td>The name and version of the authoritative specification used to create this metadata instance.</td>
<td>LOM</td>
</tr>
<tr>
<td>3.4</td>
<td>Language</td>
<td>Language of this metadata instance. This is the default language for all LangString values in this metadata instance. If a value for this data element</td>
<td>LOM</td>
</tr>
</tbody>
</table>

NOTE—This data element concerns the language of the metadata.
### 4 Technical

Technical requirements and characteristics of this resource.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4.1 Format</strong></td>
<td>Technical data type(s) of all components of this resource.</td>
<td>LOM Charstring (MIME type) 0..* Example: “application/zip”, “application/msword”</td>
</tr>
<tr>
<td><strong>4.2 Size</strong></td>
<td>The size of the digital resource in bytes (octets). The size is represented as a decimal value (radix 10). Consequently, only the digits “0” through “9” should be used. The unit is bytes, not Mbytes, GB, etc. This data element shall refer to the actual size of this resource. If the resource is compressed, then this data element shall refer to the uncompressed size.</td>
<td>LOM Charstring 0..1 “19245”</td>
</tr>
<tr>
<td><strong>4.3 Location</strong></td>
<td>Location of the resource (for download or viewing).</td>
<td>LOM Charstring (URL) 1..* Mandatory element. Example: “<a href="http://test1.km.co.at/UOL/univie/3989248%E2%80%9D">http://test1.km.co.at/UOL/univie/3989248”</a></td>
</tr>
<tr>
<td><strong>4.4 Requirement</strong></td>
<td>The technical capabilities necessary for using this resource. If there are multiple requirements, then all are required, i.e., the logical connector is AND.</td>
<td>LOM (CONTAINER) 0..*</td>
</tr>
<tr>
<td><strong>4.4.1 OrComposite</strong></td>
<td>Grouping of multiple requirements. The composite requirement is satisfied when one of the component requirements is satisfied, i.e., the logical connector is OR.</td>
<td>LOM (CONTAINER) 0..*</td>
</tr>
<tr>
<td><strong>4.4.1.1 Type</strong></td>
<td>The technology required to use this resource, e.g., hardware, software, network, etc.</td>
<td>LOM { operating system, browser } 1</td>
</tr>
<tr>
<td><strong>4.4.1.2 Name</strong></td>
<td>Name of the required technology to use this resource.</td>
<td>LOM if Type=&quot;operating system&quot; then { pc-dos, 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>D1.2 Open ICOPER Content Space</td>
<td>Implementation of 2nd Generation of Open ICOPER Content Space including Integration Mini Case Studies</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.4.1.3 Minimum Version</td>
<td>Lowest possible version of the required technology to use this resource.</td>
<td>LOM Charstring</td>
</tr>
<tr>
<td>4.4.1.4 Maximum Version</td>
<td>Highest possible version of the required technology to use this resource.</td>
<td>LOM Charstring</td>
</tr>
<tr>
<td>4.5 Installation Remarks</td>
<td>Description of how to install this resource.</td>
<td>LOM Langstring</td>
</tr>
<tr>
<td>4.6 Other Platform Requirements</td>
<td>Information about other software and hardware requirements.</td>
<td>LOM Langstring</td>
</tr>
<tr>
<td>4.7 Duration</td>
<td>Time a continuous resource takes when played at intended speed.</td>
<td>LOM Duration</td>
</tr>
<tr>
<td>5 Educational</td>
<td>Key educational or pedagogic characteristics of this resource.</td>
<td>LOM (CATEGORY)</td>
</tr>
<tr>
<td>5.1 Interactivity Type</td>
<td>Predominant mode of learning supported by this resource.</td>
<td>LOM { active, expositive, mixed } -- for a description of</td>
</tr>
<tr>
<td>5.2</td>
<td>Learning Resource Type</td>
<td>Specific type of resource. The most dominant kind shall be first.</td>
</tr>
<tr>
<td>......</td>
<td>------------------------</td>
<td>-----------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>It is mandatory to specify one learning resource type using the ICOPERv1.0 vocabulary, since it allows understanding how the resource can be made use of, without the need of inspecting the content/structure of the resource. Additional learning resource types may be specified using other vocabularies for this element, e.g. the LOMv1.0 vocabulary for this item.</td>
</tr>
<tr>
<td>5.3</td>
<td>Interactivity Level</td>
<td>The degree of interactivity characterizing this resource. Interactivity in this context refers to the degree to which the learner can influence the aspect or behaviour of the resource. NOTE—Inherently, this scale is meaningful within the context of a community of practice.</td>
</tr>
<tr>
<td>5.4</td>
<td>Semantic Density</td>
<td>The degree of conciseness of a resource. The semantic density of a resource may be estimated in terms of its size, span, or—in the case of self-timed resources such as audio or video—duration. The semantic density of a resource is independent of its difficulty. It is best illustrated with examples of expositive material, although it can be used with active resources as well. NOTE—Inherently, this scale is meaningful within the context of a community of practice.</td>
</tr>
<tr>
<td>5.5</td>
<td>Intended End User Role</td>
<td>Principal user(s) for which this resource was designed, most dominant first.</td>
</tr>
<tr>
<td>......</td>
<td></td>
<td>NOTES 1— A learner works with a resource in order to learn something. An author creates or publishes a</td>
</tr>
<tr>
<td>Section</td>
<td>Description</td>
<td>LOM</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td>-----</td>
</tr>
<tr>
<td>5.6</td>
<td>Context</td>
<td>LOM</td>
</tr>
<tr>
<td>5.7</td>
<td>Typical Age Range</td>
<td>LOM</td>
</tr>
<tr>
<td>5.8</td>
<td>Difficulty</td>
<td>LOM</td>
</tr>
<tr>
<td>5.9</td>
<td>Typical Learning Time</td>
<td>LOM</td>
</tr>
<tr>
<td>5.10</td>
<td>Description</td>
<td>LOM</td>
</tr>
<tr>
<td>Section</td>
<td>Description</td>
<td>LOM/ICOPER Type</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td>----------------</td>
</tr>
<tr>
<td>5.11</td>
<td>Language</td>
<td>Charstring</td>
</tr>
<tr>
<td>5.12</td>
<td>Learning Outcome</td>
<td>(CONTAINER)</td>
</tr>
<tr>
<td>5.12.1</td>
<td>Identifier</td>
<td>(CONTAINER)</td>
</tr>
<tr>
<td>5.12.1.1</td>
<td>Catalog</td>
<td>Charstring</td>
</tr>
<tr>
<td>5.12.1.2</td>
<td>Entry</td>
<td>Charstring</td>
</tr>
<tr>
<td>5.12.2</td>
<td>Level</td>
<td>(CONTAINER)</td>
</tr>
<tr>
<td>5.12.2.1</td>
<td>Name</td>
<td>{ proficiency level, interest level, ageing, weight }</td>
</tr>
<tr>
<td>5.12.2.2</td>
<td>Value</td>
<td>Charstring</td>
</tr>
<tr>
<td>5.12.2.3</td>
<td>Scheme</td>
<td>Charstring</td>
</tr>
<tr>
<td>5.12.2.4</td>
<td>Description</td>
<td>Langstring</td>
</tr>
<tr>
<td></td>
<td></td>
<td>element is not provided. In other words, when a level value provided is not part of a common ontology or taxonomy.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>6</td>
<td>Rights</td>
<td>This category describes the intellectual property rights and conditions of use for this resource.</td>
</tr>
<tr>
<td>6.1</td>
<td>Cost</td>
<td>Whether use of this resource requires payment.</td>
</tr>
<tr>
<td>6.2</td>
<td>Copyright and Other Restrictions</td>
<td>Whether copyright or other restrictions apply to the use of this resource.</td>
</tr>
<tr>
<td>6.3</td>
<td>Description</td>
<td>Textual description of IPR, licensing model, copyright information, etc. of this resource.</td>
</tr>
</tbody>
</table>

For resources published under a Creative Commons License, it is recommended to make use of the "x-t-cc-url" token language identifier, as defined in the LRE 4.0 Application Profile.

Example:
("en", "Licensed under a Creative Commons BY-NC-SA 3.0 License."),
("x-t-cc-url", "http://creativecommons.org/licenses/by-nc-sa/3.0")

| 7 | Relation | This category defines the relationship between this resource and other resources, if any. To define multiple relationships, there may be multiple instances of this category. If there is more than one target resource, then each target shall have a new relationship instance. | LOM (CATEGORY) | 0..* |

Use this category to describe the following relationships: resource is variation of resource; learning design implements teaching or assessment method; learning design uses learning assessment; learning assessment implements assessment method; plus any relationships based on LOM base vocabulary.

| 7.1 | Kind | Nature of the relationship between this resource and the target resource. | LOM extension | { uses, is used by, implements, is implemented by, is variation of } or any of the LOM base values { is part of, has part, is version of, has version, is format of, has format, references, is referenced by, is based on, is basis for, requires, is required by } | 1 |
### D1.2 Open ICOPER Content Space
Implementation of 2nd Generation of Open ICOPER Content Space including Integration Mini Case Studies

#### 7.2 Resource
Target resource of this relationship.

<table>
<thead>
<tr>
<th>7.2.1 Identifier</th>
<th>A globally unique label that identifies the target resource.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.2.1.1 Catalog</td>
<td>Name or designator of the identification or cataloging scheme for this entry. A namespace scheme.</td>
</tr>
<tr>
<td>7.2.1.2 Entry</td>
<td>Value or identifier within the catalog. A namespace specific thing.</td>
</tr>
<tr>
<td>7.2.2 Description</td>
<td>Description of the target resource.</td>
</tr>
</tbody>
</table>

#### 7.2.1.1 Catalog
Name or designator of the identification or cataloging scheme for this entry. A namespace scheme.

- **Example:** "ICOPER"

#### 7.2.1.2 Entry
Value or identifier within the catalog. A namespace specific thing.

- **Example:** "TM.univie.3989445"

#### 7.2.2 Description
Description of the target resource.

- **Example:** ("en", "The case-study method is used to train and improve decision-making skills. Case studies are well-prepared, structured, and reduced in their content, so that the presented situation is not too overwhelming. The method was developed in business education.")

### 8 Annotation
This category provides comments on the educational use of this learning object, and information on when and by whom the comments were created. This category enables educators to share their assessments and peer review comments of resources, learners' feedback, teacher reflections, suggestions for use, etc.,

<table>
<thead>
<tr>
<th>8.1 Entity</th>
<th>Entity (i.e., people, organization) that created this annotation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.2 Date</td>
<td>Date that this annotation was created.</td>
</tr>
<tr>
<td>8.3 Description</td>
<td>The content of this annotation.</td>
</tr>
<tr>
<td>8.4 Type</td>
<td>The type of annotation or comment.</td>
</tr>
</tbody>
</table>

- **Example:** ("en", "When using this teaching method make sure to allocate at least one hour for the final reflection round")

### 8.1 Entity
Entity (i.e., people, organization) that created this annotation.

- **Example:** "begin:vcard
version:3.0
fn:Chuck Norris
nn:Chuck Norris
type=internet:cn@nowhe.re\n\nend:vcard"

### 8.2 Date
Date that this annotation was created.

- **Example:** "2010-08-25"

### 8.3 Description
The content of this annotation.

- **Example:** ("en", "When using this teaching method make sure to allocate at least one hour for the final reflection round")

### 8.4 Type
The type of annotation or comment.

- **Example:** "teacher reflection"

### 9 Classification
This category describes where this resource falls within a particular classification system. To define

- **Example:** In addition to classification purposes identified in the base LOM schema, use this category to identify the subject area, educational
9.1 Purpose

The purpose of classifying this resource.

<table>
<thead>
<tr>
<th>LOM extension</th>
<th>(group size, educational setting) plus LOM base values {discipline, idea, prerequisite, educational objective, accessibility, restrictions, educational level, skill level, security level, competency}</th>
</tr>
</thead>
</table>
| 1             | It is **not recommended** to use the educational objective, skill level, educational level, and competency classification purposes, since these should be expressed using Learning Outcome elements (5.12).

It is **recommended** to specify at least one classification with purpose = “discipline”. Note that every discipline classification must include either a fully specified taxon path (9.2) or at least one keyword (9.4). This is an exclusive “or”, i.e. definition of both a taxon path and a keyword for any discipline classification is invalid.

9.2 Taxon Path

A taxonomic path in a specific classification system. Each succeeding level is a refinement in the definition of the preceding level. There may be different paths, in the same or different classifications, which describe the same characteristic.

<table>
<thead>
<tr>
<th>LOM (CONTAINER)</th>
<th>0..*</th>
</tr>
</thead>
</table>
|                 | If Purpose = “discipline” and no 9.4:Keyword is specified then definition of at least one taxon path is mandatory.

It is not allowed to have both keywords and taxon paths within the same classification element.

9.2.1 Source

The name of the classification system. This data element may use any recognized “official” taxonomy or any user-defined taxonomy.

<table>
<thead>
<tr>
<th>LOM Langstring</th>
<th>1</th>
</tr>
</thead>
</table>
|                 | This element is mandatory for each 9.2:Taxon Path.

Example: (“en,” “ACM”)

9.2.2 Taxon

A particular term within a taxonomy. A taxon is a node that has a defined label or term. A taxon may also have an alphanumeric designation or identifier for standardized reference. Either or both the label and the entry may be used to designate a particular taxon. An ordered list of taxons creates a taxonomic path, i.e., “taxonomic stairway”: this is a path from a more general to more specific entry in a classification.

<table>
<thead>
<tr>
<th>LOM (CONTAINER) ordered</th>
<th>1..*</th>
</tr>
</thead>
</table>
|                         | At least one taxon per 9.2:Taxon Path is mandatory.

Example: [“12,”“en,”“Physics”], [“23,”“en,”“Acoustics”], [“34,”“en,”“Instruments”], [“45,”“en,”“Stethoscope”]

A 2nd taxon path for the same learning object could be: [“56,”“en,”“Medicine”], [“67,”“en,”“Diagnostics”], [“34,”“en,”“Instruments”], [“45,”“en,”“Stethoscope”]

9.2.2.1 Id

The identifier of the taxon, such as a number or

<table>
<thead>
<tr>
<th>LOM Charstring</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Examples: “320”, “4.3.2”, “BF180”</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>9.2.2.2</td>
<td>Entry</td>
</tr>
<tr>
<td>9.3</td>
<td>Description</td>
</tr>
<tr>
<td>9.4</td>
<td>Keyword</td>
</tr>
</tbody>
</table>
Appendix B: Mapping between Foreign Vocabularies for Learning Resource Type and the ICOPER Vocabulary

<table>
<thead>
<tr>
<th>LOM learning resource type</th>
<th>ICOPER learning resource type</th>
</tr>
</thead>
<tbody>
<tr>
<td>exercise</td>
<td>learning assessment</td>
</tr>
<tr>
<td>simulation</td>
<td>learning design</td>
</tr>
<tr>
<td>questionnaire</td>
<td>learning assessment</td>
</tr>
<tr>
<td>diagram</td>
<td>other</td>
</tr>
<tr>
<td>figure</td>
<td>other</td>
</tr>
<tr>
<td>graph</td>
<td>other</td>
</tr>
<tr>
<td>index</td>
<td>other</td>
</tr>
<tr>
<td>slide</td>
<td>other</td>
</tr>
<tr>
<td>table</td>
<td>other</td>
</tr>
<tr>
<td>narrative text</td>
<td>learning design</td>
</tr>
<tr>
<td>exam</td>
<td>learning assessment</td>
</tr>
<tr>
<td>experiment</td>
<td>learning design</td>
</tr>
<tr>
<td>problem statement</td>
<td>learning assessment</td>
</tr>
<tr>
<td>self assessment</td>
<td>learning assessment</td>
</tr>
<tr>
<td>lecture</td>
<td>learning design</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LRE learning resource type</th>
<th>ICOPER learning resource type</th>
</tr>
</thead>
<tbody>
<tr>
<td>application</td>
<td>other</td>
</tr>
<tr>
<td>assessment</td>
<td>learning assessment</td>
</tr>
<tr>
<td>broadcast</td>
<td>other</td>
</tr>
<tr>
<td>case study</td>
<td>learning design</td>
</tr>
<tr>
<td>course</td>
<td>learning design</td>
</tr>
<tr>
<td>demonstration</td>
<td>learning design</td>
</tr>
<tr>
<td>drill and practice</td>
<td>learning design</td>
</tr>
<tr>
<td>educational game</td>
<td>learning design</td>
</tr>
<tr>
<td>enquiry-oriented activity</td>
<td>learning design</td>
</tr>
<tr>
<td>exploration</td>
<td>learning design</td>
</tr>
<tr>
<td>glossary</td>
<td>other</td>
</tr>
<tr>
<td>guide</td>
<td>other</td>
</tr>
<tr>
<td>lesson plan</td>
<td>teaching method</td>
</tr>
<tr>
<td>open activity</td>
<td>learning design</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>presentation</td>
<td>other</td>
</tr>
<tr>
<td>project</td>
<td>learning design</td>
</tr>
<tr>
<td>reference</td>
<td>other</td>
</tr>
<tr>
<td>role play</td>
<td>learning design</td>
</tr>
<tr>
<td>tool</td>
<td>other</td>
</tr>
<tr>
<td>other</td>
<td>other</td>
</tr>
<tr>
<td>web resource (weblog, web page, wiki, other web resource)</td>
<td>other</td>
</tr>
<tr>
<td>learning asset (audio, data, image, model, text, video)</td>
<td>other</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>OER learning resource type</strong></th>
<th><strong>ICOPER learning resource type</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Activities &amp; Labs</td>
<td>learning design</td>
</tr>
<tr>
<td>Assessments</td>
<td>learner assessment</td>
</tr>
<tr>
<td>Audio Lectures</td>
<td>learning design</td>
</tr>
<tr>
<td>Curriculum Standards</td>
<td>teaching method</td>
</tr>
<tr>
<td>Discussion Forums</td>
<td>other</td>
</tr>
<tr>
<td>Games</td>
<td>other</td>
</tr>
<tr>
<td>Homework &amp; Assignments</td>
<td>learner assessment</td>
</tr>
<tr>
<td>Lecture Notes</td>
<td>learning design</td>
</tr>
<tr>
<td>Lesson Plans</td>
<td>teaching method</td>
</tr>
<tr>
<td>Readings</td>
<td>learning design</td>
</tr>
<tr>
<td>Simulations</td>
<td>learning design</td>
</tr>
<tr>
<td>Syllabi</td>
<td>learning design</td>
</tr>
<tr>
<td>Teaching &amp; Learning Strategies</td>
<td>teaching method</td>
</tr>
<tr>
<td>Textbooks</td>
<td>learning design</td>
</tr>
<tr>
<td>Training Materials</td>
<td>other</td>
</tr>
<tr>
<td>Video Lectures</td>
<td>learning design</td>
</tr>
</tbody>
</table>
Appendix C: Mapping between the ICOPER Scenario and Prototypes

(1) At University X, a new curriculum for a course program is developed. Each course description is linked to learning outcome definitions (LOD) and suggested teaching methods (TM), both stored in the OICS.

<table>
<thead>
<tr>
<th>OpenGLM</th>
<th>Can be achieved by creating (empty) course templates with intended learning outcomes and references to teaching methods. (In practice, however, this will typically be provided in a text document.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OICS roundtrip authoring use case</td>
<td>The instructional designer can use the OICS to search for existing LODs and create/upload new LODs. Additionally, existing learning material associated with these LODs can be retrieved from the OICS to be re-used in the authoring process for the newly defined curriculum.</td>
</tr>
</tbody>
</table>

(2) Best practices for teaching methods (TM) have been elaborated by a consortium of universities, and for each of them a template has been elaborated that can be used by instructional designers.

<table>
<thead>
<tr>
<th>OpenGLM</th>
<th>Teaching methods can be modeled and described. For use by instructional designers the teaching methods can be uploaded to an institutional repository where instructional designers have read access.</th>
</tr>
</thead>
<tbody>
<tr>
<td>OICS roundtrip authoring use case</td>
<td>A retrieved TM can be used to retrieve learning materials that correspond to this TM. These can be used as examples for the creation of new learning materials using this TM.</td>
</tr>
</tbody>
</table>

(3) An instructional designer creates a new learning design (LD) for the program. She retrieves the LODs mentioned in the curriculum from the LOD repository and searches the TM repository for a suitable template including assessment methods. She imports it into her authoring environment, adds learning content and includes assessment designs retrieved from the OICS. Since assessment designs are linked to learning outcomes and assessment methods, she is able to retrieve the most relevant content. The LD is made available for feedback in a restricted collection.

<table>
<thead>
<tr>
<th>OpenGLM</th>
<th>Learning designs can be created and learning outcome definitions from OICS can be retrieved and assigned to the learning design as intended learning outcomes. Teaching methods can be searched and retrieved from the OICS, and their contained activities can be integrated into the learning design. Resources can be added, however OpenGLM does in the user interface not differentiate between learner assessments and other kinds of resource.</th>
</tr>
</thead>
<tbody>
<tr>
<td>.LRN prototype for managing assessment resources</td>
<td>The instructional designer can search learner assessments based on the assessment method they implement and/or the intended learning outcomes of the course, which are intended to be achieved by the learners. The learner assessments are imported to the LMS as resources of the course. The designer is able to edit/modify the imported resources or create new ones.</td>
</tr>
<tr>
<td>OICS roundtrip authoring use case</td>
<td>The instructional designer can use author42.ICOPER to create SCORM learning content that is integrated into the learning design (via a LMS). During the creation of this learning content, the instructional designer can use the integrated OICS search to find re-usable learning content (LDs, Assessments, SCORM content, Media Assets) that is included.</td>
</tr>
</tbody>
</table>
(4) Additional links to learning outcomes and teaching methods can be added by program management.

<table>
<thead>
<tr>
<th>OpenGLM</th>
<th>Implementation of 2nd Generation of Open ICOPER Content Space including Integration Mini Case Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>OICS roundtrip authoring use case</td>
<td>Once the learning designer uploaded the learning design to a repository where program management has read/write access (after step 4), the program managers can retrieve the learning designs and enrich them with additional learning outcomes and teaching methods. Eventually, the enriched learning designs can be stored in the OICS as new versions or they can replace the instructional designers’ original versions.</td>
</tr>
</tbody>
</table>

The metadata of learning materials published from author42.ICOPER can be enriched in the OICS. This enrichment can contain references to further LODs and TMs.

Once the LD has been approved by the program management, the LD is published.

| OpenGLM | Publishing can be achieved by sending the approved learning designs and their metadata to a repository that can be searched by the institutional LMS (see step 5). |
| .LRN prototype for managing assessment resources | The instructional designer has the possibility to publish the assessment resources into the OICS, including information about addressed learning outcomes and suggested assessment methods; therefore, the published item is a complete learner assessment (enriched resource). |
| OICS roundtrip authoring use case | Content created by the instructional designer can be published to an LMS. The LMS publishes content metadata to the OICS. This way the content is made available for learning/teaching purposes and can be found through the OICS search. The same content is also available for further re-use in the authoring tool. |

(6) It is imported into the institutional LMS, and automatically a learning opportunity is pushed to a registry service for learning opportunities.

| .LRN prototype for managing assessment resources | The assessment resource is imported in the LMS, but the learning opportunity is out of scope. |
| OICS Learning Design Search and Import, Learning Outcome export | Learning designs published to OICS can be searched for. Those learning designs can be imported into the institutional LMS (Moodle). After importing a learning design to a course, Moodle “knows” what outcomes are to be added to the learning outcome profile of learners who pass the course (see step 8). |
| CLIX ICOPER: A Learning Outcome-Based IMS-LD Learning Delivery Solution | The IMS-LD Learning Design is imported (=instantiation of the IMS-LD Learning Design) in the LMS. |
| ULA4eXact LCMS – UoLs, LOPs and Assessments management into eXact LCMS | The prototype allows to search for Learning Designs and Assessments published into OICS. Those can be imported into eXact LCMS, and after this, they can be imported into a course, from which learners may run them. |

| OICS roundtrip | The publishing process into the LMS is realized. The metadata from |
authoring use case

(7) Upon each completion of the LD, feedback from teachers and learners is collected and the metadata is enriched.

<table>
<thead>
<tr>
<th>.LRN prototype for managing assessment resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>The metadata of the learner assessments can be enriched by teachers, following the 3 use cases defined in the ICOPER LOM AP: peer review of the resources, performance results using the resources as teacher reflections and student feedback reported by the means of the teachers.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ULA4eXact LCMS – UoLs, LOPs and Assessments management into eXact LCMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCMS users may annotate LDs and assessments</td>
</tr>
</tbody>
</table>

(8) Learners completing the learning opportunity, including the successful finishing of included assessment opportunities, have their learning outcome profile augmented with entries for each achieved learning outcome. The achieved learning outcomes are evidenced by assessment records (AR), results of the assessment process.

<table>
<thead>
<tr>
<th>.LRN prototype for managing assessment resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learners successfully finishing learner assessments have their learning outcome profile augmented with entries (achievements) for each learning outcome addressed by the course and assessed during the assessment process. These achievements are evidenced by assessment records (in this case, official records supported by the University as the assessing body).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OICS Learning Design Search and Import, Learning Outcome export</th>
</tr>
</thead>
<tbody>
<tr>
<td>Once the learners complete a course (explicit clearance is given by the teacher), the learners can update their learning outcome profile at OICS with the achieved learning outcomes. These published achievements are also evidenced by an assessment record, which is an official record with title, description, date, type and the University as the assessing body.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OICS Achievement (Learning Outcome) Viewer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achieved and taught learning outcomes stored in the learning outcome profile, can be viewed in this widget.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CLIX ICOPER: A Learning Outcome-Based IMS-LD Learning Delivery Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Once the learners complete a course (explicit clearance is given by the teacher), the learners can update their learning outcome profile at OICS as well as further Internet platforms (e.g. iGoogle, LinkedIn, etc.) with the achieved learning outcomes. These published achievements are also evidenced by an assessment record, which is an official record with title, description, date, type and the University as the assessing body.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ULA4eXact LCMS – UoLs, LOPs and Assessments management into eXact LCMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upon execution of a LD/assessment, a tutor is notified about which contents have been played by users, and which learning outcomes these contents may provide. The tutor is able to decide which of these learning outcomes can be added to the users’ profiles. Users’ profiles are updated consequently.</td>
</tr>
</tbody>
</table>

(9) Prospective learners that use the OICS LOD repository for identifying learning outcomes that correspond to their learning needs, will be able to retrieve other learners that already have achieved these outcomes, and since their profile also links to learning designs and learning opportunities, relevant recommendations can be presented to the learner.
<table>
<thead>
<tr>
<th>OICS Recommendation Viewer</th>
<th>Based on the user's (logged in teacher) taught Learning Outcomes, the widget gives recommendation of other teachers with similar learning outcomes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommendation widgets in Moodle</td>
<td>Based on the logged in user's PALO profile, the widget gives recommendation of similar teachers, that can be found in local Moodle instance. Also learning designs can be recommended on PALO profile. Additionally, local Moodle course can be recommended.</td>
</tr>
<tr>
<td>Facebook Learning Outcomes Profile Application - FLOP, My skills</td>
<td>Prospective learners can look through other people profiles (on the social websites) and find learning outcomes that correspond to their learning needs</td>
</tr>
</tbody>
</table>
Appendix D: PALO Sample XML Documents

Achievement

<entry xmlns="http://www.w3.org/2005/Atom"
xmlns:palo="http://icoper.org/palo">
<!-- 2.1 Identifier optional: can be generated by the target -->
<iid>http://www.iCoper.org/user123/achievement-a.1</iid>
<!-- 2.2 Title -->
<title xml:lang="en">hardware concepts</title>
<!-- 2.3 Description-->
<content xml:lang="en">understanding about hardware</content>
<!-- 2.4 Learning Outcome - this is a URI to the LOD instances that provides more info. on Learning outcome.-->
<link rel="palo:statesAttainmentOf" href="http://oics.icoper.org/LOD/ECDL/1.1.1"/>
<!-- 3.5 Related Learning Outcome! 1st example of a narrower relation-->
<link rel="palo:isRelatedToNarrower" href="http://oics.icoper.org/LOD/ECDL/1.1.1.1"/>
<!-- 2nd example of a broader relation-->
<link rel="palo:isRelatedToBroader" href="http://oics.icoper.org/LOD/ECDL/1.1"/>
<link rel="palo:hasContext" href="http://oics.icoper.org/resolve-context/CSO-FoE/4.8.2"/>
<!-- 2.6 Assessment Record-->
<link rel="palo:hasEvidence" href="www.iCoper.org/user123/assRec/Ass003"/>
</entry>

Assessment Record

<assessmentRecord xmlns:palo="http://icoper.org/palo"
xmlns="http://icoper.org/palo">
<!-- 6.1 Identifier optional: can be generated by the target -->
<iid>www.iCoper.org/user123/assRec/Ass003</iid>
<!-- 6.2 Type-->
<type scheme="http://icoper.org/palo/vocab/AssessmentRecordType" >
certificate </type>
<!-- 6.3 Title-->
<title>Certificate of Usability Engineer</title>
<!-- 6.4 Score-->
<score>5</score>
<!-- 6.5 Date-->
<date>2009-09-21T02:13:00</date>
<!-- 6.6 Assessing Body-->
<assessingBody><![CDATA[
BEGIN:VCARD
END:VCARD
]]></assessingBody>
The student demonstrated ability in designing, implementing and managing a software development project.

http://www.univxxx.edu/diplomas/1234.pdf

http://ec.europa.eu/education/policies/educ/eqf
Appendix E: Engineering Evaluation Questionnaire

Dear prototype developer!

You and your organisation have invested a significant amount of resources implementing a prototype based on ICOPER specifications. The ICOPER specifications were designed to solve a particular interoperability problem in the context of your organisation. We are now interested in your feedback on these specifications and development effort.

Not all questions presented below are relevant for all target groups. It depends very much on your personal profile whether you will feel comfortable with some of the questions. Please do not hesitate to skip some of them if you do not feel yourself in a position of being able to answer a questions or two. On the other hand, of course we are interested in the maximum of feedback you are able to provide to us.

We are asking every prototype developer to provide at least one set of answers to these questions from a developer, but please consider it to get answers also from other stakeholders in your organisation such as management. Please add it to your prototype description for D1.2.

1. Contact information

1.1 Your roles (Note: if appropriate, select more than one):
( ) Developer (coding the prototype)
( ) Designer (design the interface)
( ) Researcher (working on requirement specifications)
( ) Decision-makers on the development of technology in an organization

1.2 Contact Details:
Name:
Tel:
Mail:
Web:

2. Prototype Summary

In your own words, which interoperability problem have you been working on? Which are the technical systems that you were aiming to connect?

Does your Prototype make full use of the ICOPER Middle Layer Specifications? If not, at which level does it support it? Which functions have you been focusing on?

Is your prototype easy to adapt or extend for the new versions of the specification in the future?

I worked with the ...
( ) WU Middle Layer Implementation
( ) KU Leuven Middle Layer Implementation

Your prototype is addressing the following end users:

( ) Learners
( ) Teachers
( ) Curriculum Developers
( ) Higher Education Management

3. Your Open Feedback (Qualitative Evaluation)

3.1 ICOPER Middle Layer Specifications

3.1.1 What do you think about the ICOPER Middle Layer Specifications? Are they helpful to achieve interoperability? Are they useful? How would you assess their relevancy?

3.1.2 Are the specifications sufficiently adaptable / extensible? Are data models sufficiently expressive / complete? Are service specifications sufficiently feature-rich / complete?

3.1.3 Were the key concepts introduced clear to you? Transferable also to your (sub-)domain?

3.1.4 Are the ICOPER Middle Layer Specifications programmer-friendly (easy to read? understandable? easy to implement?)? How would you assess the skill level on the programmer side for implementing these specs?

3.1.5 How would you summarize the highlights of the ICOPER Middle Layer Specifications? How do they differentiate themselves from other specs you are aware of? Would you consider them innovative / highly original work?

3.1.6 How would you summarize the lowlights and major weaknesses of the ICOPER Middle Layer Specifications? Have you been able to identify major weaknesses as compared to other implementations? Have you been able to identify particular things that really need to be changed? Please assess also the priority of your proposal for change.

3.1.7 Which opportunities – and potentially threats - do the ICOPER Middle Layer Specifications create for the ICOPER consortium? Do you think this work will contribute to the superiority of our products and services / our reputation in the field? Is the work inspiring to others? Will it lead to surprising results? How would you assess the opportunities and threats quantitatively (high - low)? What is required to seize the opportunities / overcome threats?

3.2 Implementation Support

3.2.1 Have you felt sufficiently supported by experts and tools?
3.2.2 How would you summarize the highlights of the ICOPER Middle Layer Implementation? How do they differentiate themselves from other specs you are aware of? Would you consider them innovative / highly original work?

3.2.3 How would you summarize the lowlights and major weaknesses of the ICOPER Middle Layer Implementation? Have you been able to identify major weaknesses as compared to other implementations? Have you been able to identify particular things that really need to be changed? Please assess also the priority of your proposal for change.

3.2.4 Which opportunities – and potentially threats - does the ICOPER Middle Layer Implementation create for your organisation? Do you think this work will contribute to the superiority of your products and services? Is the work inspiring to you? Will it lead to surprising results? How would you assess the opportunities and threats quantitatively (high - low)? What is required to seize the opportunities / overcome threats?

4. Your Quantitative Evaluation

4.1 ICOPER Middle Layer Specifications

What do you think about the ICOPER Middle Layer Specifications in general?
1: very bad 2 3 4 5 6 7: very good

Are they helpful to achieve interoperability?
1: Not at all 2 3 4 5 6 7: very helpful

The problems the ICOPER Middle Layer Specifications tackles can be considered ...
1: Not at all relevant 2 3 4 5 6 7: very relevant

I consider the ICOPER Middle Layer Specifications ...
1: Not adaptable at all 2 3 4 5 6 7: highly adaptable

I consider the ICOPER Middle Layer Specifications ...
1: very difficult to understand 2 3 4 5 6 7: very easy to understand

I consider the ICOPER Middle Layer Specifications ...
1: Not programmer-friendly at all 2 3 4 5 6 7: highly programmer-friendly

To what degree the following attributes are achieved by the ICOPER Middle Layer specification:
Conceptual integrity
I realized to a high degree 2 3 4 5 6 7: not at all realized

Correctness
I realized to a high degree 2 3 4 5 6 7: not at all realized

Completeness
I realized to a high degree 2 3 4 5 6 7: not at all realized

Balanced specificity
I realized to a high degree 2 3 4 5 6 7: not at all realized
D1.2 Open ICOPER Content Space
Implementation of 2nd Generation of Open ICOPER Content Space including Integration Mini Case Studies

Implementation transparency
I realized to a high degree 2 3 4 5 6 7: not at all realized

Evolvability
I realized to a high degree 2 3 4 5 6 7: not at all realized

Extensibility
I realized to a high degree 2 3 4 5 6 7: not at all realized

4.2 ICOPER Middle Layer Implementation

What do you think about the ICOPER Middle Layer Implementation in general?
1: very bad 2 3 4 5 6 7: very good

It it helpful to achieve interoperability?
1: Not at all 2 3 4 5 6 7: very helpful

The problems the ICOPER Middle Layer Implementation tackles can be considered ...
1: Not at all relevant 2 3 4 5 6 7: very relevant

I consider the ICOPER Middle Layer Implementation ...
1: Not adaptable at all 2 3 4 5 6 7: highly adaptable

I consider the ICOPER Middle Layer Implementation ...
1: very difficult to work with 2 3 4 5 6 7: very easy to work with

I consider the ICOPER Middle Layer Specifications ...
1: Not programmer-friendly at all 2 3 4 5 6 7: highly programmer-friendly

For each of the following quality attributes, please state how important they are for your development and to what degree the implementation currently achieves them.

Performance
1 very important 2 3 4 5 6 7: not at all important
I realized to a high degree 2 3 4 5 6 7: not at all realized

Security
1 very important 2 3 4 5 6 7: not at all important
I realized to a high degree 2 3 4 5 6 7: not at all realized

Availability
1 very important 2 3 4 5 6 7: not at all important
I realized to a high degree 2 3 4 5 6 7: not at all realized

Portability
1 very important 2 3 4 5 6 7: not at all important
I realized to a high degree 2 3 4 5 6 7: not at all realized

Reusability
1 very important 2 3 4 5 6 7: not at all important
I realized to a high degree 2 3 4 5 6 7: not at all realized

Testability
1 very important 2 3 4 5 6 7: not at all important
I realized to a high degree 2 3 4 5 6 7: not at all realized