Creative Emotional Reasoning Computational Tools Fostering Co-Creativity in Learning Processes

www.c2learn.eu

C2LEARN CONTENT REPRESENTATION

C²LEARN PROJECT DELIVERABLE NO. D4.2

Authors: National Centre for Scientific Research "Demokritos" (NCSR-D)

Dissemination level: *Public*

The C²Learn project has been supported by the European Commission through the Seventh Framework Programme (FP7), under grant agreement no 318480 (November 2012 – October 2015). The contents of this document do not represent the views of the European Commission and the Commission cannot be held responsible for any use which may be made of the information contained therein. Responsibility for the information and views set out in this document lies entirely with the authors.

DOCUMENT IDENTITY

Project category	Details
Deliverable code	D4.2
Full title	C2Learn Content Representation
Work package	WP4
Task	T4.2 Content Representation
Consortium partners leading	NCSR-D
Consortium partners contributing	NCSR-D

DOCUMENT HISTORY

Version	Date	Handling partner	Description
Draft v0.1	04/10/2013	NCSR-D	Document Setup, ToC
Draft v0.3	18/10/2013	NCSR-D	Sections 2 and 3
Draft v0.6	01/11/2013	NCSR-D	Section 4
Draft v1.0	15/11/2013	NCSR-D	Section 5
Final Version	25/11/2013	NCSR-D	Revisions and Updates
Updated Version	18/03/2013	NCSR-D	Updated deliverable

EXECUTIVE SUMMARY

C²Learn at a glance

C²Learn (www.c2learn.eu) is a three-year research project supported by the European Commission through the Seventh Framework Programme (FP7), in the theme of Information and Communications Technologies (ICT) and particularly in the area of Technology-Enhanced Learning (TEL) (FP7 grant agreement no 318480). The project started on 1st November 2012 with the aim to shed new light on, and propose and test concrete ways in which our current understanding of creativity in education and creative thinking, on the one hand, and technology-enhanced learning tools and digital games, on the other hand, can be fruitfully combined to provide young learners and their teachers with innovative opportunities for creative learning. The project designs an innovative digital gaming and social networking environment incorporating diverse computational tools, the use of which can foster co-creativity in learning processes in the context of both formal and informal educational settings. The C²Learn environment is envisioned as an open-world 'sandbox' (non-linear) virtual space enabling learners to freely explore ideas, concepts, and the shared knowledge available on the semantic web and the communities that they are part of. This innovation is co-designed, implemented and tested in systematic interaction and exchange with stakeholders following participatory design and participative evaluation principles. This happens in and around school communities covering a learner age spectrum from 10 to 18+ years.

About this document

Deliverable D4.2 provides details on the Content Representation needs of C2Learn, analyzing the different standards and technologies applicable to the problem and examining their suitability for the specific requirements posed by the C2Learn content.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF TERMS AND ABBREVIATIONS

Term/Abbreviation	Definition
LT	Learning Technologies
RTE	Run-Time Environment
SCO	Sharable Content Object
SCORM	Sharable Content Object Reference Model
XML	Extensible Markup Language

1. INTRODUCTION

The following figure depicts the core components involved in the design and execution of a C2Learn Educational Activity, and the interactions between these components.

The activities are centred on Game Sessions, which involve the invocation of one or more C2Learn Games. In order for a game to become available in C²Learn Game Sessions, it has to be declared in the *Game Registry*. To this end, the game should provide metadata regarding its usage and requirements. The metadata also include a pointer to the *Game Repository*, where the actual game is available.

In order to design an educational activity, the tutor employs the *Educational Planner*, the component that allows the design of educational plans using the resources available to the teacher (i.e. time frames, classes and games). The information about the games is retrieved from the aforementioned Game Registry. Information about the classes to participate in the educational activity is retrieved from the C²Learn *Profiling Server*.

Once a plan has been constructed, it can be used by the *Group Manager* in order to design specific game sessions over this plan. The Group Manager allows the teacher to specify the parameterization of the game instance that will be activated during the game session, as well as, the groups of students that will be playing the game. The produced game session definition is stored in the *Game Session Registry*.

When a student logins to a C²Learn Game as a group member participating in the game session, its activities are monitored and stored in the Profiling Server. Upon the finalization of the session, the creativity profiles of the participants are updated and stored in the Profiling Server, based on their actions during the session.

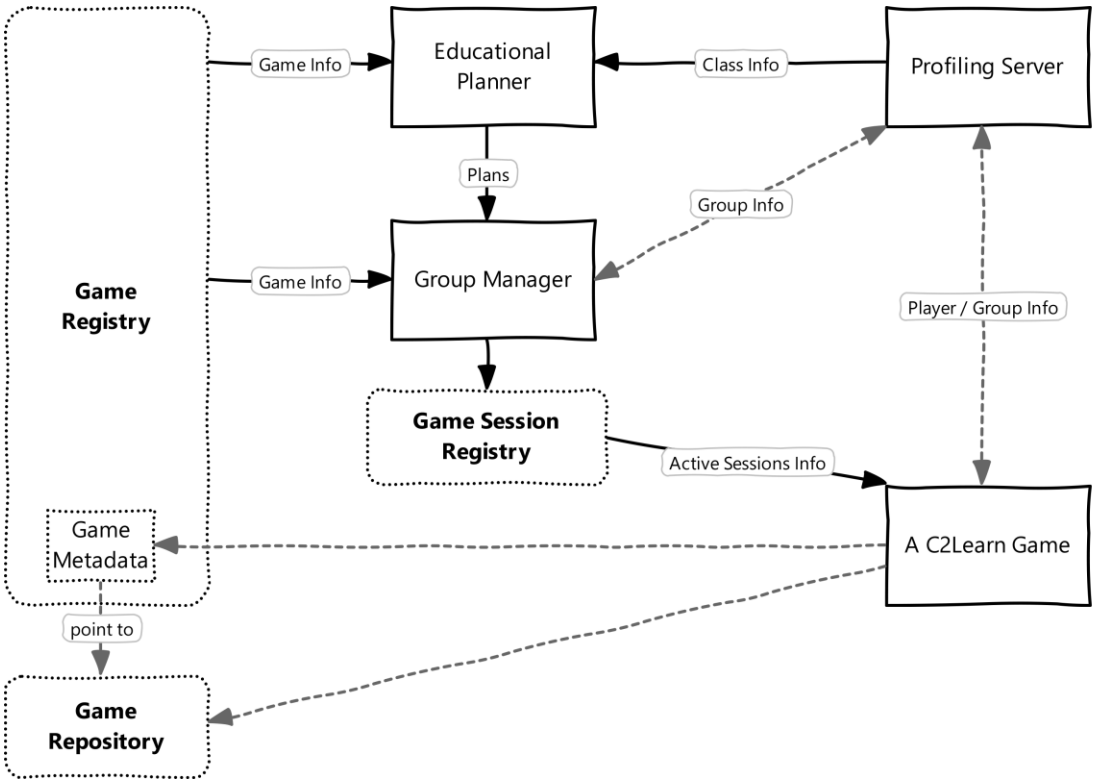


Figure 1: C2Learn Overall Architecture

The described architecture poses the representation and communication requirements that must be satisfied in order to integrate the distinct architectural components in a way that will ensure (a) that the platform is easily extensible with different games and class settings, and (b) that the produced content will be able to be incorporated with minimal effort in different learning environments.

The aim of this deliverable is to identify the constituents of the C2Learn architecture that need to bear a specific, standard-conformant representation and to examine the relevant and appropriate specifications that can serve this purpose. The communication requirements, and the respective standards to be used for satisfying them, will be analysed in deliverable D3.5, Computational Tools Interoperability Specification.

2. C2LEARN INTEROPERABILITY REQUIREMENTS

Taking into account the architecture depicted in Figure 1, we identify the following elements that require a standardized representation in order to ensure the interoperability of the associated components and assets. These elements are summarized in the following table.

Representation Requirements			
Architectural Element	**Representation Requirement**	**Importance**	**Candidate Standard / Spec**
Game Registry	The metadata describing the game should follow a standard schema / formulation	Mandatory	IEEE LOM Dublin-Core
Game Repository	The games available in C²Learn should be packaged and distributed in a standard way	Mandatory	IMS CP SCORM 2004
Educational Planner	The produced plans could be exportable in order to be used by other systems	Optional	BPMN BPEL IMS LD

Table 1: C²Learn Representation Requirements

Similarly, the communication points within the C²Learn architecture that must be conformant with relevant standards and specifications are summarized in Table 2.

Communication Requirements			
Information Type	**Communication Requirement**	**Importance**	**Candidate Standard / Spec**
Learner Experience	In the case of User Profiling, that is, how the information about the users is represented, collected and communicated between the different C2Learn components, a critical aspect is the modelling of tracking statements produced during the learning experience. These messages (tracking statements) will be stored in the C2Learn Profiling Server.	Mandatory	ADL Experience API (xAPI) ADL Learning Record Store (LRS)

Table 2: C2Learn Communication Requirements

The representation requirements will be analysed in the following sections of this document. The communication requirements will be analysed in deliverable D3.5, Computational Tools Interoperability Specification.

3. RELEVANT STANDARDS & SPECIFICATIONS FOR THE C2LEARN REPRESENTATION REQUIREMENTS

3.1 GAME REGISTRY

The Game Registry is responsible for maintaining and serving information about the games available in C2Learn. Each of the games should provide information regarding its provenance and its general characteristics (language, usage description etc.). To this end, the game registry should use a standard resource description model for representing the metadata of each game. The candidate specifications that are most relevant to the purposes of C2Learn is the *IEEE Learning Object Metadata* (LOM) standard and the *Dublin Core Metadata Initiative* (DCMI) model.

The IEEE Learning Technology Standards Committee (LTSC) is responsible for the development and maintenance of the Learning Object Metadata (LOM) standard (IEEE, 2002) since 1997. This process has been and continues to be an international effort with the active participation on the LOM Working Group by members representing more than 15 countries. This resulted in the first IEEE accredited standard to be completed by LTSC, the 1484.12.1 LOM data model standard. This is the first of a multi-part standard for Learning Object Metadata, which LTSC LOM is responsible for maintaining, developing and evolving. This responsibility is being fulfilled by current work on bindings of the data model standard and includes developing further versions of the data model standard. The IEEE LOM standard has been well received, recognized and adopted internationally.

The elements of the IEEE LOM standard are organized in the following categories:

– *General*. This category groups the general information that describes a learning object as a whole.

– *Life Cycle*. This category describes the history and current state of a learning object and those entities that have affected the learning object during its evolution.

– *Meta-Metadata*. This category describes the metadata record itself (rather than the learning object that the metadata record describes).

– *Technical*. This category describes the technical requirements and characteristics of a learning object.

– *Educational*. This category describes the key educational or pedagogic characteristics of a learning object.

– *Rights*. This category describes the intellectual property rights and conditions of use for a learning object.

– *Relation*. This category defines the relationship between a learning object and other learning objects.

– *Annotation*. This category provides comments on the educational use of a learning object, and information on when and by whom the comments were created.

– *Classification*. This category describes where a learning object falls within a particular classification system.

Figure 2 presents a generalized view of the structure of the IEEE LOM standard metadata model.

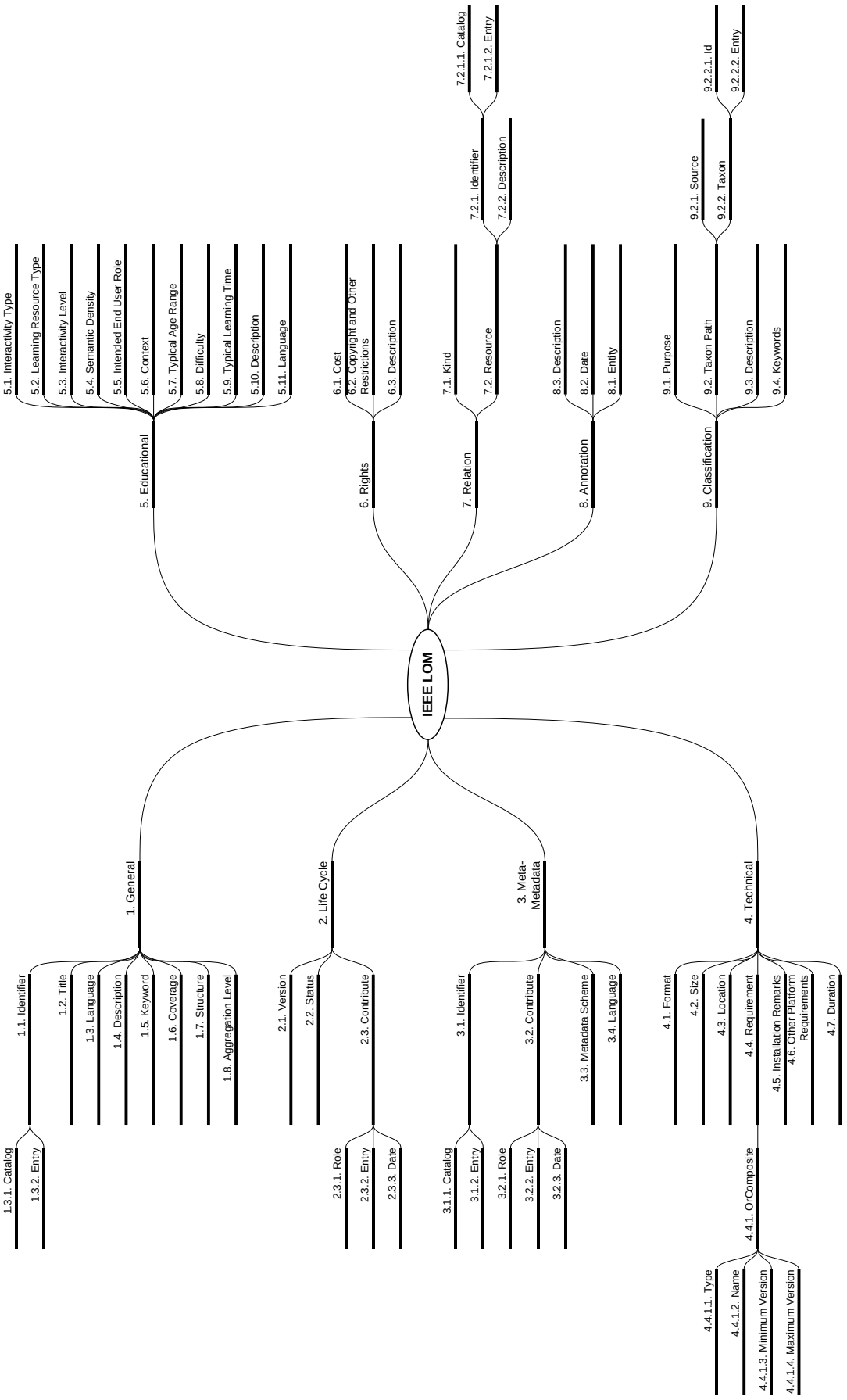


Figure 2: IEEE LOM Elements

The IEEE LOM model consists of about eighty (80) elements, many of which can have multiple instances in the description of a single object. The inherent complexity of the model results to a difficult to maintain representation, while the level of detail provided by IEEE LOM is not necessary for representing in full the C2Learn games.

On the other hand, the Dublin Core Metadata Element Set (Dublin Core Metadata Initiative, 2012) is a vocabulary of fifteen properties for use in resource description. The name "Dublin" is due to its origin at a 1995 invitational workshop in Dublin, Ohio; "core" because its elements are broad and generic, usable for describing a wide range of resources. The fifteen element "Dublin Core" described in this standard is part of a larger set of metadata vocabularies and technical specifications maintained by the Dublin Core Metadata Initiative (DCMI). The full set of vocabularies, DCMI Metadata Terms, also includes sets of resource classes (including the DCMI Type Vocabulary), vocabulary encoding schemes, and syntax encoding schemes. The terms in DCMI vocabularies are intended to be used in combination with terms from other, compatible vocabularies in the context of application profiles and on the basis of the DCMI Abstract Model.

The simplicity of the core recommendation of the Dublin Core Metadata Element Set, combined with the ease of extensibility that it provides by its definition, makes it a suitable candidate for usage within the C²Learn Game Registry. Furthermore, the IEEE LOM standard defines explicit mappings with Dublin Core, and thus a Dublin Core metadata description can be used from systems using the IEEE LOM standard without mapping ambiguities.

The C2Learn Game Registry will use the following subset of Dublin Core Metadata Elements. This set will be extended with two additional elements that will be used to define the minimum and maximum number of groups that the given game's gameplay supports. The following table summarizes the elements that will be used for providing metadata about the C²Learn games.

C2Learn Element	Description	Dublin Core Element	IEEE LOM Element
URL	The location from where the game can be accessed	DC:identifier	General.Identifier.Entry General.Identifier.Catalog = "URL"
Title	The title of the game	DC:title	General.Title
Language	The languages supported by the game	DC:language	General.Language
Description	A short description of the game's functionality	DC:description	General.Description
Date	The date the game was registered	DC:date	LifeCycle.Contribute.Date LifeCycle.Contribute.Role = "Publisher"
Publisher	The entity that published the game	DC:publisher	LifeCycle.Contribute.Entity LifeCycle.Contribute.Role = "Publisher"
Rights	A licence / ToU for the game	DC:rights	Rights.Description
minGroups	The minimum number of groups that is supported by the game	-	-
maxGroups	The maximum number of groups that is supported by the game	-	-

Table 3: C2Learn Game Description Elements and their mappings

3.2 GAME REPOSITORY

As mentioned, the Game Registry includes information for locating and retrieving the actual game deployment. In addition to being able to locate the game, it is essential that the game is distributed in a standard package structure, so that it can be used within different environments. Hence, we need to examine relevant standards and specifications for packaging digital content and assess their applicability for the specific C²Learn content (the C²Learn games).

Currently, the most adopted model for content packaging is the IMS Content Packaging Specification (IMS Global Consortium, 2004). The objective of IMS CP is to define a standardized set of structures that can be used to exchange content. The scope of IMS CP is on defining interoperability between systems that wish to import, export, aggregate, and disaggregate packages of learning content.

This specification has been adopted by the ADL as part of the SCORM reference model.

An IMS Content Package contains two major components:

1. *a (required) special XML document describing the content organization and resources of the package. The special file is called the Manifest file (imsmanifest.xml) because package content and organization is described in the context of manifests.*
2. *the physical files referenced in the Manifest.*

Sharable Content Object Reference Model (SCORM) (ADL, 2004) refines the IEEE LTSA reference architecture by specifying missing interactions. More precisely, SCORM provides a reference interaction model between a learner and learning content, and describes within a common technical framework the creation process of reusable learning content as "instructional objects", called sharable content objects (SCOs). SCORM describes that technical framework by providing a harmonized set of guidelines, specifications, and standards based on the work of several distinct e-learning specifications and standardization bodies. SCORM consists of three parts, namely:

- Run-Time Environment (RTE). The purpose of the SCORM RTE is to provide a means for interoperability between SCOs and LMSs. SCORM provides the means for learning content to be interoperable across multiple learning systems regardless of the tools used to create the content. The three components of the SCORM RTE are Launch, Application Program Interface (API) and Data Model. Launch includes defining the relationship between learning systems and SCORM content such that all SCORM-conformant content is dependent upon a SCORM-conformant learning system to be delivered and displayed to the learner. The SCORM API provides a set of predefined methods for purposes of communication between a learning system and the SCOs it launches. The SCORM Run-Time Environment Data Model provides the data elements that can be used to "get" and "set" data from and to a learning system.
- Sequencing and Navigation (SN). The SCORM SN covers the essential learning system responsibilities for sequencing content objects during run-time and allowing SCOs to indicate navigation requests. The SCORM SN is based on the IMS Simple Sequencing (SS) Specification v1.0, which defines a method for representing the intended behavior of an authored learning activity such that any conformant learning system will be able to sequence discrete content components in a consistent way. It defines the required behaviors and functionalities that SCORM-conformant learning systems must implement to process sequencing information at runtime. More specifically, it describes the branching and flow of learning content in terms of an Activity Tree, based on the results of a learner's interactions with launched content objects and an authored sequencing strategy. The SCORM SN describes how learner-initiated and system-initiated navigation events can be triggered and processed, resulting in the identification of learning content for delivery.
- Content Aggregation Model (CAM). The SCORM CAM describes the content components used in a learning activity, how to package those components for exchange from system to system and how to describe those components to enable search and discovery. The CAM promotes the consistent storage, labeling, packaging, exchange and discovery of learning content. The SCORM CAM model contains information on Metadata, Content Structure and Packaging. The SCORM CAM model extends the IMS CP specification.

Within C2Learn, we will use the SCORM CAM model for packaging the C2Learn games. The metadata accompanying the game's distribution will essentially be the metadata for the game provided by the game registry. In order to be compliant with the specification the game SCORM CAM package will include these metadata expressed in the IEEE LOM model, via the mapping defined in Table 3.

3.3 EDUCATIONAL PLANNER

In its essence, the Educational Planner is a typical Workflow Design system, which is used in C²Learn for designing the planning of educational activities. Thus, standards and specifications from the field of workflow management systems should be considered as the best candidates in this case.

A well-adopted and easily used standard for creating human understandable graphical representations of workflows is the Business Process Modelling Notation (BPMN) standard (OASIS, 2007). BPMN can be used as a common representation notation for workflows modelled using the Business Process Execution Language (BPEL) (Business Process Management Initiative, 2006). BPEL is an XML based language that represents a process, and can be directly mapped to BPMN graphical design elements (White, 2005).

However, the mapping BPMN diagrams and BPEL documents can be achieve in two distinct ways. In the first case, the BPEL format is based on the BPEL graph structure (the flow element), where the Sequence Flow will map to the link elements contained within a flow element. In the second case, the BPEL format is based on the BPEL block structure (the sequence element). When using the block structure as the foundation for mapping, link elements are only used when there exist parallel activities.

In addition to its Workflow design functionality, the Educational Planner could optionally export the educational plans following Learning Technology (LT) standards and specifications. As the C²Learn workflows are group-based and multi-role, they can be represented solely via the IMS Learning Design Specification (IMS Global Consortium, 2003). The core components of IMS LD are presented in Figure 3.

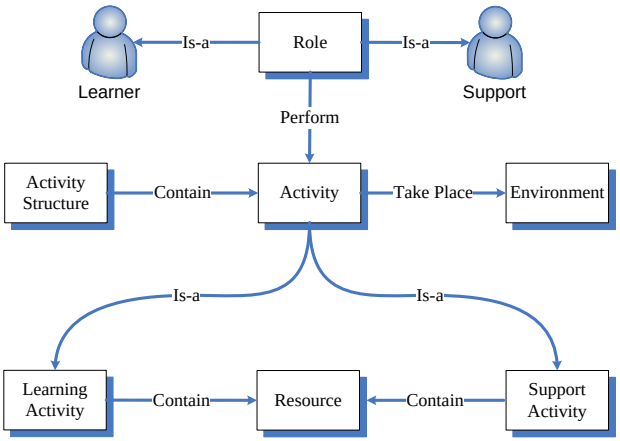


Figure 3: IMS Learning Design Core Components

To represent the learning flow (that is, the sequence of activities performed by each role), the IMS LD notation language uses the Act element. An act represents a logical categorization of a set of activities. In each act, several roles can participate by performing a Rolepart. Each rolepart represents the activities performed by the corresponding role in a specific act and contains an Activity Structure, which represents the sequence of the performed activities. An activity structure can use a nested structure of activities and/or other activity structures defining the branching of the learning flow, as shown in Figure 4.

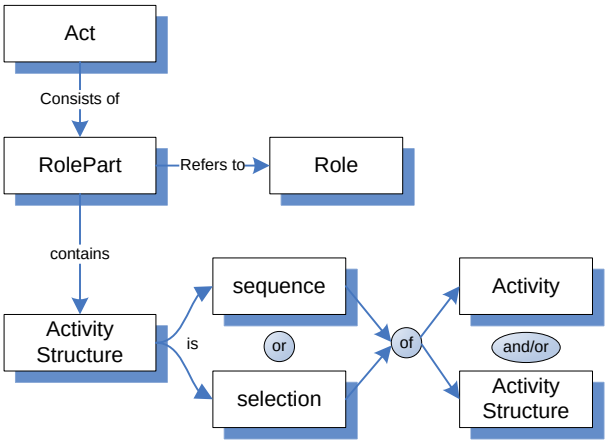


Figure 4: IMS Learning Design Sequencing Core Components

The mapping of BPMN core graphical elements with the IMS LD core element, which allows the transformation of the workflows provided by the Educational Planner to IMS LD, is presented in Table 4.

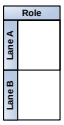
BPMN Graphical Element	Description	BPMN Graphical Notation	IMS LD Components
Pool	A Pool represents an actor (role) in a learning process.		Pool
Lane	A Lane is a horizontal sub-partition within a Pool, for logically organizing and categorizing activities.		Act RolePart
Activity	An activity represents a working item (task) that one or more actors (roles) of the learning process perform.		Activity
Sequence Flow	A Sequence Flow is used to show the order that activities will be performed in a learning process.		Flow of activities represented as nested Activity Structures
Gateway	A Gateway is used to control the divergence and convergence of Sequence Flow. Thus, it will determine branching, forking, merging, and joining of paths. Internal Markers will indicate the type of behavior control.		Gateway

Table 4: Mapping of BPMN Core Graphical Elements to IMS Learning Design Core Components

4. CONCLUSIONS

The C2Learn environment and the respective architecture pose specific representation and communication requirements for the involved content and components. It is highly desirable and particularly important to use widely adopted and well-supported standards and specifications for fulfilling these requirements and ensuring that the C2Learn outcomes can be reused and incorporated with minimal effort in other standard-conformant platforms and systems.

The present deliverable reports on the standards and specifications for satisfying the C2Learn representation requirements. Standards from three different fields are adopted, depending on the nature and functionality of the entities that are to be represented:

- From the field of Learning Technologies, we will use the IEEE LOM, IMS CP, SCORM and IMS LD standards
- From the field of Workflow management, we will use the BPMN and BPEL standards
- From the field of Resource Description, we will use the Dublin Core Metadata Element Set.

The C²Learn communication requirements will be similarly analysed in deliverable D3.5, Computational Tools Interoperability Specification.

REFERENCES

ADL. (2004). *Sharable Content Object Reference Model (SCORM).* Retrieved from http://www.adlnet.gov/scorm/scorm-2004-4th/

Business Process Management Initiative. (2006). *Business Process Modeling Notation Specification.* Retrieved November 6, 2013, from http://www.omg.org/bpmn/Documents/OMG_Final_Adopted_BPMN_1-0_Spec_06-02-01.pdf

Dublin Core Metadata Initiative. (2012, 06 14). *Dublin Core Metadata Element Set, Version 1.1.* Retrieved from http://dublincore.org/documents/dces/

IEEE. (2002). *IEEE Learning Object Medatata Standarad (IEEE LOM), IEEE P1484.12.1.* Retrieved from http://ltsc.ieee.org/wg12/

IMS Global Consortium. (2003). *IMS GLC: Learning Design Specification.* Retrieved November 6, 2013, from http://www.imsglobal.org/learningdesign/index.html

IMS Global Consortium. (2004). *IMS GLC: Content Packaging.* Retrieved from http://www.imsproject.org/content/packaging/

OASIS. (2007). *Business Process Execution Language for Web Services*. Retrieved November 6, 2013, from http://docs.oasis-open.org/wsbpel/2.0/OS/wsbpel-v2.0-OS.pdf

White, S. (2005, March). *Using BPMN to Model a BPEL Process.* Retrieved November 6, 2013, from http://www.bptrends.com/publicationfiles/03-05%20WP%20Mapping%20BPMN%20to%20BPEL-%20White.pdf